DIRECTORATE OF EDUCATION
Govt. of NCT, Delhi

SUPPORT MATERIAL
(2021-2022)

Class : XI

CHEMISTRY

Under the Guidance of

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Published at Delhi Bureau of Text Books, 25/2 Institutional Area, Pankha Road, New Delhi-110058 by **Prabhjot Singh,** Secretary, Delhi Bureau of Text Books and Printed by Arihant Offset, New Delhi-110043

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सत्यमेव जयते

MESSAGE

I would like to congratulate the members of Core Academic Unit and the subject experts of the Directorate of Education, who inspite of dire situation due to Corona Pandemic, have provided their valuable contributions and support in preparing the Support Material for classes IX to XII.

The Support Material of different subjects, like previous years, have been reviewed/ updated in accordance with the latest changes made by CBSE so that the students of classes IX to XII can update and equip themselves with these changes. I feel that the consistent use of the Support Material will definitely help the students and teachers to enrich their potential and capabilities.

Department of Education has taken initiative to impart education to all its students through online mode, despite the emergency of Corona Pandemic which has led the world to an unprecedented health crisis. This initiative has not only helped the students to overcome their stress and anxiety but also assisted them to continue their education in absence of formal education. The support material will ensure an uninterrupted learning while supplementing the Online Classes.

(H. Rajesh Prasad)

UDIT PRAKASH RAI, IAS
Director, Education & Sports

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MESSAGE

The main objective of the Directorate of Education is to provide quality education to all its students. Focusing on this objective, the Directorate is continuously in the endeavor to make available the best education material, for enriching and elevating the educational standard of its students. The expert faculty of various subjects undertook this responsibility and after deep discussions and persistent efforts, came up with Support Material to serve the purpose.

Every year the Support Material is revised/updated to incorporate the latest changes made by CBSE in the syllabus of classes IX to XII. The contents of each lesson/chapter are explained in such a way that the students can easily comprehend the concept and get their doubts solved.

I am sure, that the continuous and conscientious use of this Support Material will lead to enhancement in the educational standard of the students, which would definitely be reflected in their performance.

I would also like to commend the entire team members for their contributions in the preparation of this incomparable material.

I wish all the students a bright future.

(UDIT PRAKASH RAI)

Dr. RITA SHARMA
Additional Director of Education
(School/Exam)

सत्यमेव जयते

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Directorate of Education
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D.O. No. PA/Addl.DE/Sch/31
Dated: 29.06.2021

MESSAGE

It gives me immense pleasure to present the revised edition of the Support Material. This material is the outcome of the tireless efforts of the subject experts, who have prepared it following profound study and extensive deliberations. It has been prepared keeping in mind the diverse educational level of the students and is in accordance with the most recent changes made by the Central Board of Secondary Education.

Each lesson/chapter, in the support material, has been explained in such a manner that students will not only be able to comprehend it on their own but also be able to find solution to their problems. At the end of each lesson/chapter, ample practice exercises have been given. The proper and consistent use of the support material will enable the students to attempt these exercises effectively and confidently. I am sure that students will take full advantage of this support material.

Before concluding my words, I would like to appreciate all the team members for their valuable contributions in preparing this unmatched material and also wish all the students a bright future.

(Rita Sharma)

भारत का संविधान

भाग 4क

नागरिकों के मूल कर्तव्य

अनुच्छेद 51क

मूल कर्तव्य - भारत के प्रत्येक नागरिक का यह कर्तव्य होगा कि वह -

(क) संविधान का पालन करे और उसके आदर्शों, संस्थाओं, राष्ट्रध्वज और राष्ट्रगान का आदर करे;

(ख) स्वतंत्रता के लिए हमारे राष्ट्रीय आंदोलन को प्रेरित करने वाले उच्च आदर्शों को हृदय में संजोए रखे और उनका पालन करे;

(ग) भारत की संप्रभुता, एकता और अखंडता की रक्षा करे और उसे अक्षुण्ण बनाए रखे;

(घ) देश की रक्षा करे और आह्वान किए जाने पर राष्ट्र की सेवा करे;

(ङ) भारत के सभी लोगों में समरसता और समान भ्रातृत्व की भावना का निर्माण करे जो धर्म, भाषा और प्रदेश या वर्ग पर आधारित सभी भेदभावों से परे हो, ऐसी प्रथाओं का त्याग करे जो महिलाओं के सम्मान के विरुद्ध हों;

(च) हमारी सामासिक संस्कृति की गौरवशाली परंपरा का महत्त्व समझे और उसका परिरक्षण करे;

(छ) प्राकृतिक पर्यावरण की, जिसके अंतर्गत वन, झील, नदी और वन्य जीव हैं, रक्षा करे और उसका संवर्धन करे तथा प्राणिमात्र के प्रति दयाभाव रखे;

(ज) वैज्ञानिक दृष्टिकोण, मानववाद और ज्ञानार्जन तथा सुधार की भावना का विकास करे;

(झ) सार्वजनिक संपत्ति को सुरक्षित रखे और हिंसा से दूर रहे;

(ञ) व्यक्तिगत और सामूहिक गतिविधियों के सभी क्षेत्रों में उत्कर्ष की ओर बढ़ने का सतत् प्रयास करे, जिससे राष्ट्र निरंतर बढ़ते हुए प्रयत्न और उपलब्धि की नई ऊँचाइयों को छू सके; और

(ट) यदि माता-पिता या संरक्षक है, छह वर्ष से चौदह वर्ष तक की आयु वाले अपने, यथास्थिति, बालक या प्रतिपाल्य को शिक्षा के अवसर प्रदान करे।

CONSTITUTION OF INDIA

Part IV A (Article 51 A)

Fundamental Duties

Fundamental Duties : It shall be the duty of every citizen of India —

1. to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;
2. to cherish and follow the noble ideals which inspired our national struggle for freedom;
3. to uphold and protect the sovereignty, unity and integrity of India;
4. to defend the country and render national service when called upon to do so;
5. to promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;
6. to value and preserve the rich heritage of our composite culture;
7. to protect and improve the natural environment including forests, lakes, rivers and wild life, and to have compassion for living creatures.
8. to develop the scientific temper, humanism and the spirit of inquiry and reform;
9. to safeguard public property and to adjure violence;
10. to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievement.
11. who is a parent or guardian to provide opportunities for education to his child or, as the case may be, ward between the age of six and fourteen years.

भारत का संविधान

उद्देशिका

हम, भारत के लोग, भारत को एक [1]**[संपूर्ण प्रभुत्व-संपन्न समाजवादी पंथनिरपेक्ष लोकतंत्रात्मक गणराज्य]** बनाने के लिए, तथा उसके समस्त नागरिकों को **:**

सामाजिक, आर्थिक और राजनैतिक **न्याय,**

विचार, अभिव्यक्ति, विश्वास, धर्म

और उपासना की **स्वतंत्रता,**

प्रतिष्ठा और अवसर की **समता**

प्राप्त कराने के लिए,

तथा उन **सब में**

व्यक्ति की गरिमा और [2]**[राष्ट्र की एकता और अखंडता]** सुनिश्चित करने वाली **बंधुता**

बढ़ाने के लिए

दृढ़संकल्प होकर **अपनी इस संविधान सभा में** आज तारीख 26 नवंबर, 1949 ई. को **एतद्द्वारा इस संविधान को अंगीकृत, अधिनियमित और आत्मार्पित करते हैं।**

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1. संविधान (बयालीसवां संशोधन) अधिनियम, 1976 की धारा 2 द्वारा (3.1.1977 से) ''प्रभुत्व-संपन्न लोकतंत्रात्मक गणराज्य'' के स्थान पर प्रतिस्थापित।
2. संविधान (बयालीसवां संशोधन) अधिनियम, 1976 की धारा 2 द्वारा (3.1.1977 से) ''राष्ट्र की एकता'' के स्थान पर प्रतिस्थापित।

THE CONSTITUTION OF INDIA

PREAMBLE

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a [1]**[SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC]** and to secure to all its citizens :

JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

EQUALITY of status and of opportunity; and to promote among them all

FRATERNITY assuring the dignity of the individual and the [2][unity and integrity of the Nation];

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949 do **HEREBY ADOPT, ENACT AND GIVE TO OURSELVES THIS CONSTITUTION.**

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1. Subs. by the Constitution (Forty-second Amendment) Act, 1976, Sec.2, for "Sovereign Democratic Republic" (w.e.f. 3.1.1977)
2. Subs. by the Constitution (Forty-second Amendment) Act, 1976, Sec.2, for "Unity of the Nation" (w.e.f. 3.1.1977)

DIRECTORATE OF EDUCATION
Govt. of NCT, Delhi

SUPPORT MATERIAL
(2021-2022)

CHEMISTRY
Class : XI

NOT FOR SALE

PUBLISHED BY : DELHI BUREAU OF TEXTBOOKS

Support Material Preparation Team
Class XI – Chemistry

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5.	Mohit Garg	PGT (Chem.)	RPVV, Shalimar Bagh BT-Block, New Delhi

HOW TO LEARN - CHEMISTRY

Dear students it is going to be long journey for all of you to have bright career in Science stream. Now you all have become the part of the Secondary School environment where critical thinking has a very big and important role. There are certainly few points which you need to imbibe in order to achieve success in Science stream especially in chemistry. Let us go through these points....

1. Examination is not an end of teaching learning process, instead it is milestone to be covered with patience. If the journey of the course is not enjoyable then naturally the examination result are not up to the mark. So the first point is to enjoy the journey of teaching learning process with teachers, classmates, friends and parents.

2. If at any stage doubt come in your mind, your mere hesitation can pile a lot of big hurdles towards goal achievement. So never pile up the doubts.

3. Always try to solve the solved examples of the NCERT first and the examples taught in the class, this will broaden your vision for the topic taught and once you are comfortable in the topic taught, now you can attempt the intext and back exercises problems.

4. The challenging task is to attempt the NCERT-EXEMPLER with full passion and with discussion in the class with classmates and the teacher.

5. Sincerity, punctuality, planning and hard work are the key area where you have to attain 100% by self analysis of yourself. If these areas are not worked upon by you then the high achievement is going to be a difficult task.

6. Before examination first try to revise the learned topics instead of learning new chapters, this will remove your stress. If the time permits, new topics can be seen but time factor constrains should also be kept in mind.

7. During the examination period, the word limit of the question should be taken care of, it should not that if I write more for (1) mark question I will get 3 or 5 marks. The word limit and the marks assigned should be considered while attempting the question.

8. While attempting the question in examination as well as in note copy also the assigned question must be supported by relevant diagram, formulas and unit of the physical parameter asked.

9. The presentation part must be as good as a reflection of the Board Topper's copy (Available in Directorate site and CBSE site-TOPPER'S sheet sample copy).

10. Read theory part carefully & practice as many numerical as you can. Focus on topics like mole concept, Electronic configuration, Quantum No., Oxidation No., Periodic Properties. VSEPR theory, Hybridization, Dipole moment, Resonance, IUPAC names, Electron transfer concepts, types of reactions, reaction intermediates.

11. Select MCQs options wisely. Do not rush into choosing a particular option if unable to find the answer, use the rule of elimination to reach the most appropriate answer. Usually ruling out 3 options works out faster.

12. For case based questions and reason assertion question thorough reading of theory and concepts is very important.

13. At last one point should be kept in mind that the result is mere reflection of 3 hrs test. If my process of learning is correct. If I work sincerely, honestly and diligently the success will definitely come to me but till then I will not leave the process of learning with from teacher's, friends and mentors.

Course Structure

Class : XI (Theory) (2021-22)

Chemistry

Total period (Theory 160 + Practical 60)

Time : 3 Hours | Total Marks : 70

Unit No.	Title	No. of Periods	Marks
Unit I	Some Basic Concepts of Chemistry	12	11
Unit II	Structure of Atom	14	
Unit III	Classification of Elements and Periodicity in Properties	08	04
Unit IV	Chemical Bonding and Molecular Structure	14	21
Unit V	States of Matter: Gases, Liquids and solids	12	
Unit VI	Chemical Thermodynamics	16	
Unit VII	Equilibrium	14	
Unit VIII	Redox Reactions	06	16
Unit IX	Hydrogen	08	
Unit X	s -Block Elements	10	
Unit XI	p -Block Elements	14	
Unit XII	Organic Chemistry: Some Basic Principles and Techniques	14	18
Unit XIII	Hydrocarbons	12	
Unit XIV	Environmental Chemistry	06	
	Total	**160**	**70**

Unit I : Some Basic Concepts of Chemistry **8 Periods**

General Introduction: Importance and scope of chemistry.

Nature of matter, laws of chemical combination, Dalton's atomic theory: concept of elements, atoms and molecules.

Atomic and molecular masses, mole concept and molar mass, percentage composition, empirical and molecular formula, chemical reactions, stoichiometry and calculations based on stoichiometry.

Unit II : Structure of Atom **10 Periods**

Bohr's model and its limitations, concept of shells and subshells, dual nature of matter and light, de Broglie's relationship, Heisenberg uncertainty principle, concept of orbitals, quantum numbers, shapes of s, p and d orbitals, rules for filling electrons in orbitals - Aufbau principle, Pauli's exclusion principle and Hund's rule, electronic configuration of atoms, stability of half-filled and completely filled orbitals.

Unit III : Classification of Elements and Periodicity in Properties **06 Periods**

Modern periodic law and the present form of periodic table, periodic trends in properties of elements -atomic radii, ionic radii, inert gas radii, Ionization enthalpy, electron gain enthalpy, electronegativity, valency. Nomenclature of elements with atomic number greater than 100

Unit IV : Chemical Bonding and Molecular Structure **14 Periods**

Valence electrons, ionic bond, covalent bond, bond parameters, Lewis structure, polar character of covalent bond, covalent character of ionic bond, valence bond theory, resonance, geometry of covalent molecules, VSEPR theory, concept of hybridization, involving *s*, *p* and *d* orbitals and shapes of some simple molecules, molecular orbital theory of homonuclear diatomic molecules(qualitative idea only), hydrogen bond.

Unit V : States of Matter: Gases, Liquids and Solids **18 Period**

Three states of matter, intermolecular interactions, types of bonding, melting and boiling points, role of gas laws in elucidating the concept of the molecule, Boyle's law, Charles law, Gay Lussac's law, Avogadro's law, ideal behaviour, empirical derivation of gas equation, Avogadro's number, ideal gas equation. Deviation from ideal behaviour, liquefaction of gases, critical temperature, kinetic energy and molecular speeds (elementary idea)

Liquid State: vapour pressure, viscosity and surface tension (qualitative idea only, no mathematical derivations)

Unit VI : Chemical Thermodynamics 16 Periods

Concepts of System and types of systems, surroundings, work, heat, energy, extensive and intensive properties, state functions. First law of thermodynamics -internal energy and enthalpy, heat capacity and specific heat, measurement of ΔU and ΔH, Hess's law of constant heat summation, enthalpy of bond dissociation, combustion, formation, atomization, sublimation, phase transition, ionization, solution and dilution. Second law of Thermodynamics (brief introduction). Introduction of entropy as a state function, Gibb's energy change for spontaneous and non- spontaneous processes, criteria for equilibrium. Third law of thermodynamics (brief introduction).

Unit VII : Equilibrium 14 Periods

Equilibrium in physical and chemical processes, dynamic nature of equilibrium, law of mass action, equilibrium constant,factors affecting equilibrium- Le Chatelier's principle, ionic equilibrium- ionization of acids and bases, strong and weak electrolytes, degree of ionization, ionization of poly basic acids, acid strength, concept of pH, Henderson Equation, hydrolysis of salts (elementary idea), buffer solution, solubility product, common ion effect (with illustrative examples).

Unit VIII: Redox Reactions 06 Periods

Concept of oxidation and reduction, redox reactions, oxidation number, balancing redox reactions, in terms of loss and gain of electrons and change in oxidation number, applications of redox reactions.

Unit IX: Hydrogen 08 Periods

Position of hydrogen in periodic table, occurrence, isotopes, preparation, properties and uses of hydrogen, hydrides-ionic covalent and interstitial; physical and chemical properties of water, heavy water, hydrogen peroxide -preparation, reactions and structure and use; hydrogen as a fuel.

Unit X : *s*-Block Elements (Alkali and Alkaline Earth Metals) 10 Periods

Group 1 and Group 2 Elements General introduction, electronic configuration, occurrence, anomalous properties of the first element of each group, diagonal relationship, trends in the variation of properties (such as ionization enthalpy, atomic and ionic radii), trends in chemical reactivity with oxygen, water, hydrogen and halogens, uses. Preparation and Properties of Some Important Compounds: Sodium Carbonate, Sodium Chloride, Sodium Hydroxide and Sodium Hydrogencarbonate, Biological importance of Sodium and Potassium. Calcium Oxide and Calcium Carbonate and their industrial uses, biological importance of Magnesium and Calcium

Unit XI : *p*-Block Elements 18 Periods

General Introduction to *p*-Block Elements :

Group 13 Elements : General introduction, electronic configuration, occurrence, variation of properties, oxidation states, trends in chemical reactivity, anomalous properties of first element of the group, Boron - physical and chemical properties, some important compounds, Borax, Boric acid, Boron Hydrides, Aluminium: Reactions with acids and alkalies, uses.

Group 14 Elements : General introduction, electronic configuration, occurrence, variation of properties, oxidation states, trends in chemical reactivity, anomalous behaviour of first elements. Carbon-catenation, allotropic forms, physical and chemical properties; uses of some important compounds: oxides. Important compounds of Silicon and a few uses: Silicon Tetrachloride, Silicones, Silicates and Zeolites, their uses.

Unit XII : Organic Chemistry -Some Basic Principles and Technique 14 Periods

General introduction, methods of purification, qualitative and quantitative analysis, classification and IUPAC nomenclature of organic compounds. Electronic displacements in a covalent bond: inductive effect, electromeric effect, resonance and hyper conjugation. Homolytic and heterolytic fission of a covalent bond: free radicals, carbocations, carbanions, electrophiles and nucleophiles, types of organic reactions.

Unit XIII: Hydrocarbons **12 Periods**

Classification of Hydrocarbons Aliphatic Hydrocarbons:

Alkanes - Nomenclature, isomerism, conformation (ethane only), physical properties, chemical reactions including free radical mechanism of halogenation, combustion and pyrolysis.

Alkenes - Nomenclature, structure of double bond (ethene), geometrical isomerism, physical properties, methods of preparation, chemical reactions: addition of hydrogen, halogen, water, hydrogen halides (Markownikov's addition and peroxide effect), ozonolysis, oxidation, mechanism of electrophilic addition.

Alkynes - Nomenclature, structure of triple bond (ethyne), physical properties, methods of preparation, chemical reactions: acidic character of alkynes, addition reaction of - hydrogen, halogens, hydrogen halides and water.

Aromatic Hydrocarbons: Introduction, IUPAC nomenclature, benzene: resonance, aromaticity, chemical properties: mechanism of electrophilic substitution. Nitration, sulphonation, halogenation, Friedel Craft's alkylation and acylation, directive influence of functional group in monosubstituted benzene. Carcinogenicity and toxicity.

Unit XIV : Environmental Chemistry **06 Periods**

Environmental pollution - air, water and soil pollution, chemical reactions in atmosphere, smog, major atmospheric pollutants, acid rain, ozone and its reactions, effects of depletion of ozone layer, greenhouse effect and global warming- pollution due to industrial wastes, green chemistry as an alternative tool for reducing pollution, strategies for control of environmental pollution.

PRACTICALS

Evaluation Scheme for Examination	Marks
Volumetric Analysis	08
Salt Analysis	08
Content Based Experiment	06
Project Work	04
Class record and viva	04
Total	**30**

PRACTICAL SYLLABUS — Total Periods 60

Micro-chemical methods are available for several of the practical experiments. Wherever possible such techniques should be used :

A. Basic Laboratory Techniques

1. Cutting glass tube and glass rod
2. Bending a glass tube
3. Drawing out a glass jet
4. Boring a cork

B. Characterization and Purification of Chemical Substances

1. Determination of melting point of an organic compound.
2. Determination of boiling point of an organic compound
3. Crystallization of impure sample of any one of the following: Alum, Copper Sulphate, Benzoic Acid.

C. Experiments based on pH

(a) Any one of the following experiments :

- Determination of pH of some solutions obtained from fruit juices, solution of known and varied concentrations of acids, bases and salts using pH paper or universal indicator.
- Comparing the pH of solutions of strong and weak acids of same concentration.
- Study the pH change in the titration of a strong base using universal indicator.

(b) Study the pH change by common-ion in case of weak acid and weak bases.

D. Chemical Equilibrium.

Question Wise Break Up

Type of Ques.	Mark per Ques.	Total No. of Ques.	Total Marks
VSA / Objective	1	16	22
SA-I	2	9	18
SA-I	3	5	15
LA	5	3	15
Total		37	70

1. No chapter was weightage. *Care to be taken to cover all the chapters.*
2. *Suitable internal variations may be made for generating various templates keeping the overall weightage to different form of questions and typology of questions same.*

Choice(s):

There will be no overall choice in the question paper.

CHEMISTRY (043)

SYLLABUS FOR SESSION 2021-22

Class XI Term-I

S.No.	Unit	Periods	Marks
1.	Some Basic Concepts of Chemistry	10	11
2.	Structure of Atom	12	
3.	Classification of Elements and Periodicity in Properties	6	4
4.	Chemical Bonding and Molecular Structure	14	6
5.	Redox Reactions	4	
6.	Hydrogen	4	5
7.	Organic Chemistry : Some basic Principles and Techniques	10	9
	Total	**60**	**35**

Some Basic Concepts of Chemistry :

General Introduction: Importance and scope of chemistry. Atomic and molecular masses, mole concept and molar mass, percentage composition, empirical and molecular formula, chemical reactions, stoichiometry and calculations based on stoichiometry.

Structure of Atom :

Bohr's model and its limitations, concept of shells and subshells, dual nature of matter and light, de Broglie's relationship, Heisenberg uncertainty principle, concept of orbitals, quantum numbers, shapes of s, p and d orbitals, rules for filling electrons in orbitals - Aufbau principle, Pauli's exclusion principle and Hund's rule, electronic configuration of atoms, stability of half-filled and completely filled orbitals.

Classification of Elements and Periodicity in Properties :

Modern periodic law and the present form of periodic table, periodic trends in properties of elements -atomic radii, ionic radii, inert gas radii, Ionization enthalpy, electron gain enthalpy, electronegativity, valency. Nomenclature of elements with atomic number greater than 100.

Chemical Bonding and Molecular Structure :

Valence electrons, ionic bond, covalent bond, bond parameters, Lewis structure, polar character of covalent bond, covalent character of ionic bond, valence bond theory, resonance, geometry of covalent molecules, VSEPR theory, concept of hybridization, involving *s*, *p* and *d* orbitals and shapes of some simple molecules, molecular orbital theory of homonuclear diatomic molecules(qualitative idea only), hydrogen bond.

Redox Reactions :

Concept of oxidation and reduction, redox reactions, oxidation number, balancing redox reactions, in terms of loss and gain of electrons and change in oxidation number.

Hydrogen :

Position of hydrogen in periodic table, occurrence, isotopes, hydrides-ionic covalent and interstitial; physical and chemical properties of water, heavy water, hydrogen as a fuel.

Organic Chemistry : Some Basic Principles and Technique :

General introduction, methods of purification, qualitative and quantitative analysis, classification and IUPAC nomenclature of organic compounds. Electronic displacements in a covalent bond: inductive effect, electromeric effect, resonance and hyper conjugation. Homolytic and heterolytic fission of a covalent bond: free radicals, carbocations, carbanions, electrophiles and nucleophiles, types of organic reactions.

PRACTICALS

Term-I : A 15 mark Practical would be conducted under the supervision of subject teacher. This would contribute to the overall practical marks for the subject.

Or

In case the situation of lock down continues until Nov.-Dec. 2021, a *Practical Based Assessment (pen-paper) of 15 marks* would be conducted at the end of Term-I.

Term-I Evaluation Scheme

S.No.	Practical	Marks
1.	Volumetric Analysis	8
2.	Content Based experiment	2
3.	Class record and viva (Internal Examiner)	5
	Total	**15**

Micro-chemical methods are available for several of the practical experiments, wherever possible such techniques should be used :

A. Basic Laboratory Techniques

1. Cutting glass tube and glass rod
2. Bending a glass tube
3. Drawing out a glass jet
4. Boring a cork

B. Characterization of Chemical Substances (2 marks)

1. Determination of melting point of an organic compound.
2. Determination of boiling point of an organic compound

C. Quantitative Estimation (8 marks)

(i) Using a mechanical balance/electronic balance.

(ii) Preparation of standard solution of Oxalic acid.

(iii) Determination of strength of a given solution of Sodium hydroxide by titrating it against standard solution of Oxalic acid.

(iv) Preparation of standard solution of Sodium carbonate.

(v) Determination of strength of a given solution of hydrochloric acid by titrating it against standard Sodium Carbonate solution.

SYLLABUS FOR SESSION 2021-22

Class XI Term-II

S.No.	Unit	Periods	Marks
1.	States of Matter : Gases and Liquids	9	15
2.	Chemical Thermodynamics	14	
3.	Equilibrium	12	
4.	s-Block Elements	5	11
5.	Some p-Block Elements	9	
6.	Hydrocarbons	10	9
	Total	**59**	**35**

States of Matter: Gases and Liquids :

Three states of matter, intermolecular interactions, types of bonding, melting and boiling points, role of gas laws in elucidating the concept of the molecule, Boyle's law, Charles law, Gay Lussac's law, Avogadro's law, ideal behaviour, empirical derivation of gas equation, Avogadro's number, ideal gas equation and deviation from ideal behaviour.

Chemical Thermodynamics :

Concepts of System and types of systems, surroundings, work, heat, energy, extensive and intensive properties, state functions.

First law of thermodynamics -internal energy and enthalpy, heat capacity and specific heat, measurement of ΔU and ΔH, Hess's law of constant heat summation, enthalpy of bond dissociation, combustion, formation, atomization, sublimation, phase transition, ionization, solution and dilution. Second law of Thermodynamics (brief introduction).

Introduction of entropy as a state function, Gibb's energy change for spontaneous and non- spontaneous processes.

Third law of thermodynamics (brief introduction).

Equilibrium :

Equilibrium in physical and chemical processes, dynamic nature of equilibrium, law of mass action, equilibrium constant, factors affecting equilibrium - Le Chatelier's principle, ionic equilibrium- ionization of acids and bases, strong and weak electrolytes, degree of ionization, ionization of poly basic acids, acid strength, concept of pH, buffer solution, solubility product, common ion effect (with illustrative examples).

_s_-Block Elements :

Group 1 and Group 2 Elements -General introduction, electronic configuration, occurrence, anomalous properties of the first element of each group, diagonal relationship, trends in the variation of properties (such as ionization enthalpy, atomic and ionic radii), trends in chemical reactivity with oxygen, water, hydrogen and halogens, uses.

Some _p_-Block Elements : General Introduction to p-Block Elements

Group 13 Elements : General introduction, electronic configuration, occurrence, variation of properties, oxidation states, trends in chemical reactivity, anomalous properties of first element of the group, Boron - physical and chemical properties.

Group 14 Elements : General introduction, electronic configuration, occurrence, variation of properties, oxidation states, trends in chemical reactivity, anomalous behaviour of first elements. Carbon-catenation, allotropic forms, physical and chemical properties.

Hydrocarbons : Classification of Hydrocarbons Aliphatic Hydrocarbons:

Alkanes - Nomenclature, isomerism, conformation (ethane only), physical properties, chemical reactions.

Alkenes - Nomenclature, structure of double bond (ethene), geometrical isomerism, physical properties, methods of preparation, chemical reactions: addition of hydrogen, halogen, water, hydrogen halides (Markownikov's addition and peroxide effect), ozonolysis, oxidation, mechanism of electrophilic addition.

Alkynes - Nomenclature, structure of triple bond (ethyne), physical properties, methods of preparation, chemical reactions: acidic character of alkynes, addition reaction of - hydrogen, halogens, hydrogen halides and water.

Aromatic Hydrocarbons :

Introduction, IUPAC nomenclature, benzene: resonance, aromaticity, chemical properties: mechanism of electrophilic substitution. Nitration, sulphonation, halogenation, Friedel Craft's alkylation and acylation, directive influence of functional group in monosubstituted benzene. Carcinogenicity and toxicity.

PRACTICALS

Term-II : At the end of Term-II, **a 15 mark Practical** would be conducted under the supervision of subject teacher. This would contribute to the overall practical marks for the subject.

Or

In case the situation of lockdown continues beyond December 2021, a *Practical Based Assessment (pen-paper) of 10 marks and Via 5 marks* would be conducted at the end of Term-II by the subject teacher. This would contribute to the overall practical marks for the subject.

Term-II Evaluation Scheme

S.No.	Practical	Marks
1.	Salt Analysis	8
2.	Content Based Experiment	2
3.	Project Work and Viva (Internal)	5
	Total	**15**

A. Qualitative Analysis (Marks 8)

(a) Determination of one anion and one cation in a given salt

Carbons - Pb^{2+}, Cu^{2+}, As^{3+}, Al^{3+}, Fe^{3+}, Mn^{2+}, Ni^{2+}, Zn^{2+}, Co^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, Mg^{2+}, NH_4^+

Anions - $(CO_3)^{2-}$, S^{2-}, NO_2^-, SO_3^{2-}, SO_4^{2-}, NO_3^-, CL^-, Br^- I^-, PO_4^{3-}, $C_2O_4^{2-}$, CH_3COO^- (Note : Insoluble salts excluded)

(b) Detection of -Nitrogen, Sulphur, Chlorine in organic compounds.

B. Crystallization of impure sample of any one of the following : Alum, Copper Sulphate, Benzoic Acid (Marks 2)

PROJECTS scientific investigations involving laboratory testing and collecting information from other sources.

Guidelines on Syllabus for Visually Handicapped students.

Schools are expected to rationalise and divide the syllabus of practicums for visually handicapped students into two halves on the basis of collective guidelines given for the same in the complete syllabus and as per the convenience of their students. This flexibility is given in view of the special....

Chemistry - XI

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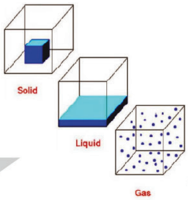


Chapter - 1

Some Basic Concepts of Chemistry

FAST TRACK : QUICK REVISION

- **Matter :** Anything that has mass and occupies space.
- **Precision :** If refers to the closeness of various measurements for the same quantity.
- **Accuracy :** It refers to the agreement of a particular value to the true value of the result.
- **Mass and weight :** Mass of a substance is the amount of matter present in body, while weight is the force exerted by gravity on an object. The mass of a substance is constant whereas its weight may vary from one place to another due to change in gravity.
- **Volume :** $1\ L = 1\ dm^3 = 10^3 cm^3 = 10^{-3}\ m^3$
- **Temperature :** $K = °C + 273.15$; $\frac{°F - 32}{9} = \frac{°C}{5}$
- **Standard Temperature Pressure (STP) :** 0°C (273.15 K) temperature and 1 atm pressure.
- **Normal Temperature Pressure (NTP) :** 20°C (293.15 K) temperature and 1 atm pressure.
- **Standard Ambient Temperature Pressure (SATP) :** 25°C (298.15 K) temperature and 1 atm pressure
- **Scientific Notation :** Expressing a number in the form $N \times 10^n$, and N can vary between 1 to 9.99.
- **Significant figures :** These are meaningful digits which are known with certainty.
- **Laws of Chemical Combination :**
  - **Law of Conservation of Mass (Antonie Lavoisier) :** Mass can neither be created nor be destroyed.
  - **Law of Definite Proportions (Joseph Proust) :** A given compound always contains the same elements in the same proportion by mass.

- **Law of Multiple Proportions (John Dalton) :** When two elements combine to form two or more compounds, then the different masses of one element, which combine with a fixed mass of the other, bear a simple ratio to one another.
- **Gay Lussac's Law :** When gases combine or are produced in a chemical reaction, they do so in a simple ratio provided all gases are in the same temperature and pressure.

  e.g., $2H_2\,(g) + O_2\,(g) \rightarrow 2H_2O\,(g)$

  2 Vol 1 Vol 2 Vol

  (at same T, P)

- **Atomic Mass :** It is defined as the average relative mass of an atom of an element as compared to the mass of an atom of carbon – 12 taken as 12.

  Atomic mass is represented by '*u*' (unified mass).

  $1u = 1.66056 \times 10^{-24}$ g

- **Molecular mass :** It is algebraic the sum of the atomic mass of the elements present in the molecule.

  For example : Molecular mass of $CH_4 = (1 \times 12) + (4 \times 1) = 16$ u

- **Avogadro Number :** It is the amount of atoms or molecules present in one mole of a substance.

  Avogadro number $(N_A) = 6.022 \times 10^{23}$ mol^{-1}

- **Molar Mass :** The mass of one mole of a substance in grams is called its molar mass.

  For example : Molar mass of $CH_4 = (1 \times 12) + (4 \times 1) = 16$g mol^{-1}

- **Mole (*n*) :** It is amount of a substance that contains as many particles or entities as the number of atoms in exactly 12 grams of pure C-12.

  1 mole of a substance = Molar mass of substance = Avogadro's Number of chemical units = 22.4L volume at STP of gaseous substance

  e.g., 1 mole of CH_4 = 16g of $CH_4 = 6.022 \times 10^{23}$ molecules of CH_4 = 22.4L at STP

  $$n = \frac{w\,g}{M_m} = \frac{\text{VL (at STP)}}{22.4\text{L}} = \frac{x \text{ particles}}{N_A} = \frac{MV}{1000}$$

- **Molar Volume (V_m) :** It is volume occupied by one mole of gas at STP.

  Molar volume of a gas = 22.4L at STP (273 K, 1atm) or 22.7L at STP (273 K, 1 bar)

Calculating Molar Volume: PV = nRT

$$\therefore\ V = \frac{nRT}{P} = \frac{1\text{mol} \times 0.082\text{L atm K}^{-1}\text{mol}^{-1} \times 273\text{K}}{1\text{ atm}} = 22.4\text{L}$$

Or

$$V = \frac{nRT}{P} = \frac{1\text{ mol} \times 0.083\text{ L bar K}^{-1}\text{ mol}^{-1} \times 273\text{ K}}{1\text{ bar}} = 22.7\text{ L}$$

- **Percentage Composition :** Mass % of the element

$$= \frac{\text{Mass of element in a molecule of the compound} \times 100}{\text{Molecular mass of the compound}}$$

- **Empirical Formula :** It represents the simplest whole number ratio of various atoms present in a compound. For *e.g.*, CH is the empirical formula of benzene.
- **Molecular Formula** : It shows the exact number of different of atoms present in a molecule of a compound. For *e.g.*, C_6H_6 is the molecular formula of benzene.
- **Relationship between empirical and molecular formulae :**
Molecular formula = n × Empirical formula

Where; $$n = \frac{\text{Molar mass}}{\text{Empirical formula mass}}$$

- **Information Conveyed by a chemical equation :**

	$N_2(g)$	+	$3H_2(g)$	→	$2NH_3(g)$
(i)	1 molecule of N_2	+	3 molecules of H_2	→	2 molecules of NH_3
(ii)	1 mole of N_2	+	3 mole of H_2	→	2 mole of NH_3
(iii)	1 × 28g of N_2	+	3 × 2 g of H_2	→	2 × 17 g of NH_3
(iv)	1 × 22.4L of N_2 at STP	+	3 × 22.4L of H_2 at STP	→	2 × 22.4L of NH_3 at STP

- **Limiting Reagent** : It is the reactant which gets consumed first or limits the amount of product formed.
- **Mass Percent** : It is the mass of the solute in grams per 100 grams of the solution.

$$\text{Mass percent} = \frac{\text{Mass of solute in } g \times 100}{\text{Mass of solution in } g}$$

- **Parts per million (ppm) :** It is part of solute per million part of solution by mass.

$$\text{ppm} = \frac{\text{Parts of solute (by mass)} \times 10^6}{\text{Parts of solution (by mass)}}$$

- **Molarity (M)** : It is number of moles of solute dissolved per litre (dm^3) of the solution.

$$\text{Molarity} = \frac{\text{No. of moles of solute}}{\text{Volume of solution in L}}$$

Molarity equation : $\underset{\text{(Before dilution)}}{M_1V_1} = \underset{\text{(After Dilution)}}{M_2V_2}$

Molarity of a solution decreases on increasing temperature.

Molarity of pure water is 55.56 mol L^{-1}

- **Molality (*m*)**—It is number of moles of solute dissolved per 1000g (1kg) of solvent.

$$\text{Molality} = \frac{\text{No. of moles of solute}}{\text{Mass of solvent in kg}}$$

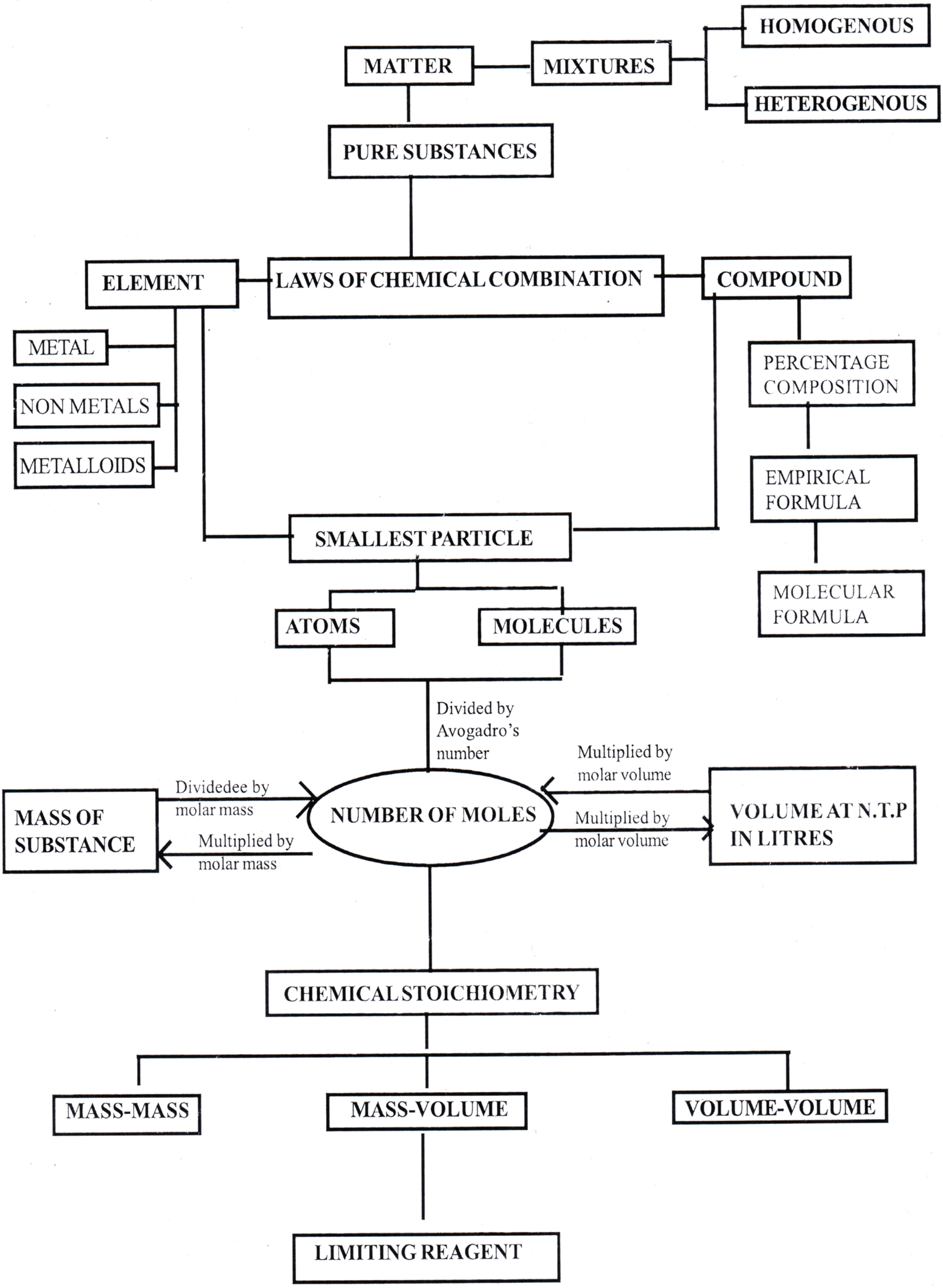
Molality is independent of temperature.

- **Mole Fraction(*x*)** is the ratio of number of moles of one component to the total number of moles (solute and solvents) present in the solution.

$$x_1 = \frac{n_1}{n_1 + n_2} \text{ and } x_2 = \frac{n_2}{n_1 + n_2}$$

The sum of all the mole fractions in a solution is equal to one. *i.e.*, $x_1 + x_2 = 1$

MIND MAP
SOME BASIC OF CONCEPTS OF CHEMISTRY



CASE BASE : QUESTIONS

1. Read the passage given below and answer the following questions:

The ideas underlying our modern understanding of thermodynamics and kinetic theory were developed during the nineteenth century. Central to these developments was the discovery that matter reacting chemically does not do so simply between equal masses of the samples involved. We now call the study of this phenomenon 'stoichiometry', defined as: 'the relationship between the amounts of substance that react together, and the products that are formed'.

Another development during the nineteenth century that was central to our modern understanding of the chemical nature of matter was the observation by Avogadro that 'equal volumes of ideal or perfect gases, at the same temperature and pressure, contain the same number of particles, or molecules'. This is now known as Avogadro's law. It provides the motivation to formulate expressions for the quantity of a sample that reacts with another sample. The most notable example of such a formulation is the gram-molecule, which has been used to refer to both a unit and a quantity.

(Reference: Milton Martin J. T. 2011A new definition for the mole based on the Avogadro constant: a journey from physics to chemistry *Phil. Trans. R. Soc.* A.3693993–4003)

The following questions are multiple choice questions. Choose the most appropriate answer:

I. The concept of stoichiometry mentioned in the study is based on the

a. formation of chemical bonds.

b. amount of reactant and product involved in a chemical reaction.

c. idea of temperature and pressure required for the reaction to occur.

d. oxidation states of reactant and product involved.

II. How much gram-molecules of H_2O are produced on combustion of 32 g of methane in excess oxygen?

a. 72 b. 4

c. 2 d. 36

III. When an antacid tablet is used, $Ca(OH)_2$ reacts with HCl in the stomach to form inert $CaCl_2$ and H_2O. If the molar mass of $Ca(OH)_2$ is 75 g/mol, how many moles of HCl are required to fully react with 150 g of $Ca(OH)_2$?

a. 4 b. 1

c. 8 d. 2

IV. What must be held constant when applying Avogadro's law?

a. pressure and temperature

b. volume and temperature

c. moles and temperature

d. pressure and volume

ANS:- I-B, II-B, III-A, IV-A

2. Read the passage given below and answer the following questions:

The goal of this study was to examine the means used by textbook authors to introduce, define, and explain the mole concept in high school and introductory college chemistry textbooks. The analysis was framed by four questions:

1. How is the mole defined?
2. What concepts about the atom are introduced prior to the mole?
3. Is Avogadro's constant presented as an experimentally determined value?
4. What is the context for introducing the mole?

Twenty nine high school and introductory college level chemistry texts were examined. After independent reading of appropriate sections of each text, discussion of differences, second or third readings of texts, and subsequent discussions, both authors reach 100% agreement concerning the results. Major conclusions were

1. Two ways of defining the mole dominate the texts. One way defines the mole as Avogadro's number (6.02×10^{23}) particles; the other method defines the mole in terms of carbon 12.
2. All texts that present a definition in terms of C-12 introduce and define concepts about the atom prior to introducing the mole.
3. Most texts at all levels point out that the value 6.02×10^{23} is an experimentally determined quantity.

4. Nearly all texts discuss the mole in relation to die problem of finding a way to count particles that are too small to be directly weighed. Most texts also use a familiar counting unit, such as the dozen, to introduce the mole by analogy.

(Reference: John R. Staver, Andrew T. Lumpe, A content analysis of the presentation of the mole concept in chemistry textbooks, Journal of Research in Science Teaching).

In these questions (Q. No. (i) to (iv) , a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement

i. ASSERTION: Equal moles of different substances contain same number of constituent particles.

REASON: Equal weights of different substances contain the same number of constituent particles.

ii. ASSERTION: Both 106g of sodium carbonate and 12g of carbon have same number of carbon atoms.

REASON: Both contain 1 g-atom of carbon which contains 6.02×10^{23} carbon atoms

iii. ASSERTION: Both 32g SO_2 and 8g CH_4 have same number of molecules.

REASON: Equal moles of substances have equal number of molecules.

iv. ASSERTION: Average atomic mass of an element depends mainly on the heavier isotope.

REASON: The average atomic mass of an element is the sum of the masses of its isotopes, each multiplied by its natural abundance

ANS:- I-C, II-A, III-A, IV-D

MULTIPLE CHOICE QUESTIONS (MCQ)

1. Which of the following is dependent of temperature ?

(a) Molarity (b) Molality

(c) Mole fration (d) Mass percentage

2. 4 g of NaOH dissolved in 100 ml solution. Molarity of the solution is

(a) 1 M (b) 10 M

(c) 0.1 M (d) 4 M

3. Which has the maximum number of molecules among the following ?

(a) 44g of CO_2 (b) 44g of O_2

(c) 8g of H_2 (d) 64g of SO_2

4. 10 mol of Zn react with 10 mol of HCl. Calculate the number of moles of H_2 produced.

(a) 5 mol (b) 10 mol

(c) 20 mol (d) 2.5 mol

5. The number of oxygen atoms in 4.4g of CO_2 is approximately

(a) 1.2×10^{23} (b) 6×10^{22}

(c) 6×10^{23} (d) 12×10^{23}

6. The molarity of a solution obtained by mixing 750 mL of 0.5 M HCl with 250 ml of 2 M HCl will be

(a) 0.975 M (b) 0.875 M

(c) 1.00 M (d) 1.175 M

7. Number of atoms of He in 100 u of He (Atomic mass of He is 4 u)

(a) 25 (b) 50

(c) 100 (d) 400

8. 6.02×10^{20} molecules of urea are present in 100 mL of its solution. The concentration of the solution is

(a) 0.02 M (b) 0.01 M

(c) 0.001 M (d) 0.1 M

9. A gaseous hydrocarbons gives upon combustion, 0.72 g of water and 3.08 g of CO_2. The empirical formula of the hydrocarbon is :

(a) C_6H_5 (b) C_7H_8

(c) C_2H_4 (d) C_3H_4

10. The density of solution prepared by dissolving 120 g of urea (Mol. mass = 60 u) in 1000 g of water is 1.15 g/mL. The molarity of the solution is

(a) 0.50 M (b) 1.78 M

(c) 1.02 M (d) 2.05 M

Ans: 1. (a), 2. (a), 3. (b), 4. (a), 5. (a), 6. (b), 7. (a), 8. (b),

9. (b), 10. (d)

FILL IN THE BLANKS

1. 17 g of NH_3 gas will occupy a volume of ____________ cm^3 at NTP.
2. The number of Li atoms in ____________ g. is 6.022×10^{24} atoms.
3. (1/12)th of the mass of carbon atom is ____________
4. Number of atoms of oxygen in 24 g of O_3 is ____________
5. The number of moles of barium carbonate which contains 1.5 moles of oxygen atoms is ____________
6. A mixture having 2 g of H_2 and 32 g of oxygen occupies a volume of ____________ at NTP.
7. If the phosphate of a metal has the formula MPO_4 the formula of the metallic sulphate is ____________
8. At NTP, the mass of 1 litre of gas is 3 g. Molecular mass of the gas is ____________
9. The percentage mass of magnesium in chlorophyll is 2.68% The number of magnesium atoms in 2 g of chlorophyll is ____________
10. The mass of one molecule of carbon dioxide is ____________

11 Percentage of nitrogen in urea is ____________

12 Number of carbon atoms present in 18 g of glucose ($C_6H_{12}O_6$)

13. 0.5 mole of triatomic gas contains ____________________ atoms.

14. A binary compound contains 50% A (at. mass = 16) and 50% B (at. mass 32). The empirical formula of the compound is _____________.

15. The number of hydrogen atoms in 60 u of ethane is____________

Ans: 1.	22400	2.	70 g	3.	1 u
4.	9.033×10^{23}	5.	0.5	6.	44.8 litre
7.	$M_2(SO_4)_3$	8	67.2	9.	1.34×10^{21}
10.	7.3×10^{-23}	11.	46.67	12.	3.61×10^{23}
13.	9.033×10^{23}	14.	A_2B	15.	7.226×10^{24}

TRUE AND FALSE TYPE QUESTIONS

Write true or false for the following statements

1. Equal volumes of different gases under similar conditions of temperature and pressure contain equal number of molecules.
2. 1 mole of $C_{12}H_{22}O_{11}$ contain 22 hydrogen atoms.
3. Nitrogen forms five oxides. It proves the law of multiple proportions.
4. The atomicity of phosphorus is four.
5 Molarity change with change in temp.
6. Empirical formula = $(\text{Molecular formula})_n$.
7. Gram-atomic mass of an element may be defnined as the mass of Avogadro's number of atoms.
8. Gay-Lussac's law of chemical combination is valid for all substances.
9. Avogadro's number varies with temperature and pressure.
10. 18 g of water vapour and 18 g of ice will contain the same number of molecules.

Ans: 1. (T) 2. (F) 3. (T) 4. (T) 5. (T)
6. (F) 7. (T) 8. (F) 9. (F) 10. (T)

MATCH THE COLUMNS

1.

	Column X		Column Y		Column Z
a.	8 g CH_4	i.	0.1 mol	p.	Emp. formulation $\rightarrow$ CH_2O
b.	1.7 g NH_3	ii.	0.5 mol	q.	50% oxygen
c.	CH_3OH	iii.	40% carbon	r.	1.806×10^{23} atoms of hydrogen
d.	$C_6H_{12}O_6$	iv.	Vapour density = 16	s.	25% hydrogen

2.

	Column X		Column Y
a.	Molarity	i.	For very dilute solution
b.	Molality	ii.	No units
c.	mole fraction	iii.	Mol L^{-1}
d.	ppm	iv.	independent of temperature

3.

	Column X		Column Y		Column Z
a.	40 g of He	i.	3.011×10^{23} atoms	p.	0.5 moles
b.	35 g of Li	ii.	10 atoms	q.	1.67×10^{-23}
c.	40 u of He	iii.	6.022×10^{24} atoms	r.	10 moles
d.	16 g of O_2	iv.	3.011×10^{24} atoms	s.	5 moles

4.

	Column X		Column Y
a.	Petrol	i.	Heterogenous mixture
b.	Graphite	ii.	Compound
c.	Sucrose	iii.	Element
d.	Milk	iv.	Homogeneous mixture

Ans: 1. a.(ii). (s), b.(i). (r), c.(iv). (q), d.(iii). (p)

2. a.(iii), b.(iv), c.(ii), d.(i)

3. a.(iii). (r), b.(iv). (s), c.(ii). (q), d.(i). (p)

4. a.(iv), b.(iii), c.(ii), d.(i)

ASSERTION AND REASON TYPE QUESTIONS

Directions for Q. No.1-10

A Both Assertion & Reason are true and the reason is the correct explanation of the assertion.

B Both Assertion & Reason are true but the reason is not the correct explanation of the assertion.

C Assertion is true statement but Reason is false.

D Assertion is false but Reason is true.

1. Assertion : A solution of table salt in a glass of water is homogeneous

   Reason : A solution having same composition throughout is heterogeneous

2. Assertion : The molecular weight of oxygen is 32 amu.

   Reason : The atomic weight of oxygen is 16 amu

3. Assertion : No of moles of H_2 in 0.224 L of hydrogen is 0.01 mole.

   Reason : 22.4 L of H_2 at STP contain 6.023×10^{23} moles.

4. Assertion : Atomic mass of Na is 23.

   Reason : An atom of sodium is 23 times heavier than 1/12th mass of C-12 isotope.

5. Assertion : Number of atoms of He in 60 u of He is 15.

   Reason : Atomic weight of He is 4 u.

6. Assertion : In a gaseous reaction, the ratio of volumes of reactants and products is in agreement with their molar ratio.

   Reason : Volume of gas is inversely proportional to its moles at particular temperature and pressure.

7. Assertion : The Empirical mass of ethane is half of its molecular mass.

   Reason : The empirical formula represents the simplest whole number ratio of various atoms present in a compound.

8. Assertion : Significant figures for 0.200 is 3 whereas for 200 is 1

   Reason : Zero at the end or right of a number are significant provided they are not on the right side of the decimal point.

9. Assertion : One molar aqueous solution has always higher concentration than One molal aqueous solution

   Reason : The molality of solution depends upon the density of solution whereas molarity does not.

10. Assertion : In a combustion reaction in the air, oxygen is the limiting reagent

Reason : Limiting reagent is the reactant in a chemical reaction that limits the amount of product that can be formed.

Ans: 1.C 2.A 3.C 4.A 5.A 6. C 7.A 8.C 9.B 10.D

ONE WORD ANSWER TYPE QUESTIONS

1. What is the SI unit of density?
2. What is the SI unit of molarity?
3. Calculate the number of atoms in 32 u of He. [**Ans.** : 8]
4. What is the volume of 17 g of NH_3 gas at STP? [**Ans.** : 223.4 L]
5. How many molecules of SO_2 are present in 11.2 L at STP?
[**Ans.** : 3.011×10^{23}]
6. Which has more number of atoms ? 1.0 g Na or 1.0 g Mg
[**Ans.** : 1.0 g Na]
7. How many oxygen atoms are present in 16 g of ozone (O_3)?
[**Ans.** : 2.007×10^{23}]
8. Calculate the number of molecules present in 22.0 g of CO_2.
[**Ans.** : 3.011×10^{23}]
9. A substance has molecular formula $C_6H_{12}O_6$. What is its empirical formula.
10. Empirical formula of a compound X (Molar mass = 78 mol^{-1}) is CH. Write its molecular formula.

1-MARK QUESTIONS

1. Name two chemical compounds used in treatment of cancer.
2. What is AZT ? Mention its use in medical science.
3. Classify following as pure substances and mixtures : air, glucose, gold, sodium and milk.
4. Which measurement is more precise 4.0g or 4.00g ? [**Ans.** 4.00 g]

5. How many significant figures are there in (i) 3.070 and (ii) 0.0025 ?

[**Ans.** (i) 4 (ii) 2]

6. Express the following in the scientific notation : (i) 0.0048 (ii) 234,000

7. If ten volumes of dihydrogen gas react with five volumes of dioxygen gas, how much volume of water vapour would be produced ?

[**Ans.** 10 volumes]

8. Define unified mass (u).

9. Define molar volume of a gas.

10. At STP, what will be the volume of 6.022×10^{23} molecules of H_2 ?

[**Ans.** 22.4L]

11. 1L of a gas at STP weighs 1.97g. What is molecular mass ?

[**Ans.** 44.128 g mol^{-1}]

12. Write the relationship between empirical formula and molecular formula.

13. Which is more informative ? Empirical formula or Molecular formula.

14. How are 0.5 mol Na_2CO_3 and 0.5 M Na_2CO_3 different from each other ?

15. Why molality is preferred over molarity of a solution ?

16. Define molarity of a solution.

17. What is the effect of temperature on molarity of solution ?

18. What is limiting reactant in a reaction ?

2-MARKS QUESTIONS

1. Classify following substances as element, compounds and mixtures : water, tea, silver, steel, carbon dioxide and platinum.

2. The body temperature of a normal healthy person is 37°C. Calculate its value in°F.

3. At what temperature will both the Celsius and Fahrenheit scales read the same value?

4. Convert 5L into m^3.

5. What does the following prefixes stand for :

(a) pico (b) nano (c) micro (d) deci

6. How many significant figures are present in the following :

(i) 4.00005

(ii) 0.004

7. Convert '450 pm' into SI unit and write the answer in scientific notation upto 2 significant figures.

[**Ans**. 4.5×10^{-10} m]

8. Hydrogen peroxide and water contain 5.93% and 11.2 % of hydrogen respectively. Show that the data illustrate law of multiple proportions.

9. The density (in g mL^{-1}) of a 3.60 M sulphuric acid solution that is 29% H_2SO_4 (Molar mass = 98 g mol^{-1}) by mass will be ....

[**Ans.** 1.21 g/mL]

10 The cost of table salt (NaCl) is Rs. 10 per Kg. calculate its cost per mole. (Molar mass of NaCl is 58.5 $gmol^{-1}$) [**Ans.** 0.58 Rs]

11 Calculate the mole fraction of the solute in a 1.00 molal aqueous solution. [**Ans.** 0.0177]

12 Dissolving 120 g of urea (Molar mass of urea = 60 g mol^{-1}) in 1000 of water gave a solution of density 1.15 g/mL. Calculate the molarity of the solution. [**Ans.** 2.05 M]

13 Calculate the percentage of N in urea. (Molar mass of urea = 60 g mol^{-1}) [**Ans.** 46.66]

14 25 ml of 3.0 M HCl are mixed with 75 mL 0f 4.0 M HCl. If the volumes are additive, the molarity of the final mixture will be. [**Ans.** 3.75 M]

15 How many atoms and molecules are present in 124 gm of phosphorus (P_4) [**Ans.** Atoms = 4 N_A & Molecules = N_A]

16 45.4 L of dinitrogen reacted with 22.7 L of dioxygen and 45.4 L of nitrous oxide was formed.

The reaction is given below : $2N_2\ (g) + O_2\ (g) \longrightarrow 2N_2O\ (g)$

Which law is being obeyed in this experiment? Write the statement of the law.

17 Give one example each of a molecule in which empirical formula and molecular formula is

(i) Same (ii) Different.

18 Calculate the number of moles in the following masses :

(i) 7.85g of Fe;
(ii) 7.9mg of Ca

19 Calculate the percent of carbon, hydrogen and oxygen in ethanol (C_2H_5OH) [**Ans.** 52.14%, 13.13%, 34.73%]

20 How much copper can be obtained from 100 g of $CuSO_4$? [**Ans.** 39.8g]

21 Calculate the amount of water (g) produced by the combustion of 16 g of methane. [**Ans.** 36g]

22 How many moles of methane are required to produce 22 g CO_2 (g) after combustion? [**Ans.** 0.5 mol]

23 A solution is prepared by adding 2 g of a substance A to 18 g of water. Calculate the mass per cent of the solute. [Ans. 10%]

24 Calculate molarity of water if its density is 1.00 g mL^{-1}.

[**Ans.** 55.56 M]

25 Calculate the molarity of NaOH in the solution prepared by dissolving its 4 g in enough water to form 250 mL of the solution. [**Ans.** 0.4 M]

26 The density of 3 M solution of NaCl is 1.25 g mL^{-1}. Calculate molality of the solution. [**Ans.** 2.8m]

27 NH_3 gas can be prepared by Haber's process as, $N_2(g) + 3H_2\ (g) \rightarrow 2NH_3(g)$. At a particular moment concentration of all the species is 2 moles; calculate the concentration of N_2 and H_2 taken initially.

[**Ans.** 3 mole, 5 moles]

3-MARKS QUESTIONS

1. Calculate the average atomic mass of Mg using the following data:

	% Natural Abudance	Molar mass
^{24}Mg	80	24
^{25}Mg	10	25
^{26}Mg	10	26

2. The following data are obtained when dinitrogen and dioxygen react together to form different compounds :

	(i)	(ii)	(iii)	(iv)
Mass of dinitrogen	14	14	28	28
Mass of dioxygen	16	32	32	80

Which law of chemical combination is obeyed by the above experimental data ? Give its statement.

3. Calculate :

(i) Mass in gram of 5.8 mol N_2O

(ii) Number of moles in 8.0 g of O_2

(iii) Molar mass if 11.2 L at STP weigh 8.5 g.

[**Ans.** (i) 255.2 g (ii) 0.25 mol (iii) 17 g mol^{-1}]

4. In three moles of ethane (C_2H_6), calculate the following :

(i) Number of moles of carbon atom,

(ii) Number of moles of hydrogen atoms,

(iii) Number of molecules of ethane.

[**Ans.** (i) 6 moles, (ii) 18 moles, (iii) 1.81×10^{24}]

5. 16 g of an ideal gas SOx occupies 5.6 L at STP. What is its molecular mass ? What is the value of X ? [**Ans.** 64u, x = 2]

6. Calculate the number of moles :

(i) 5.0 L of 0.75 M Na_2CO_3

(ii) 7.85 g of Fe

(iii) 34.2 g of sucrose ($C_{12}H_{22}O_{11}$)

[**Ans.** (i) 3.75, (ii) 0.14, (iii) 0.1]

7. Calculate the number of atoms in each of the following :

(i) 52 moles of Ar. (ii) 52u of He (iii) 52g of He.

[**Ans.** (i) 3.13 × 1025 (ii) 13 (iii) 7.83 × 1024]

8. Vitamin C is essential for the prevention of scurvy. Combustion of 0.2000g of vitamin C gives 0.2998g of CO_2 and 0.819g of H_2O. What is the empirical formula of vitamin C ? [**Ans.** $C_3H_4O_3$]

9. A compound contains 4.07% hydrogen, 24.27% carbon and 71.65% chlorine. Its molar mass is 98.96 g. What are its empirical and molecular formulas? [**Ans.** CH_2C1, $C_2H_4Cl_2$]

10. A compound made up of two elements A and B has A = 70%, B = 30%. Their relative number of moles in the compound is 1.25 and 1.88, calculate :

(i) Atomic masses of the elements A and B

(ii) Molecular formula of the compound , if its molecular mass is found to be 160. [**Ans.** (i) 56 and 16, (ii) A_2B_3]

11. The reaction $2C + O_2 \longrightarrow 2CO$ is carried out by taking 24.0 g of carbon and 96.0 g of O_2. Find out.

(i) Which reactant is left in excess ?

(ii) How much of it is left ?

(iii) How many grams of the other reactant should be taken so that nothing is left at the end of the reaction ? [**Ans.** (i) O_2, (ii) 64 g, (iii) 72]

12. A 10 g sample of a mixture of calcium chloride and sodium chloride is treated with Na_2CO_3 to precipitate calcium as calcium carbonate. This $CaCO_3$ is heated to convert all the calcium to CaO and the final mass of CaO is 1.62 g. Calculate % by mass of NaCl in original solution.

[**Ans.** 67.9%]

13. 3.0 g of H_2 react with 29.0 g of O_2 yield H_2O.

(i) Which is the limiting reagent.

(ii) Calculate the maximum amount of H_2O that can be formed

(iii) Calculate the amount of reactant left unreacted

[**Ans.** H_2 , 26.8g H_2O & 5.2 g O_2]

14 Zinc and hydrochloric acid react according to the reaction:

$$Zn(s) + 2HCl(aq) \longrightarrow ZnCl_2(aq) + H_2(g)$$

If 0.30 mol Zn are added to hydrochloric acid containing 0.52 mol of HCl, How many moles of H_2 are produced ?

[HCl is limiting reagent; H_2 formed = 0.36 mol]

15 How many moles of Lead (II) chloride will be formed from a reaction between 6.5 g of PbO and 3.2 g of HCl ? [Atomic mass of Pb = 207 U]

[**Ans.** 0.029 mole]

16 What volume of oxygen at N.T.P is needed to cause the complete combustion of 200 ml of acetylene ?Also calculate the volume of carbon dioxide formed. [**Ans.** 500 mL of O_2 & 400 mL of CO_2]

5-MARKS QUESTIONS

1 (i) A black dot used as a full stop at the end of a sentence has a mass of about one attogram. Assuming that the dot is made up of carbon, calculate the approximate number of carbon atoms present in the dot. [Hint : 1 attogram = 10^{-18}g] [**Ans.** 5.02×10^4]

(ii) Which one of the following will have largest number of atoms ?

(a) 1g Au (s) (b) 1g Na (s) (c) 1g Li (s) (d) 1g of Cl_2(g)

[**Ans.**. (i) 39.81 g (ii) 1 g of Li]

2. (i) What is the difference between empirical formula and molecular formula ?

(ii) A welding fuel gas contains carbon and hydrogen only. Burning a small sample of it in oxygen gas 3.38 g carbon dioxide, 0.690 g of water and no other products. A volume of 10.0 L (measured at STP) of this welding gas is found to weigh 11.6 g. Calcuate

(i) Empirical formula, (ii) molar mass of the gas, and (iii) Molecular formula. [**Ans.** (i) CH, (ii) 26 g mol^{-1}, (iii) C_2H_2]

3. (i) What is the difference between Molarity and Molality.

   (ii) The Molarity of a solution of sulphuric acid is 1.35 M. Calculate its molality. (The density of acid solution is 1.02 g cm^{-3}).

[**Ans.**. 1.52 m]

4. (i) Define : (a) Mole fraction (b) Mass percentage.

   (ii) If the density of methanol is 0.793 kg L^{-1}, what is its volume needed for making 2.5 L of its 0.25 M solution ? [**Ans.** 0.0025 L]

HOTS QUESTIONS

1 In a compound $C_xH_yO_z$, the mass % of C and H is 6:1 and the amount of oxygen present is equal to the half of the oxygen required to react completely C_xH_y. Find the empirical formula of the compound.

[**Ans.** $C_2H_4O_3$]

2 A crystalline salt when heated becomes anhydrous and loses 51.2 % of its weight. The anhydrous salt on analysis gave the following percentage composition

Mg = 20.0% , S = 26.6 % , O = 53.33 %

Calculate the molecular formula of the anhydrous salt and the crystalline salt. Molecular weight of the anhydrous salt is 120.

[**Ans.** $MgSO_4.7H_2O$]

3 An LPG cylinder weighs 14.8 kg when empty. When full, it weighs 29.0 kg and shows a pressure of 2.5 atm. In the course of use at 27°C, the weight of cylinder is reduced to 23.2 kg. Find the volume of n-butane in cubic meters used up at 27°C and 1 atm (Molecular weight of n-butane = 58). [**Ans.** 2.463 m^3]

4 2.5 g of $CaCO_3$ was placed in 50 ml of a solution of HCl.1.05 g of $CaCO_3$ was left after the reaction. Calculate:

(a) the weight of HCl per litre

(b) the Molarity of HCl [**Ans.** (a) 21.17 g, (b) 0.58 M]

UNIT TEST-I

Time allowed : 1 hour **Maximum Marks : 20**

General instructions :

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

---

1. If 30 mL of H_2 and 20 mL of O_2 react to form water, what is left at the end of the reaction ? (1)
   (a) 10 mL of H_2 (b) 5 mL of H_2
   (c) 10 mL of O_2 (d) 5 mL of O_2
2. 7.5 grams of a gas occupy 5.6 litres of volume at STP the gas is (1)
   (a) NO (b) N_2O (c) CO (d) CO_2
3. Write the relationship between empirical formula and molecular formula. (1)
4. Why molarity is preferred over molarity in expressing the concentration of solution ? (1)
5. Which has more number of atoms ? 1.0 g Na or 1.0g Mg? (1)
6. How many atoms and molecules are present in 124 g of phosphorus (P_4)? (2)
7. (a) How many significant figures are present in 0.0102. (2)
   (b) Write the number in scientific notation 1013.6.
8. A sample of drinking water was found to be severely contaminated with chloroform $CHCl_3$. The level of contamination was 15 ppm (by mass).
   (a) Express this in percent by mass.
   (b) Determine the molarity of chloroform in the water sample. (3)
9. A compound contains 4.07% hydrogen, 24.27% carbon and 71.65% chlorine. Its molar mass is 98.96 g. What are its empirical and molecular formula ? (3)
10. (a) Explain the following terms:
    (i) Gay Lussac's law (ii) Limiting reagent
    (b) 3.0 g of H_2 react with 30.0 g of O_2 yield H_2O.
    (i) Which is the limiting reagent?
    (ii) Calculate the maximum amount of H_2O that can be formed.
    (iii) Calculate the amount of reactant left unreacted. (5)

UNIT TEST-II

Time allowed : 1 hour **Maximum Marks : 20**

General instructions :

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

---

1. One mole of oxygen gas at STP is equal to -------------- (1)

   (a) 6.022×10^{23} molecules of oxygen

   (b) 6.022×10^{23} atoms of oxygen

   (c) 16 g of oxygen

   (d) 32 g of oxygen

2. 1g of $M_2\ CO_3$ on treatment with excess HCl produces 0.01186 moles of CO_2. The molar mass of M_2CO_3 in g mol^{-1} is ? (1)

   (a) 1186 (b) 84.3 (c) 118.6 (d) 11.86

3. How many atoms are present in 16 g of ozone? (1)

In following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and Reason are true and Reason is the correct explanation of Assertion

(b) Assertion and Reason are true but Reason is not the correct explanation of Assertion

(c) Assertion is true but Reason is false

(d) Both Assertion and Reason are false

4. **Assertion** : The empirical mass of ethene is half of its molecular mass. (1)

   Reason : The empirical formula represents the simplest whole number ratio of various atoms present in a compound.

5. **Assertion** : Combustion of 16 g of methane gives 18 g water. (1)

Reason : In the combustion of methane, water is one of the products.

6. If 2 litres of N_2 is mixed with 2 litres of H_2 at a constant temperature and pressure, then what will be the volume of NH_3 formed? (2)

7. Calculate the percentage of Copper in a sample of $CuCl_2$ (2)

(Atomic mass of Cu = 63.5u, Cl = 35.5u)

8. In an experiment, when HCl was reacted with $CaCO_3$ at STP, 48 Cm^3 of CO_2 was formed. Calculate the number of mole of CO_2 and number of molecules. (3)

9. In the reaction $2A + 4B \rightarrow 3C + 4D$, when 5 moles of A react with 6 moles of B, then (3)

   (i) Which is the limiting reagent

   (ii) Calculate the amount of C formed

   (iii) Calculate the amount of excess reagent left after reaction

10. (a) How many grams atoms are there in 8.0 g of S? (5)

    (b) The molarity of solution of H_2SO_4 is 1.35 M. Calculate its molality.

    (The density of solution is 1.02 g cm^{-3})

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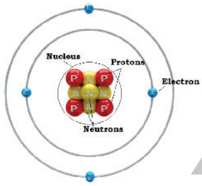


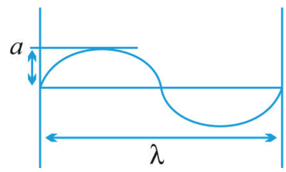
Chapter - 2 Structure of Atom

FAST TRACK : QUICK REVISION

- **Information about fundamental particles of atom**

Name of Constant	UNIT	Electron	Proton	Neutron
Mass	amu	0.000546	1.00728	1.008665
	kg	9.109×10^{-31}	1.673×10^{-27}	1.675×10^{-27}
Charge	Coloumbs	-1.602×10^{-19}	$+1.602 \times 10^{-19}$	Zero
	esu	-4.8×10^{-10}	$+4.8 \times 10^{-10}$	Zero
	Relative Charge	-1	$+1$	Zero

- **Electromagnetic radiations :** Energy emitted from any source (in forms of waves) in which electric and magnetic fields oscillated perpendicular to each other and travelling with a velocity of light is known as EM radiation.
- **Characteristics of waves :**



(a) Wavelength : The distance of one crest and one trough in a wave. Denoted by 'λ'.

(b) Frequency : Number of waves passing through a given point in one second.

Denoted by υ. $\left[\begin{array}{l} \upsilon = \dfrac{1}{t} \Rightarrow \text{sec}^{-1} \text{ or Hz} \\ t = \text{Time period} \end{array}\right]$

(c) Amplitude : The height of crest or depth of a trough denoted by 'a'.

(d) Wave Number : Number of waves per unit length denoted by $\bar{\upsilon}$

$$\bar{\upsilon} = \frac{1}{\lambda} = \text{cm}^{-1} \text{ (or m}^{-1}\text{)}$$

(e) Velocity : Linear distance travelled by a wave in one second.

$$\text{velocity of light } c = \frac{\text{Distance}}{\text{Time}} = \lambda \times \frac{1}{t} = \upsilon\lambda$$

$$\therefore \quad \upsilon = \frac{c}{\lambda}$$

- **Energywise** order for EM radiation.

cosmic < γ rays < X rays < UV < VIBGYOR < IR < Microwaves < Radiowaves

$\longrightarrow$

λ (**Increases**) υ (**Decreases**) Energy (**Decreases**)

- **Photon :** A packet or particle of light energy is knows as **Photon.**

- **Planck's quantum theory :** The energy emitted or absorbed by a source is discontinuous in form of small packet of energy, called **quantum**. Quantum of light is called **photon.**

  $E \propto v$

  $E = hv$ (h = Planck's constant)

  $E = nhv$ ($h = 6.626 \times 10^{-34}$ J sec)

  If 'n' photons are emitted $E = nh\upsilon$

- **Photo electric effect :** The phenomenon of ejection of electrons from a metal surface when a light of suitable frequency falls on metal surface.

  $$h\upsilon - h\upsilon_0 = \frac{1}{2}\text{mv}^2$$

  $h\upsilon \Rightarrow$ Energy of incident light on metal surface.

  $h\upsilon_0 \Rightarrow$ Work function of metal.

  $\frac{1}{2}\text{mv}^2$ = Kinetic energy by which e^- is emitted from metal surface.

- **de Broglie equation :** All material particles in motion also exhibit wave like properties.

  $$\lambda = \frac{\text{h}}{\text{mv}} = \frac{\text{h}}{\text{p}}$$

  For microscopic particles mass is very less therefore Wavelength of wave associated with it can be detected.

For macroscopic particles mass is large, λ of wave associated with it can not be detected. Hence dominant wave character.

Hence microscopic bodies have dual nature, where as macroscopic bodies have particle nature.

Heisenberg's Uncertainty Principle

It is impossible to determine the exact position and velocity of a moving subatomic particle simultaneously with accuracy.

$$\Delta x \times m\Delta v \geq \frac{h}{4\pi}$$

Δx = uncertainty in position

Δv = uncertainty in velocity

Bohr's theory for H [H like one e^- systems He^+; Li^{2+}]

(1) e^- revolving round the nucleus in circular path [stationary state; SHELL] with a definite angular momentum $\frac{nh}{2\pi}$ [Here n = no. of shell of e^-] and with definite energy

$$E_n = \left[\frac{-2\pi^2 me^4 z^2}{n^2 h^2}\right] \Rightarrow -2.18 \times 10^{-18}\,\frac{Z^2}{n^2}\ \text{J/Atom.}$$

(2) As n increases, Energy of e^- becomes less – ve [Due to less force of Proton attraction]

As n decreases, Energy of e^- becomes More – ve [Due to more force of attraction by protons]

(3) In infinity shell e^- has zero force of attraction therefore zero energy.

(4) Electron energy only changes by definite values $\Delta E = E_f - E_i$.

Hydrogen spectrum : When e^- in hydrogen atom is provided energy it gets excited to higher shell from ground state, it comes back to ground state by emitting energy in definite values.

"Quanta" : The emission of light energy is known as emission spectra. It corresponds to each atom depending upon which energy shell e^- is excited.

It is **discontinuous** spectra as 'λ' of light radiations do not merge with each other like in VIBGYOR (Continous Spectra).

When e^- falls from any excited state to

$$\frac{1}{\lambda} = 1{,}09{,}678\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]Z^2 \quad R = \text{Rydberg constant} = 109678\ \text{cm}^{-1}$$

$n_i = 1, n_f = 2, 3, 4, ...$	[Lyman series] (UV)
$n_i = 2, n_f = 3, 4, 5, ...$	[Balmer series] (VIBGYOR)
$n_i = 3, n_f = 4, 5, 6$	[Paschen series] IR.
$n_i = 4, n_f = 5, 6, 7$	[Bracket series] IR.
$n_i = 5, n_f = 6, 7, 8$	[Pfund series] IR.

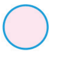
Quantum numbers : The noumbers which **completely** define the **state** of e^- in an atom.

(1) Principal Quantum No. : It describes the distance of e^- from **nucleus '*n*'** *i.e.*, defines the **shell** no. It is denoted by '*n*'.

n = 1, 2, 3, 4, 5, ...

K, L, M, N, O .....

(2) Azimuthal (*l*) Quantum No. : It defines the path of e^- decided by angular momentum of e^-. Each angular momentum value corresponds to one subshell. The no. of subshells in a shell is 0 to $n - 1$.

n	l (0 to n-1)				
1	0	$l = 0$	'*s*'	subshell	
2	0, 1	$l = 1$	'*p*'	subshell	
3	0, 1, 2	$l = 2$	'*d*'	subshell	
4	0, 1, 2, 3	$l = 3$	'*f*'	subshell	

All subshells are wave functions for locating e^-.

In the same shell energy increase $s < p < d < f$.

(3) Magnetic Quantum No. : It gives the no. of magnetic orientations an e^- can have in a subshell. That is number of orbitals in a sub-shell. $m_s = -l........o........+ l = (2l + 1)$.

(4) Spin Quantum No. : An e^- is continuously spinning on its own axis.

The value of $s = \frac{1}{2}$ or $-\frac{1}{2}$

An orbital can have maximum two e^- one with clockwise and other with anticlockwise spin.

Aufbau principle

(a) Electrons are filled in increasing order of energy of sub-shell.

(b) As '$n + l$' value increases energy of e^- increases in that sub-shell.

(c) For two sub-shells with same '$n + l$' value, as 'n' value increases energy of e^- increases.

Pauli's principle

No two electrons can have same set of four quantum numbers in an atom.

Hund's rule of maximum multiplicity

The pairing of e^- in degenerate orbitals (different orbitals with same energy) will get paired only once they have been singly occupied with same spin.

IMPORTANT POINTS

The filling of e^- in subshells follows this order. (As per Aufbau principle)

(A) $1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < 5s < 4d < 5p < 6s < 4f < 5d < 6p < 7s < 5f < 6d < 7p$

(B) Half filled and completely filled subshells have more **stability** than incompletely filled subshells.

$Cr = [Ar]\ 4s^1\ 3d^5$

$Cu = [Ar]\ 4s^1\ 3d^{10}$

(C) As the shell no. inc. size of subshell increases *e.g.*, size of ($2s > 1s$) ; ($3p > 2p$); ($4d > 3d$)

(D) The region in an orbital where probability of finding the e^- is zero is known as **Nodal plane** (or Node).

The no. of [radial nodes] = $n - l - 1$ and Angular Nodes = l,

Total nodes = n–1.

(E)

ψ(psi)	**ψ^2(psi square)**
A wave function for locating an electron	The square of wave function where the probability of finding the e^- is maximum. [Each value of ψ^2 is a region and **defines** one orbital]

(F)

Orbit	**Orbital**
(1) A definite distance from the nucleus for finding the e^- [e^- as a particle].	(1) A probability region for locating the e^- around the nucleus. It is a wave function [e^- as a wave]
(1) It has definite size and e^- in this orbit has definite energy.	(2) It does not define definite size. But only a boundary region diagram of a wave for locating the e^-.

MIND MAP - STRUCTURE OF ATOM

ATOM

Thomson Model

Rutherford Model

Bohr's Model

(i) *In an atoms, the electrons revolve around the nucleus in a fixed* orbit of fixed radii having fixed velocity.

(ii) *Each orbit is associated with definite energy and therefore these are known as* ***energy shell***

K,	L,	M,	N,	O
1	2	3	4	5

(iii) angular momentum of electrons in an atom is quantised.

Sub atomic particles

Electron
Charge $= 1.602\ 1892 \times 10^{-19}$ C
Mass $= 9.109534 \times 10^{-31}$ Kg

Proton
Charge (positve) $= 1.6 \times 10^{-19}$ C
Mass $= 1.67265 \times 10^{-27}$ Kg

Neutron
Mass $= 1.675 \times 10^{-24}$ g

Wave mechanicalmodel
Schrodinger wave equation $\hat{H}\psi = E\psi$
ψ The orbital wave function
ψ^2 Electron probability density

Developments leading to Wave mechanical model

de Broglie relation
The wavelength of the wave associated with any particle is inversly proportional to its momentum. $s = h/p$

Heisenberg's uncertainty principle
It states that it is impossible to determine simultaneously, the exact position and exact momentum (velocity) of electron. $\Delta x \times m\Delta v = h/4\pi$

$\psi^2 = 0$
Node

Radial Node
A radial node is a **circular ring**
Number of radial nodes $= (n - l - 1)$

angular node is a **flat plane**
Number of angular nodes $= l$

Total nodes = n – l

ψ^2 Maximum represent orbital

s-orbital
spherical, $l = 0$

p-orbital
dumbbell, $l = 1$

d-orbital
double dumbbell, $l = 2$

f-orbital
$l = 3$

solutions of schrondinger wave equation

Principal quantum number (n)
It determines the size and to large extent the energy of orbital

Azimuthal quantum number (l)
It defines the three dimensional shape of the orbital.

Magnetic quantum number (m_l)
It gives information about the spatial orientation of the orbital with respect to the standard set of coordinate axis.

Spin quantum number (m_s)
It describes the spin orientation of the electron.

CASE BASED QUESTIONS

1. **Read the passage given below and answer the following questions:**

The capacities of shells with a given principal quantum number are fixed by (1) the rules governing the permitted values of the quantum numbers and (2) the Pauli Exclusion Principle. The permitted values of the quantum numbers are :

Principal quantum number	n	1 to ∞
Azimuthal quantum number	l	0 to n–1 (n values)
Magnetic quantum number	m_l	$-l$ to $+l$, ($2l+1$ values)
Spin quantum number	m_s	– ½ or + ½ (2 values)

The Pauli Exclusion Principle states that no two electrons in the same atom may have the same values of all four quantum numbers. It follows that, for a given value of n, there are $2n^2$ different sets of values for the quantum numbers, because l may have the values O, 1, . . ., n–1, and for each value of l there are $2l+1$ values of m_l and for each set of values of l and m there are just two choices for m_s.

(Reference : Thomas H. Hazlehurst, J. Chem. Educ. 1941, 18, 12, 580 Publication Date: December 1, 1941, Journal of American Chemical Society).

The following questions are multiple choice questions. Choose the most appropriate answer:

(i) Based on the concept of quantum numbers mentioned in the study, which of the following value sets of quantum numbers are not possible?

(a) n=0, l=0, m_l= 0, m_s= -1/2

(b) n=5, l=3, m_l= -4, m_s= +1/2

(c) n=3, l=1, m_l= -1, m_s= -1/2

(d) n=6, l=1, m_l= 0, m_s= +1/2

(ii) What will be the maximum possible number of electrons having m_s = -1/2 for n=5?

(a) 50 (b) 25

(c) 32 (d) 72

(iii) Which of the following quantum numbers can distinguish between two electrons present in the same orbital?

(a) Azimuthal quantum number

(b) Principal quantum number

(c) Magnetic quantum number

(d) Spin quantum number

(iv) Maximum number of electrons having n = 3 and l = 1 is-

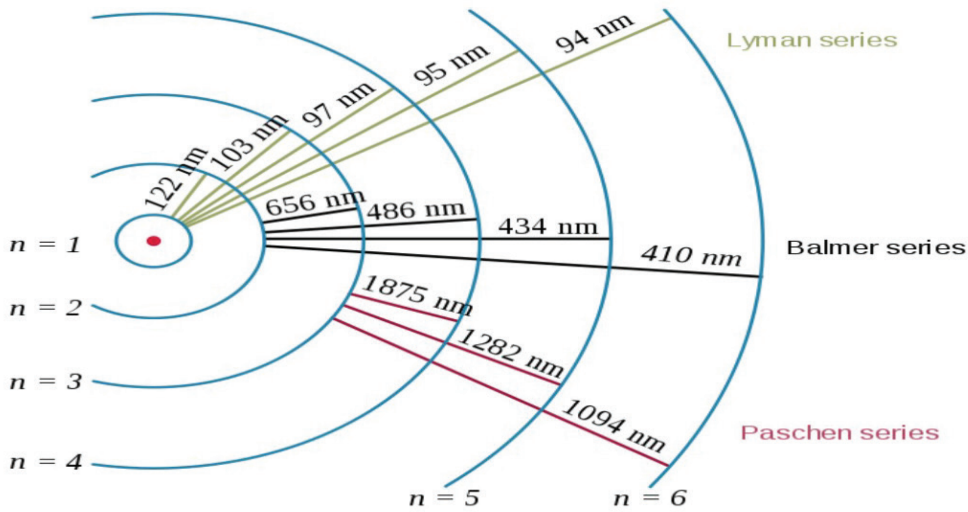
(a) 14 (b) 6

(c) 10 (d) 2

ANS: I-B, II-B, III-D, IV-B

2. Read the passage given below and answer the following questions:

A hydrogen atom consists of an electron orbiting its nucleus. The electromagnetic force between the electron and the nuclear proton leads to a set of quantum states for the electron, each with its own energy. These states were visualized by the Bohr model of the hydrogen atom as being distinct orbits around the nucleus. Each energy state, or orbit, is designated by an integer, *n* as shown in the figure. The Bohr model was later replaced by quantum mechanics in which the electron occupies an atomic orbital rather than an orbit, but the allowed energy levels of the hydrogen atom remained the same as in the earlier theory.



Spectral emission occurs when an electron transitions, or jumps, from a higher energy state to a lower energy state. To distinguish the two states, the lower energy state is commonly designated as n', and the higher energy state is designated as n. The energy of an emitted photon corresponds to the energy difference between the two states. Because the energy of each state is fixed, the energy difference between them is fixed, and the transition will always produce a photon with the same energy.

(Reference : Andrew, A. V. (2006). "2. Schrödinger equation". Atomic spectroscopy Introduction of theory to Hyperfine Structure p. 274 ISBN 978-0-387-255736. https://en.wikipedia.org/wiki/Hydrogen_spectral_series).

In these questions (Q. No. (i) to (iv) , a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices :

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement

i. ASSERTION: The energy states of H-atom are independent of azimuthal quantum number.

REASON: H-atom does not have any inter-electronic repulsion as it has only 1 e^-.

ii. ASSERTION: A spectral line will be seen for a $2p_x - 2p_y$ transition.

REASON: Energy is released when electron drops to lower stationary state.

iii. ASSERTION: For Balmer series of hydrogen spectrum, the value $n_1 = 2$ and $n_2 = 3, 4, 5...$.

REASON: The value of n_2 for a line in Balmer series of hydrogen spectrum having the highest wavelength is 6.

iv. ASSERTION: Electromagnetic radiations of fixed wavelengths are absorbed by the H-atom.

REASON: Radiations corresponding to the energy difference between the two stationary states are absorbed.

ANS:- I-A, II-D, III-C, IV-A

MULTIPLE CHOICE QUESTIONS (MCQ)

1. Packet of energy is called

   (a) Electron (b) Photon

   (c) Position (d) Proton

2. Orbital which is not possible

   (a) 2p (b) 3d

   (c) 3s (d) 3f

3. the magnetic quantum number of an atom is related to the

   (a) size of the orbital (b) spin angular momentum

   (c) orbital angular momentum (d) orientation of the orbital in space

4. The principal quantum number of an atom is related to the

   (a) size of the orbital (b) spin angular momentum

   (c) orbital angular momentum (d) orientation of the orbital in Spence

5. The designation of an orbital with in = 4 and 1 = 3

   (a) 4s (b) 4p

   (c) 4d (d) 4f

6. What transition in the hydrogen spectrum would have the same wavelength as the Balmer transition n = 4 to n = 2 in the He^+ spectrum?

   (a) n = 4 to n =1 (b) n = 3 to n = 2

   (c) n = 3 to n = 1 (d) n = 2 to n = 1

7. The wave number of first line of Balmer series of hydrogen in 15200 cm-1. The wave number of the first Balmer line of Li^{2+} ion is

   (a) 15200 cm^{-1} (b) 60800 cm^{-1}

   (c) 76000 cm^{-1} (d) 136,800 cm^{-1}

8. An electron is moving in Bohr's orbit. Its de Broglie wavelength is λ. What is the circumference of the forth orbit?

   (a) $2/\lambda$ (b) 2λ

   (c) 3λ (d) $3/\lambda$

9. Which of the following statements in relation to the hydrogen atom is correct?

(a) 3s-orbital is lower in energy than 3p-orbital

(b) 3p-orbital is lower in energy than 3-d-orbital

(c) 3s and 3p orbitals all have the same energy.

(d) 3s, 3p and 3d orbitals all have the same energy.

10. For principle quantum number, n = 4, the total number of orbitals having 1 = 3 is

(a) 3 (b) 7

(c) 5 (d) 9

11. The number of d-electrons retained in Fe^{2+} (At. no. of Fe = 26) ion is

(a) 3 (b) 4

(c) 5 (d) 6

12. Pauli exclusion principle helps to calculate the maximum number of electrons that can be accommodated in any

(a) orbital (b) subsell

(c) shell (d) All of these

Ans. 1. (b), 2. (d), 3. (d), 4. (a), 5. (d), 6. (d), 7. (d), 8. (c), 9. (d), 10. (b), 11. (d), 12. (a)

FILL IN THE BLANK

1. Bohr's theory is based on ________ of radiation.

2. The angular momentum of the electron in the 4th energy shell in the hydrogen atom is ________.

3. Lines of Balmer series appear in ________ region.

4. The maximum number of electrons in Fe^{3+} (At. No. 26) is ________.

5. Li^{2+} and He^{+} ions have spectrum similar to ________ atom.

6. Bohr's atomic theory is not able to explain the atomic spectra of atoms containing ________ electron.

7. An electron in the first shell will have ________ stability and ________ energy than an electron in the third shell.

8. The space or three-dimensional region round the nucleus where there is maximum probability of finding an electron of specific energy is called an_____

9. According to _____ no two electrons in an atom will have all the four quantum numbers _____

10. When there are two electrons in the same orbital they have _____ spins.

11. The s-subhells have _____ shape and the p-subshells have_____

12. The maximum number of electrons on a subshell is equal to _______ where l = _______

Ans.

1.	Planck's theory	2.	$\frac{2h}{\pi}$
3.	Visible	4.	23
5.	H-atom	6.	more than 1
7.	Larger, lower	8.	orbital
9.	Pauli exclusion principle; similar		
10.	Opposite		
11	Spherical, dumb bell shape.		
12.	2l + 1; azimuthal quantum numbers		

TRUE AND FALSE TYPE QUESTIONS

Write true or false for the following statements

1. Bohr's theory cannot explain the spectra of multi-electron atoms.
2. Bohr's theory based on the Planck's quantum theory.
3. Size of orbital is determined by principal quantum number.
4. Fe^{2+} ion has more number of unpaired electrons than Fe^{3+}.
5. The outer electronic configuration of chromium atom is $3d^4 4s^2$.
6. The designation of an orbital n=4 and l=0 is 4s.
7. All photons of light have same energy.
8. Fe^{3+} has $3d^5$ configuration.

9. The number of subshells is always equal to the order of the orbit.

10. Two electrons in the same orbital has antiparallel spin.

11. The second orbit in He^+ ion has radius as the first orbit in hydrogen atom.

12. Heisenberg principle is applicable to microscopic particles.

13. 3s orbital has 2 radial nodes.

Ans. 1. (T) 2. (T) 3. (T) 4. (F) 5. (F) 6. (T) 7. (F)
8. (T) 9. (F) 10. (T) 11. (T) 12. (T), 13. (T)

MATCH THE COLUMNS

1. Match the following

List-I		List-II	
a.	Lyman series	p.	Visible region
b.	Balmer series	q.	Infrared region
c.	Paschen series	r.	Absorption spectrum
d.	Brackett series	s.	Ultraviolet region

2. Match the following

List-I		List-II		List-III
a. Principal quantum number	p.	Spin of electrons	i.	$-l$ to $+l$
b. Azimuthal quantum number	q.	Size of orbital	ii.	0 to ∞
c. Magnetic quantum number	r.	Orientation of the orbital	iii.	$\pm$ ½
d. Spin quantum number	s.	Shape of the orbital	iv.	0 to (n–1)

3. Match the following

	List-I		List-II		List-III
a.	2s	p.	Dough not shape	i.	along z-axis
b.	$2p_x$	q.	Spherical	ii.	In between x & y-axis
c.	$3d_{xy}$	r.	Dumb bell	iii.	non-directional
d.	$3d_{z^2}$	s.	Double dumb bell	iv.	along x-axis

4. Match the following

List-I		List-II	
a.	2s	p.	Two nodal planes
b.	ψ^2	q.	One radial node
c.	Heisenberg's uncertainty principle	r.	Electron probability density
d.	$3d_{yz}$	s.	Microscopic particles

Ans.: 1. a. (s), b. (p), c. (q), d. (q)

2. a. (q). (ii), b. (s). (iv), c. (r). (i), d. (p). (iii)

3. a. (q). (iii), b. (r). (iv), c. (s). (ii), d. (p).(i)

4. a. (q), b. (r), c. (s), d. (p)

ASSERTION AND REASON TYPE QUESTIONS

Directions: (Questions 1 to 10)

A. Both Assertion & Reason are true and the reason is the correct explanation of the assertion.

B. Both Assertion & Reason are true but the reason is not the correct explanation of the assertion.

C. Assertion is true statement but Reason is false.

D. Assertion is false but Reason is true.

1. **Assertion :** Number of orbitals in 3rd shell is 9.

   Reason : Number of orbitals for a particular value of n = n^2.

2. **Assertion :** Two nodal planes are present in $3d_{xy}$.

   Reason : Number of nodal planes = l

3. **Assertion :** The energy of an electron is largely determined by its principal quantum number.

   Reason : The principal quantum number is a measure of the most probable distance of finding the electrons around the nucleus.

4. **Assertion :** An orbital cannot have more than two electrons, moreover, if an orbital has two electrons they must have opposite spins.

   Reason : No two electrons in an atom can have same set of all the four quantum numbers.

5. Assertion: Black body is an ideal body that emits and absorbs radiations of all frequencies.

   Reason: The frequency of radiation emitted by a body goes from a lower frequency to higher frequency with an increase in temperature.

6. Assertion: 2p orbitals do not have any radial nodes.

   Reason: The number of radial nodes in p-orbitals is given by (n-2) where n is the principal quantum number.

7. Assertion: The opposite lobes of a p-orbital have opposite sign whereas opposite lobes of d-orbital have the same sign.

   Reason: The opposite lobes of a p-orbital have opposite charge whereas the opposite lobes of d-orbital have the same charge.

8. Assertion: Electronic configurations of Cr^{3+} (containing 21 electrons) is same as that of Sc(Z=21) i.e., isoelectronic species have the same electronic configuration.

   Reason: Orbitals of atoms are filled in order of increasing energy following aufbau principle.

9. Assertion: Hydrogen has one electron in its orbit but it produces several spectral lines.

   Reason: There are many excited energy levels available.

10. Assertion: The free gaseous Cr atom has six unpaired electrons.

    Reason: Half-filled d-orbitals have greater stability.

Ans. 1. A 2. A 3. A 4. A 5. B 6. D 7. C 8. D 9. A 10. A

ONE WORD ANSWER TYPE QUESTIONS

1. Write the name of the theory which explain the wave nature of light.
2 Write the name of the theory which explain the Black body radiations and photo electric effect
3 If the length of the crest of a wave is 4 pm. Write the wavelength of this wave. [Ans.8 pm]
4. A radiation emitted from a hot iron is photon or quantum ?
5. Out of the d orbitals which does not have four lobes ?
6. What is the lowest value of n that allows g orbitals to exist ?
7. Which quantum number is not obtained from solution of Schrödinger wave equation ?
8. Which of the following orbitals are possible ?

   1p, 2s, 2p and 3f
9. Write the name of non-directional subshell.
10. Write the name of quantum number which determines the orientation of orbitals ?
11. Write the name of quantum number which determines the shape of orbitals.
12. How many orbitals are present in 'g' subshell ?

1-MARK QUESTIONS

1 Write the relation between frequency and wave number.
2 Cs shows maximum photoelectric effect, why ?
3 Distinguish between a photon and a quantum.
4 The line spectrum of an element is known as fingerprints of its atom. Comment.
5 What is the value of the Bohr's radius for the third orbit of hydrogen atom?
6 What type of metals are used in photoelectric cell ? Give one example. [**Ans.** With large size, less work function.]
7 Which series of lines of the hydrogen spectrum lie in the visible region'?
8 Mention the physical significance of ψ and ψ^2.
9 Why did Heisenberg's uncertainty principle replace the concept of definite orbit by the concept of probability?

10. What is uncertain in uncertainty principle ?

11. Can a moving cricket ball have a wave character ? Justify your answer.

12. Heisenberg uncertainty principle has no significance in our everyday life. Explain.

13. Write the Schrodinger wave equation.

14. Why uncertainty in position is more when uncertainty in velocity is less for an electron ?

15. What are the four quantum numbers of 19th electron of copper ?

(Given : Atomic number of copper = 29)

16. How many electrons will be present in the sub-shells having ms, value of – 1/2 for n = 4 ?

17. Write the electronic configuration of Ni^{3+}. (At. No. of Ni = 28)

18. How many radial and angular nodes are present in 2p orbital.

[**Ans.** Radial nodes = 0, Angular nodes = 1]

2-MARKS QUESTIONS

Q. 1. Define black body and black body radiations.

Q. 2. Give the essential postulates of Bohr's model of an atom. How did it explain?

(i) the stability of the atom ?

(ii) origin of the spectral lines in H-atom ?

Q. 3. What is quantisation ? How quantisation of energy was introduced in Bohr's model ?

Q. 4. What transition in the hydrogen spectrum would have the same wavelength as the Balmer transition $n = 4$ to $n = 2$ of He^{+}spectrum?

[**Ans.** $n_1 = 1$ and $n_2 = 2$]

Q. 5. What transition of Li^{2+} spectrum will have the same wavelength as that of the second line of Balmer series in He^{+}spectrum ?

[**Ans.** $n_2 = 6$ to $n_1 = 3$]

Q. 6. Calculate the energy required for the process

$$He^{+}(g) \longrightarrow He^{2+}(g) + e^{-}$$

The ionization energy for the H atom in the ground state is 2.18×10^{-18} J atom^{-1}] [**Ans.** 8.72×10^{-18} J]

Q. 7. Calculate the wave number for the longest wavelength transition in the Balmer series of atomic hydrogen. [**Ans.** 1.523×10^{6} m^{-1}]

Q. 8. To which orbit the electron in H atom will jump on absorbing 12.1 eV energy ? [**Ans.** 3rd orbit]

Q. 9. Calculate the energy associated with the first orbit of He^{+}. What is the radius of this orbit? [**Ans.** – 54.38 eV, 0.2645 Å]

Q. 10. What is the distance of separation between 3rd and 4th orbit of H-atom? [**Ans.** 3.703 Å]

Q. 11. The energy of electron in the first Bohr's orbit is – 13.6 eV. Calculate the energy of electron in the first excited state. [**Ans.** – 3.4 eV]

Q. 12. Calculate the number of protons emitted in 10 hours by a 60 W sodium lamp emitting radiations of wavelength 6000 Å.

Q. 13. Which one has a higher energy, a photon of violet light with wavelength 4000 Å or a proton of red light with wavelength 7000 Å ?

[Given. $h = 6.62 \times 10^{-34}$ J sec.]

Q. 14. A 100 watt bulb emits monochromatic light of wavelength 400 nm. Calculate the number of protons emitted per second by the bulb.

[**Ans.** 2.012×10^{20} s^{-1}]

Q. 15. What are the maximum number of emission lines when the excited electron of a H atom in $n = 4$ drops to the ground state ? [**Ans.** 6]

Q. 16. Which has more energy, light radiation of wavelength 400 pm or light radiation of frequency 10^{15} Hz ?

Q. 17. Find the energy of electron in 4th shell of Li^{2+} ion.

Q. 18. What is the wave number of an electron with shortest wavelength radiation in Lyman spectrum of He^{+} ion?

Q. 19. Write short note on :

(a) Continuous and discontinuous spectrum.

(b) Absorbtion and emission spectrum.

Q. 20. Calculate the mass of the photon with wavelength of 3.6 Å.

[**Ans.** 6.135×10^{-29} kg]

Q. 21. Calculate the mass of the photon with wavelength of 5 pm.

Q. 22. On the basis of uncertainty principle show that an electron cannot exist with in atomic nucleus. *(Given : Nuclear radius = 10^{-15} m)*

[***Hint :*** *Taking 10^{-15} m as Δx, the Δv comes much higher than the velocity of light and hence is not possible*]

Q. 23. Explain why the uncertainty principle is significant only from the motion of subatomic particles and is negligible for macroscopic particles?

Q. 24. List two differences between orbit and orbital .

Q. 25. Show that the circumference of the Bohr orbit for the hydrogen atom is an integral multiple of the de Broglie wavelength associated with the electron revolving around the orbit

Q. 26. Comment on "Bohr's model is against the Heisenberg uncertainty principle".

Q. 27. What are the similarities and difference in 2*s* and $2p_x$ orbitals and 1s and 2*s* orbitals ?

Q. 28. Draw shape of $d_{x^2-y^2}$ orbital.

Q. 29. On the basis of Pauli's exclusion principle show that the maximum number of electrons in the M -shell ($n = 3$) of any individual atom is 18.

Q. 30. Designate each subshell with $n = 4$.

Q. 31. List the possible values for all the quantum numbers for the following subshell.

(a) 2*p* (b) 4*f*

Q. 32. Write down the electronic configuration of Fe^{3+} and Ni^{2+}. How many unpaired electrons are present? (Given Atomic number, Fe = 26, Ni = 28).

Q. 33. Out of principal, angular, magnetic and spin quantum number, which quantum number determines the ?

(a) Shape of the orbital
(b) Number of orbitals in an orbit
(c) Size of the orbital
(d) Spin orientation of the electron.

Q. 34. What is the Hund's rule of maximum multiplicity ? Explain with suitable example.

Q. 35. Explain why :

(a) The three electrons present in 2p subshell of nitrogen remain unpaired.

(b) Cr has configuration $3d^5\ 4s^1$ and not $3d^4\ 4s^2$.

Q. 36. (a) What is difference between 'l' and 'L'?

(b) Nitrogen has 7 proton, 7 electron and 7 neutrons. Calculate the number of electron, protons and neutrons in N^{3-} ion.

Q. 37. Which one is having higher energy?

(a) Last electron of Cl^- or last electron of O^{2-}.

(b) $n = 4, l = 3$ or $n = 5, l = 2$.

3-MARKS QUESTIONS

Q. 1.(i) The energy associated with the first orbit in the hydrogen atom is -2.18×10^{-18} J atom^{-1}. What is the energy associated with the fourth orbit ?

(ii) Calculate the radius of Bohr's third orbit for hydrogen atom.

[**Ans.**– 1.36×10^{-19} J atom^{-1} .4.761 nm]

Q. 2. A bulb emits light of wave length 4500Å. The bulb is rated as 150 watt and 8% of the energy is emitted as light. How many photons are emitted by the bulb per second ? [**Ans.** $n = 27.2 \times 10^{18}$]

Q. 3. When light with a wavelength of 400 nm falls on the surface of sodium, electrons with a kinetic energy of 1.05×10^5 J mol^{-1} are emitted.

(a) What is the minimum energy needed to remove an electron from sodium ?

(b) What is the maximum wavelength of light that will cause a photoelectron to be emitted ?

[**Ans.** $a = 3.2255 \times 10^{19}$ J, $b = 616$ nm]

Q. 4. Compare the frequency of light radiations emitted when electron falls from 5th shell to the 2nd shell in Li^{2+} ion and electron falls from 4th shell to the 1st shell in He^+ ion.

Q. 5. Calculate the number of waves made by Bohr electron in one complete revolution in its third orbit. [**Ans.** 3]

Q. 6. What should be the ratio of velocities of CH_4 and O_2 molecules so that they are associated with de Broglie waves of equal wavelength ? [**Ans.** 2]

Q. 7. Calculate the wavelength of an electron that has been accelerated in a particle accelerator through a potential difference of 1 kv.

[Given 1eV = 1.6 × 10^{-19} J] [**Ans.** 3.87×10^{-7} m]

Q. 8. (i) Discuss the similarities and differences between a 1s and 2s orbital.

(ii) Draw the shape of d_{z^2} .

Q. 9. Calculate the wavelength of a tennis ball of mass 60 gm moving with a velocity of 10 m per second. *($h = 6.626 \times 10^{-34}$ kg m^2 s^{-1})*

[**Ans.** 10^{-3} metre]

Q. 10. Calculate the wavelength of 1000 kg rocket moving with a velocity of 3000 km/hr. *($h = 6.626 \times 10^{-34}$ kg m^2 s^{-1})*

[**Ans.** 7.9512×10^{-40} m]

Q. 11. Calculate the uncertain it in the velocity of a cricket ball of mass 150 g, if uncertainity in its position is of the order of 1 Å.

[**Ans.** 3.5×10^{-24} m s^1]

Q. 12. (a) What is de-Broglie wavelength for an electron moving with velocity of light?

(b) What is the angular momentum of electron in 5th shell?

Q. 13. Two particles A and B have wavelength $\lambda_A = 5 \times 10^{-10}$ m and λ_B = 10×10^{10} m. Find their frequency, wave number and energies. Which has more penetrating power and why ?

Q. 14. (a) Which has max. uncertainty regarding position and why ?

Electron, proton and neutron.

(b) Find the number of waves associated with a light radiation of time period 5 ns.

Q. 15. If an electron in He^+ has angular momentum of $5h/2\pi$. Find its energy and wavelength associated with it. Find the kinetic energy of this electron.

Q. 16 .(i) An atomic orbital has $n = 2$. What are the possible values of l and m_l ?

(ii) List the quantum numbers (m_1 and l) of electrons for $3d$ orbital.

(iii) Which of the following orbitals are possible ?

$2d$, $1s$, $2p$ and $3f$.

Q. 17. (a) Write the maximum number of electron in a subshell with $l = 3$ and $n = 4$.

(b) Write the maximum number of electron that can be associated with the following set of quantum numbers ?

$n = 3$, $l = 1$ and $m_l = -1$

(c) Write the maximum number of electron that can be accomodated in an atom in which the highest principal quantum number value is 4.

Q. 18. (i) Write the electronic configurations of the following ions :

(a) H^- (b)Na^+ (c)O^{2-} (d) F^-

(ii) What are the atomic numbers of elements whose outermost electrons are represented by (a) $3s^1$(b) $2p^3$ and (c) $3p^5$?

(iii) Which atoms are indicated by the following configurations ?

(a) [He] $2s^1$ (b) [Ne] $3s^2$ $3p^3$ (c) [Ar] $4s^2$ $3d^1$.

Q. 19. Calculate:

(a) Total number of spherical nodes in $3p$ orbital.

(b) Total number of nodal planes in $3p$ orbital.

(c) Nodal planes in $3d$ orbital.

5-MARKS QUESTIONS

Q. 1.(a) Define Photoelectric effect ? Mention its one practical application in daily life.

(b) Electrons are emitted with zero velocity from a metal surface when it is exposed to radiation of wavelength 6800 Å. Calculate threshold frequency (ν_o) and work function (W_o) of the metal.

[**Ans.** $\nu_o = 4.41 \times 10^{14}$ s^{-1} $W_o = 2.92 \times 10^{-19}$ J]

Q. 2.(a) The electronic energy in Bohr's orbit is negative .How will you account for it?

(b) The ionisation energy of hydrogen atom is 13.6 eV. What will be the energy of the first orbit of He^+ and Li^{2+} ions ?

[**Ans.** E_1 of $He^+ = -54.4$ eV, E_1 of $Li^{2+} = -122.4$ eV]

Q. 3.(a) Define the following terms :

(i) Threshold frequency (ii) Work function.

(b) The work function for C*s* atom is 1 .9 eV. Find threshold wavelength (λ_0)and threshold frequency (ν_0) of this light radiation. If C*s* metal is irradiated with a radiation of wavelength 500 nm find kinetic energy and velocity of emitted electron.

Q. 4.(a) State de Broglie equation. Write its significance.

(b) A beam of helium atoms moves with a velocity of 2.0×10^3 m s^{-1}. Find the wavelength of the particle constituting the beam

($h = 6.626 \times 10^{-34}$ J s) [**Ans.** 49.9 pm]

Q. 5.(a) State Heisenbergs uncertainty principle. Give its mathematical expression. Also give its significance.

(b) Calculate the uncertainity in the position of a dust particle with mass equal to 1 mg if the uncertainity in its velocity is $5.5 \times 10^{-20} ms^{-1}$.

[**Ans.** 9.55×10^{10} m]

Q. 6.(a) Cricket ball, a tennis ball and a proton which has more uncertainity in velocity and which follows Heisenberg uncertainity principle maximum.

(b) What is the similarity in de-Broglie and Heisenberg principle? Which is different from Bohr theory for structure of atom?

(c) Why energy in a given subshell is negative?

Q. 7.(a) Write short notes on:

(i) Aufbau principle (ii) Pauli's principle (iii) Hund's rule.

(b) Write the electronic configuration of the following ions :

(i) Fe^{3+} (ii) Cu^+ [Given Atomic number of Fe and Cu are 26 & 29]

Q. 8.(a) Draw the shapes of the following orbitals.

(i) $3d_{xy}$ (ii) d_{z^2}

(b) What is the total number of orbitals associated with the principal quantum number $n = 3$?

(c) Using s, p, d, f notations, describe the orbital with the following quantum numbers:-

(a) $n = 3, l = 0$, (b) $n = 4, l = 2$, (c) $n = 5, l = 3$, (d) $n = 1, l = 0$

Q .9. Explain the following :

(i) Energy of electron is not decided by : n, l ,m and s.

(ii) Maximum number of electron with – 1/2 spin for $n = 3$ is 6,9,12 or none.

(iii) Maximum number of electron can be present for $n + l = 4$.

(iv) 3f subshell is not possible.

(v) Maximum number of electrons in a subshell is :

$(2l + 1)$ or $(4l + 1)$ or n^2

Q. 10.(a) A neutral atom has 2K, 8L and 15 M electrons. Find the total numbers of electrons in s, p, d and f subshell.

(b) How many unpaired electrons are present in the following ions :

Al^{+}, Cr^{2+}, Co^{3+} and Mn^{2+}

(Given Atomic number : Al=13, Cr = 24, Co = 27 & Mn = 25)

(c) One electron is present in 4f subshell. What is the sum of $n + l + m_1 + m_s$ values assuming 'f' subshell follows – 3 to + 3 order of filling electron.

Q. 11. Answer the following :

(a) $n + l$ value for 14th electron in an atom.

(b) Increasing order of filling electron in 4f, 5p and 6d subshells.

(c) 'm' and 'l' value for last electron of Mg atom.

(Given atomic number of Mg is 12)

(d) Subshell in which last electron is present in Ga.

(Given Atomic number of Ga is 31)

(e) Sum of spin of all the electron in element having atomic number 14.

UNIT TEST-I

Time allowed : 1 Hour **Maximum Marks : 20**

General instructions :

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

---

1. Designation for an orbital with $n = 4$ and $l = 3$ is (1)

   (a) 4s (b) 4p (c) 4d (d) 4f

2. Maximum number of unpaired electrons in chromium is (1)
   (Given: Atomic number of Cr = 24)

   (a) 4 (b) 5 (c) 6 (d) 7

3. Which series of lines of the hydrogen spectrum lie in the visible region'? (1)

4. Why de-Broglie's wavelength is not significant for macroscopic objects.(1)

5. Which of the following is not possible ?

   (a) 2p (b) 3d (c) 3f (d) 4p (1)

6. Write two difference between orbit and orbital. (2)

7. Calculate the wave number for the longest wavelength transition in the paschen series of atomic hydrogen. (2)

8. (a) How many orbitals are associated with $n = 4$? (3)

   (b) How many electrons will be present in the sub-shells having ms value of $-1/2$ for $n = 3$?

   (c) Draw the shape of d_{z^2}.

9. Calculate the uncertainty in the position of a dust particle with mass equal to 1 mg if the uncertainty in its velocity is 5.5×10^{-20} ms^{-1}. (3)

10. (i) The energy associated with the first orbit in the hydrogen atom is -2.18×10^{-18} J $atom^{-1}$. What is the energy associated with the fifth orbit?

    (ii) Calculate the radius of Bohr's fifth orbit for hydrogen atom.

    (iii) Calculate the radial and angular nodes in 2p orbital.

    (iv) Define the black body and black body radiations. (5)

UNIT TEST-II

Time allowed : 1 Hour **Maximum Marks : 20**

General instructions :

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

---

1. The de-Broglie wavelength associated with a ball of mass 1 kg having kinetic energy 0.5j is (1)

   (a) 6.626×10^{-34} m (b) 13.20×10^{-34} m

   (c) 10.38×10^{-21} m (d) 6.626×10^{-34} Å

2. The radius of which of the following orbit is same as that of first orbit of hydrogen atom? (1)

   (a) He^+ (n = 2) (b) Li^{2+} (n = 2) (c) Li^{2+} (n = 3) (d) Be^{3+} (n = 2)

3. Which series of hydrogen spectrum lies in the UV region'? (1)

   In following questions a statement of Assertion followed by a statement of Reason is given. Choose the correct answer out of the following choices.

   (a) Assertion and Reason are true and Reason is the correct explanation of Assertion.

   (b) Assertion and Reason are true but Reason is not the correct explanation of Assertion.

   (c) Assertion is true but Reason is false.

   (d) Both Assertion and Reason are false.

4. **Assertion :** It is impossible to determine the exact position and exact momentum of an electron simultaneously.

   Reason : The path of an electron in an atom is clearly defined. (1)

5. **Assertion :** All isotopes of a given element show the same type of chemical behaviour.

   Reason : The chemical properties of an atom are controlled by the number of electrons in the atom. (1)

6. Calculate the number of angular nodes and radial nodes in 3p orbital. (2)

7. Calculate the mass of photon with wavelength 3.6A°. (2)

8. What transition in the hydrogen spectrum would have the same wavelength as the Balmer transition n = 4 to n = 2 of He^+ spectrum? (3)

9. (a) The energy associated with Bohr's first orbit is -2.18×10^{-18} J $atom^{-1}$. What is the energy associated with fifth orbit?

(b) The work function for Caesium atom is 1.9eV. Calculate the threshold wavelength.

[Given : lev = 1.6×10^{-19} J]

(c) How many sub-shells are associated with n = 4? (1×3=3)

10. (i) How many electrons will present in sub-shell having spin quantum number value of –½ for n = 4?

(ii) Which of the following transition will have minimum wavelength and why?

$n_4 \rightarrow n_1$, $n_4 \rightarrow n_2$, $n_2 \rightarrow n_1$

(iii) Give the number of radial nodes for 3s and 2p orbitals. (5)

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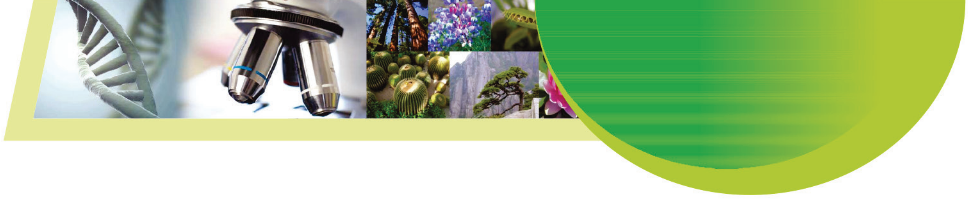
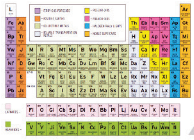




Chapter - 3

Classification of Elements and Periodicity in Properties

FAST TRACK : QUICK REVISION

- **The first systematic classification of elements was provided by Russian chemist D.I. Mendeleev.**

1. **Mendeleev's periodic law**

   "The physical and chemical properties of elements are periodic functions of their atomic weight."

2. It was modified to **Modern Periodic law :**

   "The physical and chemical properties of elements are periodic functions of their atomic numbers."

   It is the long form of periodic table :

   7 Horizontal rows are called Periods and 18 Vertical columns are called Group

   Group-1 are called **Alkali metals** Group-2 are called **Alkaline earth metals**.

   Group-15 are called **Pnicogens** Group-16 are called **Chalcogens**

   Group-17 are called **Halogens** Group-18 are called **Noble gases**

3. 1st period – 2 elements 2nd and 3rd period – 8 elements

   4th and 5th period – 18 elements 6th period – 32 elements

   7th period – Incomplete (32 elements)

4. Groups

   1 and 2 – '*s*' block elements last electron entered in '*s*' subshell [s^1, s^2]

   3 to 12 – '*d*' block elements last electrons entered in '*d*' subshell [d^1 to d^{10}].

   13 to 18 – '*p*' block elements last electrons enter in '*p* ' subshell [p^1 to p^6].

   Two *f*-block series lanthanoids and actinoids are placed in the bottom of periodic table.

5. (A) In 's' and 'p' block elements the electrons enters in outer most shell.
   In 'd' block elements the electron enters in the penultimate shell $(n-1)$.
   'f' block elements last electron enter the antepenultimate shell $(n-2)$.

   (B) 'f' block elements are placed in between 'd' block elements.
   'f' block elements in 2 rows [4f lanthanoids, 5f actinoids]

6. **General outer electronic configuration**

   's' block : ns^1, ns^2 [Group 1 to 2]

   'p' block : ns^1np^1 to $ns^2\,np^6$ Group 13 to 18

   'd' block : $ns^{0-2}\,(n-1)\,d^{1 \text{ to } 10}$ Group 3 to 12

   'f' block : $(n-2)f^{1 \text{ to } 14}\,(n-1)d^{0,\,1}\,ns^2$

7. **General periodic trends in properties of elements**

- **ATOMIC RADIUS**

  (A) Left to right decreases due to effect of successive increasing nuclear change without addition of a new shell.

  (B) From top to bottom atomic radius increases due to successive addition of shell.

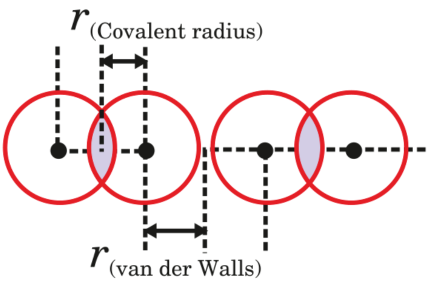
  (C) Noble gases have large radius than **group 17** due to complete filling of electron in outer shell electron-electron repulsion mildy increases.

- **COVALENT RADIUS**

  It is half of the distance between the centre of nuclei of two adjacent similar atoms which are bonded to each other by single covalent bond.

- **van der Waal's Radius**

  van der Waal's radius is defined as one-half the distance between the centres of nuclei of two nearest like atoms belonging to two adjacent molecules of the element in the solid state.



- **METALLIC RADIUS**

  Half of the distance between the centres of the nuclei of two adjacent atoms in the metallic crystal. A comparison of the three atomic radii show that van der Waal's radius is maximum while the covalent radius has the least value.

  van der Waal's radius > Metallic radius > Covalent radius

- **IONIC RADIUS**

  (A) Cation radius < Atomic radius – due to more no. of protons than number of electron coloumbic force increases, size decreases.

  $[Mg^{2+} < Mg^{+} < Mg]$

  (B) Anion radius > Atomic radius – Due to more number of electron than number of protons

  $[N^{3-} > O^{2-} > F^{-}]$

  Electron-Electron repulsion increase, coloumbic force of attraction decreases.

  (C) For Isoelectronic species – More is the charge of cation lesser the size.

  More is the charge of anion, more is the size.

  (D) Order of size – $O^{2-} > F^{-} > Na > Na^{+} > Mg^{2+}$

8. (A) Ionisation enthalpy :

The minimum amount of energy which is required to remove the most loosely bound electron from an isolated atom in the gaseous state is called Ionisation enthalpy.

$$M(g) + \text{Energy} \longrightarrow M^{+} + e^{-}$$

$$IE_3 > IE_2 > IE_1$$

(B) Variation of I.E along a period:

Ionisation enthalpy increase along the period because atomic radii decrease and nuclear charge increase along the period.

I ionisation enthalpy Li < B < Be < C < O < N < F < Ar

II ionisation enthalpy Be < C < B < N < F < O < Ne

(C) Variation down the group:

Ionisation enthalpy decrease down the group because atomic radius increase down the group.

Metallic behaviour : Decrease from left to right due to increase in ionisation enthalpy.

Non metallic behaviour : Increase from left to right due to more number of electron in outershell and added electron goes towards nucleus.

9. Screening effect or shielding effect:-

It is the decrease in the force of attraction between nucleus and outermost electron due to presence of inner shell electrons. As a result, the outer most electrons does not feel full charge of the nucleus. The actual charge felt by an electron is called effective Nuclear charge.

Shielding effect is in the following order **s > p > d > f**

d & f subshell show weak sheilding effect because their orbital size are large and are more diffused.

10. Isoelectronic species:

Ions of different elements which have the same number of electrons but different no. of protons are called isoelectronic ions.

	Na^+	Mg^{2+}	Al^{3+}	N^{3-}	O^{2-}	F^-
No. of Protons	11	12	13	7	8	9
No. of electrons	10	10	10	10	10	10

Ionic Radii $Al^{3+} < Mg^{2+} < Na^+ < F^- < O^{2-} < N^{3-}$

11. Electron gain enthalpy:

The enthalpy change when an extra electron is added to neutral gaseous atom to form anion.

$$E(g) + e^- \longrightarrow E^-(g)$$

- **Trends : From left to right** – Increase due to decrease in size, more attraction of added electron by nucleus.
- **From top to bottom**—Decreases as the added electron is away from nucleus due to increase in size.
- ***Cl* has more negative electron gain enthalpy than fluorine** – Due to small size of fluorine extra added electron has more inter electronic repulsion than chlorine which has large size.
- Similarly Phosphorus and Sulphur have negative electron gain enthalpy than nitrogen and oxygen respectively.
- **Maximum electron gain enthalpy** – Chlorine (in periodic table)

- **Electron gain enthalpy –**
  Halogen > Oxygen > Nitrogen > Metal of group 1 and 13 and non metal of group 14 > metal of group 2.
- 2nd electron gain enthalpy is always positive.

12. Electro negativity:

The tendency of an atom to attract the shared pair of electron towards itself in a bonded state.

- Fluorine is the most electronegative element in the periodic table.
- Cesium is the least electronegative element in the periodic table.
- Electro-negativity decreases down the group and increases along the period

Difference between electron gain enthalpy and Electronegativity.

Electron gain enthalpy is the energy, but electronegativity is not the energy, it is only the tendency of an atom in a molecule to attract the shared pair of electrons. Three highest electronegative atoms F > O > N.

Maximum electronegative Assign to F.

* Lightest element : **Hydrogen**
* Lightest metal : **Lithium**
* Heaviest metal (highest density) : **Osmium**
* Most reactive metal : **Caesium**
* Most reactive nonmetal : **Fluorine**
* Most malleable metal : **Gold**
* Electrically best conductor : **Silver**
* Metals which are relatively volatile : **Zn, Cd, Hg**
* Strongest reducing agent in aqueous solution : **Lithium**
* Strongest oxidising agent : **Fluorine**
* The element of lowest ionisation energy : **Caesium**
* The element of highest ionisation energy : **Helium**
* The most electronegative element : **Fluorine**
* The element of highest electron gain enthalpy : **Chlorine**
* The group containing most electropositive metals : **Group 1**
* The group containing most electronegative metals : **Halogens Group 17**
* The group containing maximum number of gaseous elements : **Group 18**

13. **Second period element**—Show different behaviour that I group **element**—Due to (a) small size (b) High electron negativity (C) High polarising power (d) absence of '*d*' orbital.

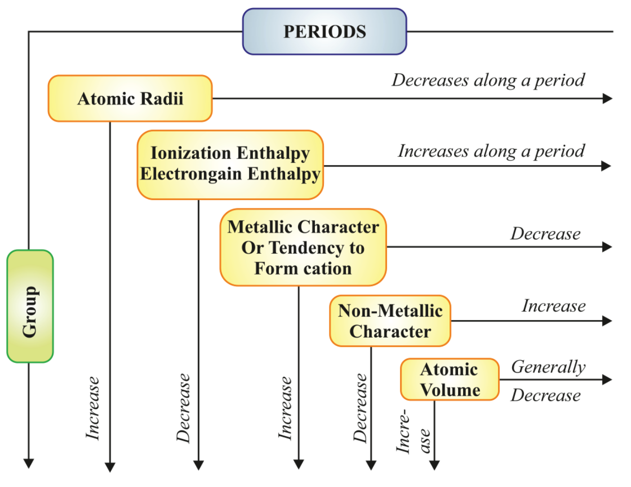
$Na_3[Al(OH)_6]$ exists but $Na[B(OH)_4]$ not exists.

14. The similarities in properties of first member of a group to second member of just next higher group due to comparable atomic radius, nearly same polarising power of ions is known as **diagonal relationship.**

Li Be B C N

Na Mg Al Si P

Elements with number of e^-	**in valance shell**
(a) 1, 2, 3	metals
(b) 4	metalloids
(c) 5, 6, 7	non-metals
(d) 8	noble gas



MIND MAP

CLASSIFICATION OF ELEMENTS AND PERIODICITY IN PROPERTIES

MODERN PERIODIC TABLE
By Mosley (1912)
"The physical and chemical properties of the elements are periodic function of their atomic numbers"

- **Groups**
  18 groups
  Vertical coloumns contain elements having similiar outer electronic configurations
- **Periods**
  7 Periods
  Horizontal rows
- **Blocks**
  4 Blocks
  (s, p, d, f)
  - **s-block**
    General electronic configuration ns^{1-2}
    [Group-1 Except hydrogen alkali metals]
  - **p-block**
    General electronic configuration $ns^2\,np^{1-6}$
    Group-13: Boron family
    Group-14: Carbon family
    Group-15: Pnictogens
    Group-16: Chalcogens
    Group-17: Halogens
    Group-18: Aerogens
  - **d-block**
    General electronic configuration $(n-1)\,d^{1-10}ns^{0-2}$
    Group-3 to 12
    They are called transition elements.
  - **f-block**
    General electronic configuration $(n-2)f^{1-14}\,(n-1)\,d^{0-1}ns^2$
    They are called Inner transition elements
    Two series: Lanthanoids & Actinoids
- Periodic trends in properties of elements
  - Trends in Physical properties
    - Atomic & Ionic radii — Increase down the group & decrease along the period
    - Ionization enthalpy
    - Electron gain enthalpy
    - Eletronegativity
    - (Ionization enthalpy, Electron gain enthalpy, Eletronegativity) — Decrease down the group & Increase along the period
  - Trends in Chemical properties
    - Valence
    - Acidity of Hydrides
    - Acidity of oxide

CASE BASED STUDY QUESTIONS

1. Read the passage given below and answer the following questions:

A period is a horizontal row in the periodic table. Although groups generally have more significant periodic trends, there are regions where horizontal trends are more significant than vertical group trends, such as the f-block, where the lanthanides and actinides form two substantial horizontal series of elements.

Elements in the same period show trends in atomic radius, ionization energy, electron affinity, and electronegativity. Moving left to right across a period, atomic radius usually decreases. This occurs because each successive element has an added proton and electron, which causes the electron to be drawn closer to the nucleus. This decrease in atomic radius also causes the ionization energy to increase when moving from left to right across a period. The more tightly bound an element is, the more energy is required to remove an electron. Electronegativity increases in the same manner as ionization energy because of the pull exerted on the electrons by the nucleus. Electron affinity also shows a slight trend across a period. Metals (left side of a period) generally have a lower electron affinity than non-metals (right side of a period), with the exception of the noble gases.

(Reference: https://en.wikipedia.org/wiki/Periodic_table)

The following questions are multiple choice questions. Choose the most appropriate answer:

(i) The atomic radii of Elements Z and X are compared. Element Z is having larger radius than Element X. (Both the elements does not have noble gas configuration and exist in same period in the periodic table)

Based on this you can say that the:

A) Element Z is located to the left side of Element X in the periodic table

B) Element Z is located to the right side of Element X in the periodic table

C) Element Z and X are probably in the same group

D) None of the above

(ii) In which of the following atoms is the 3s orbital closest to the nucleus?

A) Br B) Cl

C) I D) Same distance in all of these atoms

(iii) __________ have the lowest first ionization energies of the groups listed.

A) Alkali metals

B) Transition metals

C) Halogens

D) Noble gases

(iv) The correct order of electronegativity is

A) $Cl > F > O > Br$

B) $F > O > Cl > Br$

C) $F > Cl > Br > O$

D) $O > F > Cl > Br$

ANS:- I-A, II-B, III-C, IV-B

2. Read the passage given below and answer the following questions:

As the number of protons increase within a period (or row) of the periodic table, the first ionization energies of the transition-metal elements are relatively steady, while that for the main-group elements increases. The effective nuclear charge mirrors and may explain the periodic trends in the first ionization energies of the transition-metal and main-group elements. The differing periodic trends in the effective nuclear charge are due to a greater increase in shielding in the transition-metal elements than in the main-group elements. The difference in shielding is due to the entry of electrons into an inner-shell orbital for the transition-metal elements, while electrons enter an outer-shell orbital for the main-group elements.

(Reference: Paul S. Matsumoto J. Chem. Educ. 2005, 82, 11, 1660 Publication Date: November 1, 2005, Journal of the American Chemical Society)

In these questions (Q. No. (i) to (iv) , a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement

i. ASSERTION: The first ionization energies of the transition-metal elements are relatively steady.

REASON: Electrons are added into an inner-shell orbital for the transition-metal elements along the period.

ii. ASSERTION: The first ionisation energy of Be is greater than that of B.

REASON: 2p orbital is lower in energy than 2s orbital.

iii. ASSERTION: The ionisation of s-electron requires more energy than ionisation of p-electron of the same shell

REASON: The s-electrons are closer to the nucleus than p-electrons and hence are more strongly attracted by the nucleus.

iv. ASSERTION: The first ionisation enthalpy of aluminium is lower than that of magnesium.

REASON: Ionic radius of aluminium is smaller than that of magnesium.

ANS:- I-A, II-C, III-A, IV-B

MULTIPLE CHOICE QUESTIONS (MCQ)

1. According to modern periodic law, the physical and chemical properties of elements are the periodic functions of their ?

   (a) Density (b) Atomic Number

   (c) Mass Number (d) Atomic Mass

2. Highest electropositive element in the periodic table is

   (a) Cs (b) Rb

   (c) K (d) Na

3. The correct order of ionic radii of the species N^{3-}, O^{2-}, Na^+ and F^- is

   (a) $Na^+ < F^- < O^{2-} > N^{3-}$ (b) $F^- < O^{2-} < N^3 > Na^+$

   (c) $O^{2-} < N^{3-} < F^- > Na^+$ (d) $N^{3-} < Na^+ < F^- > O^{2-}$

4. The basic strength of the oxides follows the order

   (a) $Al_2O_3 > MgO > Na_2O$ (b) $Al_2O_3 < MgO < Na_2O$

   (c) $Na_2O_3 < MgO > Al_2O_3$ (d) $Al_2O_3 > MgO > Na_2O$

5. The correct order of the size of C, N, P, S follows the order

   (a) $N < C < P < S$ (b) $C < N < S < P$

   (c) $C < N < P < S$ (d) $N < C < S < P$

6. Which of the following oxide is most acidic?

   (a) Na_2O (b) Al_2O_3

   (c) P_2O_5 (d) SO_3

7. Downward in a group, electropositive character of elements

   (a) increases (b) decreases

   (c) remains same (d) none of these

8. Element which has more negative electron gain enthalpy is

   (a) F (b) O

   (c) Cl (d) S

9. The electronegativity of the following elements increase in the order

   (a) C, N, Si, P (b) N, Si, C, P

   (c) Si, P, C, N (d) P, Si, N, C

10. The ionisation enthalpy of nitrogen is more than that of oxygen molecules because of
    (a) greater attraction of electrons by the nucleus
    (b) extra stability of the half filled p-orbitals
    (c) smaller size of nitrogen
    (d) more penetrating effect

Ans: 1. (b), 2. (a), 3. (a), 4. (b), 5. (d), 6. (d), 7. (a), 8. (c), 9. (c), 10. (d)

FILL IN THE BLANKS

1. Lightest metal in s-block elements is ______________ .
2. In the periodic table, horizontal rows are known as ______________ .
3. Elements of s-blocks and p-blocks are collectively called ____________.
4. Most electropositive elements belong to ____________ group.
5. Most electronegative elements belong to ____________ group.
6. The elements above atomic number 92 are called ____________.
7. The inner-transition elements belong to _________ block of the periodic table and are shown separately at the _________ of the periodic table.
8. An element having electronic configuration [Ar] $3d^5$, $4s^2$ belongs to _____________ block.
9. Ca^{2+} has smaller ionic radius than K^+ ion because it has ____________.
10. The maximum electronegativity is shown by _____________.
11 The maximum ionisation enthalpy is shown by ____________.
12 The cation is _________ and the anion is _________ than the parent atom.

Ans:
1. Lithium
2. periods
3. normal elements or representative elements
4. 1^{st}
5. 17^{th}
6. transuranic elements
7. F –, bottom
8. s –
9. more protons
10. F –
11. H
12. smaller, bigger

TRUE AND FALSE TYPE QUESTIONS

Write true or false for the following statements

1. First ionisation enthalpy of Be is higher than B.
2. Every period of the periodic table (except first period) starts with a member of alkali metal.
3. The energy liberated during the removal of one electron from an atom is called its ionisation potential.
4. Flourine has more negative electron gain enthalpy than chlorine.
5 Mg^{2+} ion has smaller size than Mg.
6. Electronegativity of F is larger than that of Cl but electron gain enthalpy of Cl is larger than of F.
7. The decreasing order of electronegativity of F, O and N is F > O > N.
8. Group-18 contain maximum gaseous elements.
9. Al_2O_3 is an amphoteric oxide.
10. Helium has the highest ionisation enthalpy.

Ans: 1. (T) 2. (T) 3. (T) 4. (F) 5. (T)
6. (T) 7. (T) 8. (T) 9. (T) 10. (T)

MATCH THE COLUMNS

1.

	Column A		Column B		Column C
a.	Lightest element	i.	Caesium	p.	Is^1
b.	Lightest metal	ii.	Osmium	q.	$[He]\ 2s^1$
c.	Heaviest metal	iii.	Lithium	r.	$[Xe]\ 6s^1$
d.	Most reactive metal	iv.	Hydrogen	s.	d-block element

2.

	Column A		Column B
a.	Fluorine	i.	High negative electron gain enthalpy
b.	Helium	ii.	Most electropositive element
c.	Chlorine	iii.	Most electronegative element
d.	Caesium	iv.	Highest ionisation enthalpy

	Column C
p.	$[Xe]\ 6s^1$
q.	$[He]\ 2s^2\ 2p^5$
r.	Is^2
s.	$[Ne]\ 3s^2\ 3p^5$

3.

	Column A		Column B
a.	Na_2O	i.	Amphoteric oxide
b.	Cl_2O_7	ii.	Acidic oxide
c.	Al_2O_3	iii.	Neutral oxide
d.	CO	iv.	Basic oxide

4.

	Column A		Column B
a.	s & p-block	i.	Inner transition elements
b.	d-block	ii.	s-block elements
c.	f-block	iii.	Transition elements
d.	group-1 and group-2	iv.	Representative elements

Ans: 1. a. (iv). (p), b. (iii). (q), c. (ii). (s), d. (i). (r)
2. a. (iii). (q), b. (iv). (r), c. (i). (s), d. (ii). (p)
3. a.(iv), b.(ii), c.(i), d.(iii)
4. a.(iv), b.(iii), c.(i), d.(ii)

ASSERTION AND REASON TYPE QUESTIONS

Directions for Q. No.1-10

A Both Assertion & Reason are true and the reason is the correct explanation of the assertion.

B Both Assertion & Reason are true but the reason is not the correct explanation of the assertion.

C Assertion is true statement but Reason is false.

D Assertion is false but Reason is true.

1. Assertion : Ionic radius of Na^+ is smaller than Na
Reason : Effective nuclear charge of Na^+ is higher than Na

2. Assertion : First ionisation enthalpy of N is higher than O.
Reason : Extra stability of fully filled up 2p subshell of N atom

3. Assertion : Electron gain enthalpy of Cl is more negative than F atom.
Reason : F is more electronegative than Cl atom.

4. Assertion : First ionisation enthalpy of Galium is higher than aluminium.
Reason : Weak sheliding effect of 3d subshell is Galium.

5. Assertion: Noble gases have positive electron gain enthalpy.
Reason: Noble gases have stable closed shell electronic configuration.
6. Assertion: F is more electronegative than Cl.
Reason: F has more electron affinity than Cl.
7. Assertion: The ionic size of O^{2-} is bigger than that of F^- ion.
Reason: O^{2-} and F^- are isoelectronic ions.
8. Assertion: The ionic radii follows the order: $I^- < I < I^+$.
Reason: Smaller the value of z/e, larger the size of the species.
9. Assertion: The first ionisation enthalpy of aluminium is lower than that of magnesium.
Reason: Ionic radius of aluminium is smaller than that of magnesium.
10. Assertion: First ionisation energy for nitrogen is higher than that of oxygen.
Reason: Across a period effective nuclear charge decreases.

Ans: 1. A 2. A 3. B 4. A 5.A 6.C 7.B 8.D 9.B 10.C

ONE WORD ANSWER TYPE QUESTIONS

1. Metals are placed on which side of modern periodic table?
2. Which block of modern periodic table represent inner transition elements?
3. Name a halogen which has more negative electron gain enthalpy value?
4. Which element is iso-electronic with Na^+ ? [**Ans.** Ne]
[Given a atomic number of Sodium (Na) : 11]
5. An element is placed in 5th period and 3rd group what is its atomic number? [**Ans.** 39]
6. What is covalency of Al in $[AlCl_4]^-$? [**Ans.** 4]
7. Write the IUPAC Symbol for the element having atomic number 120. [**Ans.** Ubn]
8. Write the name of the group containing maximum number of gaseous elements.
9. Write the name of the subshell which show weakest sheilding effect.
10. Write the name of most electropositive element in the periodic table.
11. In what period and group will an element with Z = 118 will be present.

1-MARK QUESTIONS

1. Which pair of elements has similar properties?
   13, 31, 11 & 21
2. Name the element which exhibit diagonal relationship with Be.
   [**Ans.** 13, 31]
3. Which group elements are known as halogens?
4. The element with ns^2, np^5 configuration is non-metal or metal?
5. Define van der Waal's radius.
6. Write the outer shell configuration of atomic number 31. [**Ans.** $4s^2$, p^1]
7. Find the group number and period number of element having atomic number 52. [**Ans.** Period = 5th, Group = 16th]
8. Arrange O^{2-}, O^{-1}, O in decreasing radius (size). [**Ans.** $O^{2-} > O^{-1} > O$]
9. Why noble gas have bigger size than halogens?
10. Why first electron gain enthalpy of sulphur is more negative then oxygen?
11. Write general outer electronic configuration of 4f series elements.
    [**Ans.** $6s^2$, $5d^{0-1}$, $4f^{1}$ to 14]
12. Write two isoelectronic species with Br (35). [**Ans.** Kr^+, Se^{-1}]
13. Show that 4th period can have maximum 18 elements in it.
14. Second I.E. is always more than first I.E., why?
15. Electronegativity of F > Cl > Br > I, why?
16. Arrange F and Cl in terms of increasing chemical reactivity?
17. Second I.E. of Na is more than second IE of Mg. Why?
18. I.E. for cation is more than neutral atom. Why?
19. Define diagonal relationship with the help of an example.
20. Out of O^- and O, which has more negative electron gain enthalpy?
21. Mention any two anomalous properties of second period elements.

2-MARKS QUESTIONS

1. Cations are smaller than their parent atom whereas anions are larger in size than their parent atom. Explain.
2. Ionisation energy of nitrogen is more than 'O' and 'C' both, why ?
3. First ionisation energy of boron is less than Be but size of Be is less than Boron. Why ?
4. Electron gain enthalpy of Mg is positive. Explain.
5. Define co-valency.
6. The reactivity of halogens decrease down the group but of alkali metals increases down the group. Why?
7. Name a halogen, a metal and a group13 element which are liquid at 30°C. [**Ans.** Br, Hg, Ga]
8. The reducing power of elements increases down the group but reverse is true for oxidising power along a period. Why ?
9. What is the formula of binary compound formed between :
   (a) 1st element of I group and iodine ?
   (b) 2nd element of II group and 1st element of 17th group ?
10. Arrange in the following in increasing order of property indicated:
    (a) Size I, F, Cl, Br
    (b) Oxidising power I, F, Br, Cl
11. Oxygen is more non-metallic than nitrogen but less than fluorine why ?
12. LiCl, LiBr, LiI are covalent as well as ionic why ?
13. $PbCl_2$ is more stable than $PbCl_4$. Why ? [**Ans.** Inert pair effect]
14. [Magnesium and Lithium both form nitrides why ?
15. Which has least I.E. [$3p^3$, $3p^6$, $2p^3$, $2p^6$]?
16. (a) I.E. of sulphur is lower than chlorine.
    (b) Arrange the following in decreasing order of their electro-negativity:
    F, O, N, Cl, C, H.
17. Element 'A' in group 17 (2nd period)
    'B' in group 16 (2nd period)
    'C' in group 15 (2nd period)
    Arrange 'A', 'B' and 'C' in their decreasing order of electro-negativity and ionisation enthalpy.

18. Element 'A' 13 group forms ionic compounds. Write the :

(a) Formula of its oxide.

(b) Arrange the following in their decreasing electro-positive character Mg, Na, Al, Si.

19. Write the atomic number of element place diagonally to :

(a) Group 14, period 4 (b) Group 2, period 5

(c) Group 17, period 4

20. An element has outer shell electronic configuration $4s^2$ $4p^3$. Find :-

(a) The atomic number of element place next below it.

(b) Atomic number of next noble gas.

3-MARKS QUESTIONS

1. What is metallic radius, Covalent radius, van der waal's radius. Give one example for each.

2. Oxygen has first electron gain enthalpy exothermic while second endothermic still a large number of ionic oxides are formed. Why ?

3. In some properties Boron shows different properties with respect to rest of the membering the group. Justify.

4. Out of group 17, 18 and I, predict:-

(a) Which has most negative first electron gain enthalpy ?

(b) Which shows most metallic behaviour ?

(c) Which has highly positive electron gain enthalpy?

5. What are (a) representative elements, (b) Transition elements, (c) Lanthanoid and actinoids. Give their positions in modern periodic table.

6. Why LiF, NaF, KF, RbF, CsF are ionic ? But LiF is less ionic than CsF.

7. (a) Why Ca has larger atomic radius than Al ?

(b) Why $2s^2$ electron is difficult to remove than $2p$ electron ?

8. (a) Why the compounds of group 17 with group 13 elements are more ionic and stable than with (group 1) elements? (b) Na_2O is more ionic than Li_2O. why?

9. Explain the following data :

Ionisation energy Cl < H < O < N < F.

10. IE_2 of 3rd period elements is as follows. Why ?

Mg < Si < Al < P < S < Cl < Ar < Na.

11. Account fot the following:

(a) Halogens have very high negative electron gain enthalpy

(b) The electron gain enthalpy of Cl (Z = 17)is more negative than that of Fluorine (Z = 9).

(c) Ionisation enthaply of Nitrogen (Z = 7) is more than oxygen (Z =8).

12. What are the d- block elements? Write any four properties of d - block elements and give their general outer electronic configuration.

13. Explain the following:

(a) Modern Periodic law

(b) Electro-negativity

(c) Shielding effect

14. Among the second period elements the actual ionisation enthalpies are in the order Li < B < Be < C < O < N < F < Ne. Explain why?

(i) Be has higher $(\Delta_i H)_1$ than B

(ii) O has lower $(\Delta_i H)_1$ than N and F ?

15. What do you understand by the isoelectronic species ? Name a species that will be isoelectronic with each of the following atoms or ions.

(i) F^- (ii) Ar (iii) Ca^{2+} (iv) Rb^+

16. (a) Show by a chemical reaction with water that Na_2O is a basic oxide and Cl_2O_7 is an acidic oxide.

(b) Name a species that will be isoelectronic with each of the following atoms or ions, (i) F^- (ii) Ca^{2+}

17. The first ionisation enthalpy values (in $kJmol^{-1}$) of group-13 elements are:

B	Al	Ga	In	Tl
801	577	579	558	589

How would you explain this deviation from the general trend ?

18. The first (IE_1) and the second (IE_2) ionisation enthalpies (kJ mol^{-1}) of three elements are given below:

	I	II	III
IE_1	403	549	1142
IE_2	2640	1060	2080

Identify the element which is likely to be:-

(a) a non metal

(b) an alkali metal

(c) an alkaline earth metal

5-MARKS QUESTIONS

1. (A) Which of the following have same chemical properties :

(a) Atomic number 17, 53

(b) Atomic number 8, 52

(c) Both

(d) None

(B) Answer the following :

(i) B, Al, Ga (decreasing order of atomic radii).

(ii) C, S, N (decreasing order of $(\Delta Heg)_1$)

(iii) Al forms amphoteric oxide. Why ?

(iv) Si is a semiconductor while 'C' is a non-metal, why ?

2.

Element	$\Delta_i H^\ominus{}_1$	$\Delta_i H^\ominus{}_2$	$\Delta egH^0{}_1$
I	1681	3374	– 328
II	1008	1846	– 295
III	2372	5251	+ 48

(a) The most reactive non-metal.

(b) The least reactive non-metal.

(c) The least reactive element. Give reasons also.

[**Ans.** (a) 1 (b) II (c) III]

UNIT TEST-I

Time allowed : 1 Hour **Maximum Marks : 20**

General instructions :

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

---

1. Which of the following show the weakest shielding effect ? (1)

   (a) s (b) p (c) d (d) f

2. Which has highest electronegativity ? (1)

   (a) Cl (b) O (c) N (d) S

3. Which pair of elements has similar properties? (1)

   13, 31, 11, 21

4. Write general outer electronic configuration of 4f series elements. (1)

5. Write the IUPAC symbol for the element having atomic number 120. (1)

6. (a) Explain why cation are smaller and anions larger in radii than their parent atoms? (2)

   (b) Define accuracy & precision.

7. The first ionisation enthalpy values (in kJ mol^{-1}) of group-13 elements are : (2)

B	Al	Ga	In	Tl
801	577	579	558	589

   How would you explain this deviation from the general trend?

8. (a) Show by a chemical reaction with water than Na_2O is a basic oxide and Cl_2O_7 is an acidic oxide. (3)

   (b) Name a species that will be isoelectronic with each of the following atoms or ions. (i) F^- (ii) Ca^{2+}

9. Explain the following :

   (a) Shielding effect

   (b) Diagonal relationship

   (c) Anomalous behavior of second period elements.

10. (a) Alkali metals do not form dis-positive ions. Why? (5)

    (b) Why is the IUPAC name and symbol of the element having atomic number 117.

    (c) Are the oxidation state and covalency of Al in $[Al(H_2O)_6]^{2+}$ same?

    (d) Why are there fourteen elements in the Lanthanide series?

UNIT TEST-II

Time allowed : 1 Hour **Maximum Marks : 20**

General instructions :

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

---

1. In the P^{3-}, S^{2-} and Cl^- ions, the increasing order of size is (1)

   (a) Cl^-, S^{2-}, P^{3-} (b) P^{3-}, S^{2-}, Cl^-

   (c) S^{2-}, Cl^-, P^{3-} (d) S^{2-}, P^{3-}, Cl^-

2. The element with positive electron gain enthalpy is (1)

   (a) hydrogen (b) sodium (c) oxygen (d) neon

3. Write the IUPAC name and symbol for the element with atomic number 118. (1)

In following questions a statement of question followed by a statement of reason is given. Choose the correct answer out of the following choices :

(a) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.

(b) Both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

(c) Assertion is true but Reason is false.

(d) Both Assertion and Reason are false.

4. **Assertion :** Electron gain enthalpy becomes less negative as we go down a group. (1)

   Reason : Size of the atom increases on going down the group and the added electron would be farther from the nucleus.

5. **Assertion :** Boron has a smaller first ionisation enthalpy than Beryllium.(1)

   Reason : The penetration of 2s electron to the nucleus is more than 2p electron hence 2p electron is more shielded by the inner core than 2s electron.

6. Out of O and S, which has higher negative electron gain enthalpy and why? (2)

7. Assign the position of elements having outer electronic configuration :

   (i) $ns^2\ np^4$ for n = 3

   (ii) (n-1) $d^2\ ns^2$ for n = 4

8. Consider the element N, P, O and S and arrange them is order of : (3)
   (i) increasing 1st I.E.
   (ii) increasing negative electron gain enthalpy
   (iii) increasing non-metallic character

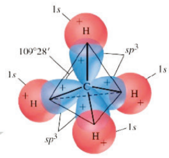
9. The first (IE_1) and second (IE_2) ionisation enthalpies ($kJmol^{-1}$) of three elements I, II and III are given below :

Element	IE_1	IE_2
I	403	2640
II	549	1060
III	1142	2080

   Identify the element which is likely to be
   (i) non-metal
   (ii) an alkali metal
   (ii) an alkaline earth metal (3)

10. (a) Lithium shows diagonal relationship with which element and why?
    (b) Among the elements of second period Li to Ne, pick out element:
        (i) with the highest 1st I.E.
        (ii) with the highest electronegativity
        (iii) with largest atomic radius
        (iv) most reactive non-metal (5)

*****



Chapter - 4

Chemical Bonding and Molecular Structure

FAST TRACK : QUICK REVISION

- **Kossel-Lewis Concept:** Atoms take part in chemical combination to complete octet in their valence shell. This is known as octet rule.
- **Limitation of Octet Rule:** The octet rule, though useful but have some exceptions e.g. BF_3, NO_2, PCl_5, SF_6 etc.
- **Lewis Symbol or Electron Dot Structure:** Representing valence electrons by dots placed around the letter symbol of the element.

Types of Chemical Bonds:

(i) **Covalent Bond:**

(a) Formed by sharing of electrons.

(b) It may be polar and nonpolar.

(c) It is directional in nature.

(ii) **Ionic Bond:**

(a) Formed by transfer of electrons.

(b) Formation of ionic bond is favored by high lattice enthalpy, Low ionization enthalpy of metal atom and more negative electron gain enthalpy of nonmetal atom.

(c) It is non directional in nature.

- **Formal Charge (F.C.):**

(i) It is charge appeared on individual atom in covalent molecule.

(ii) F.C. = (Total No. of valence electrons in free atom) – (Total No. of unshared electrons) – ½ (Total No. of shared electrons)

Greater the F.C on atoms lesser the stability of that Lewis structure.

- **Lattice Enthalpy:** Energy released when one mole of a crystalline solid is formed constituent gaseous ions.

Bond length:

(i) It is equilibrium distance between the nuclei of two bonded atoms in a molecule.

(ii) Greater the size of bonded atoms shorter the bond length.
e.g., $H-F < H-Cl < H-Br < H-I$

(iii) Greater the s character shorter the bond length.
e.g., $C_{sp^3}-H > C_{sp^2}-H > C_{sp}-H >$

(iv) Bond length decreases with increase in bond order.
e.g., $C-C > C=C > C\equiv C$

- **Bond angle:**

(i) It is angle between the orbitals containing bonding electron pairs around central atom in a molecule or complex ion.

(ii) Greater the electronegativity of central atom larger the bond angle
e.g., $NH_3 > PH_3$

(iii) Greater the number of lone pair around central atom smaller the bond angle. **e.g.,** $CH_4 > NH_3 > H_2O$

- **Bond Enthalpy:**

(i) It is defined as amount of energy required to break one mole of bonds of a particular type between two atoms in gaseous state.

(ii) For diatomic molecules, Bond enthalpy = Bond dissociation enthalpy

(iii) For polyatomic molecules, Bond enthalpy = Average of all possible bond dissociation enthalpies.

(iv) Bond enthalpy α Bond order α 1/(Bond length)

- **Resonance:**

(i) According to the concept of resonance, whenever a single Lewis structure cannot describe a molecule accurately, a number of structures with similar energy, position of nuclei, bonding and non-bonding pairs of electrons are taken as canonical structures of the resonance hybrid which describes the molecule accurately.

(ii) Resonance averages the bond characteristics as a whole.

- **Partial ionic character of covalent bond A–B:**

$= 16(X_A - X_B) + 3.5(X_A - X_B)^2$,

where X_A and X_B are electro-negativities of A & B.

- **Partial covalent character in ionic bond (Fajan's rule):**
  (i) Fajan's rule is used to predict partial covalent character in ionic bond.
  (ii) Gretaer the polarizing power of cation and polarisability of anion greater the covalent character in ionic bond.
  (iii) Polarising power of cation α Charge density [(Charge)/Radius)].
  (iv) Polarisability of anion α size of anion.

- **Dipole moment:**
  (i) Dipole moment (μ) = charge (Q) × distance of separation (d)
  (ii) Unit: Debye (D), $1D = 3.33564 \times 10^{-30}$ Cm
  (iii) Being vector quantity, dipole moment of polyatomic molecule is taken as the resultant of all the bond moments.
  (iv) If $\mu = 0$, molecule is non polar or symmetric.
  (v) If $\mu \neq 0$, molecule is polar or asymmetric.

- **Hydrogen bond:**
  (i) It is dipole-dipole interaction between molecules in which 'H' atom is inserted between two highly electronegative elements i. e. F, O or N only.
  (ii) Hydrogen bond may be intra-molecular (when present within single molecule) and intermolecular (when present b/w two same or different molecules).
  (iii) Hydrogen bonds are stronger intermolecular forces than van der Waal forces.

- **Sigma (σ) and pi (π) bonds:**
  (i) Sigma bond is formed by axial overlapping and pi bond is formed by sideways overlapping of atomic orbitals.
  (ii) Sigma bond is stronger than pi bond due to greater extent of overlapping.
  (iii) Single covalent bond = 1 σ bond
  Double covalent bond = 1 σ bond + 1 π bond
  Triple covalent bond = 1 σ bond + 2 π bond

- **VSEPR Theory:** (VSEPR = Valence Shell Electron Pair Repulsion): The shape of a molecule depends upon the number of valence shell electron pairs (lp and bp) around the central atom and magnitude of repulsive forces between them
  i.e., lp–lp > lp–bp > bp–bp

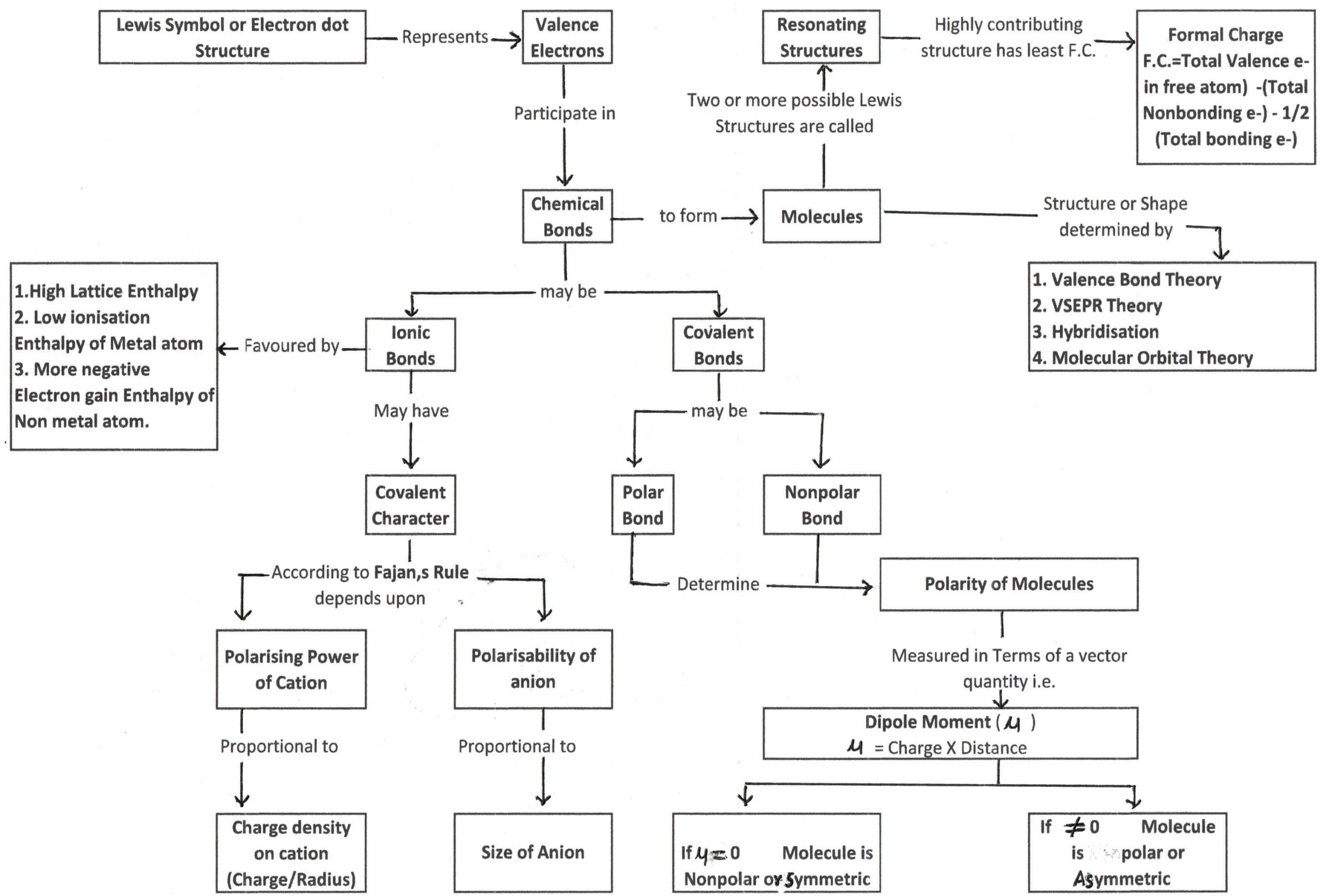
- **Hybridisation:**
  (i) It is the phenomena of mixing of atomic orbitals of nearly same energy to form the new orbitals of equal energy and identical shape.
  (ii) The new orbitals are called hybrid orbitals and determine the shape of molecules.
- **Molecular Orbital Theory (MOT):**
  (i) The overlap of atomic orbitals of same symmetry to form bonding and antibonding molecular orbitals by addition and substraction of their wave functions is known as MO theory.
  (ii) The electrons are filled in molecular orbitals in order of their increasing energy.
  i.e., $\sigma 1s, \sigma^*1s, \sigma 2s, \sigma^*2s, \pi 2p_x = \pi 2p_y, \sigma 2p_z, \pi^*2p_x = \pi^*2p_y, \sigma^*2p_z$ (upto 14 electrons)

  $\sigma 1s, \sigma^*1s, \sigma 2s, \sigma^*2s, \sigma 2p_z, \pi 2p_x = \pi 2p_y, \pi^*2p_x = \pi^*2p_y, \sigma^*2p_z$ (For more than 14 electrons)

  (iii) Bond order = $1/2\ (N_b - N_a)$
  N_a = No of electrons in anti-bonding molecular orbitals
  N_b = No of electrons in bonding molecular orbitals

Total electron pairs	Bond pairs	Lone pairs	Type of hybridization	Geometry due to repulsion	Bond angle	Example
2	2	0	sp	Linear	180°	$BeCl_2$
3	3	0	sp^2	Non-polar Planar	120°	BF_3
3	2	1	sp^2	Angular	<120°	SO_2
4	4	0	sp^3 or dsp^2	Tetrahedral	109°28′	CH_4
4	3	1	sp^3 or dsp^2	Pyramidal	<109°28′	NH_3
4	2	2	sp^3 or sp^2	Bent	<109°28′	H_2O
5	5	0	sp^3d	Trigonal bipyramidal	120° & 90°	PCl_5
5	4	1	sp^3d	See Saw	<120 ° & <90°	SF_4
5	3	2	sp^3d	Bent T-shaped	<90°	ClF_3
5	2	3	sp^3d	Linear	180°	I_3^-
6	6	0	sp^3d^2	Octahedral	90°	SF_6
6	5	1	sp^3d^2	Square pyramidal	<90°	BrF_5
6	4	2	sp^3d^2	Square planar	90°	XeF_4
7	7	0	sp^3d^3	Pentagonal bipyramidal	90° & 72°	IF_7
7	6	1	sp^3d^3	Pentagonal pyramidal	<90° & <72°	
7	5	2	sp^3d^3	Pentagonal planar	72°	XeF_5^-

MIND MAP
CHEMICAL BONDING AND MOLECULAR STRUCTURE



CASE BASED STUDY-QUESTION

PASSAGE -1

Pauling introduced the concept of hybridisation. According to him the atomic orbitals combine to forms new set of equivalent orbitals known as hybrid orbitals. Unlike pure orbitals, the hybrid orbitals are used in bond formation .The phenomenon is known as hybridisation which can be defined as the process of intermixing of the orbitals of slightly different energies so as to redistribute their energies, resulting in the formation of new set of orbitals of equivalent energies and shape.

Source: NCERT

The following questions are multiple choice questions. Choose the most appropriate answer:

I. In SF_6 molecules , which sets of d-orbitals is involved ?

(A) dx^2-y^2, dz^2 (B) dz^2, dxy

(C) dxy, dyz (D) dx^2-y^2, dxy

II. In IF_7 molecule, which orbitals are involved

(A) dx^2-y^2, dz^2, dxy (B) dxy, dyz, dzx

(C) dx^2-y^2, dxy, dxz (D) dz^2, dyz, dzx

III. In PCl_5 molecule, d-orbitals involved is

(A) dxy (B) dyz

(C) dx^2-y^2 (D) dz^2

IV. Which of the following orbitals cannot undergoes hybridisation amongst themselves

(A) 3d, 4s (B) 2s, 2p

(C) 4s, 4d (D) 3s, 3p, 4s

ANS. : I-A, II-A, III-D, IV-D

PASSAGE -2

It can be said that covalent compound has partial ionic character due to the electronegativity difference of the two elements in a covalent bond .Dipole moment parameter is used to find the % of ionic character in the covalent compound. We can also said that ionic compounds do have some covalent character which can be explained qualitatively on the basis of the Fajan's Rule. According to Fajan rule a cation which has smaller size, high ionic charge must have large polarising power and the anion which has large size and high ionic charge must have large polarisibility. Both these factors help to develop covalent character in the molecule.

In these questions (Q. No V-VIII , a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement

V. ASSERTION:CO_2 molecule has zero dipole moment despite polar bond.

REASON: CO_2 molecule is linear in nature.

VI. ASSERTION: The dipole moment of Dichlorobenzene molecule can be zero.

REASON:The Dichlorobenzene must be 1, 4 Dichlorobenzene.

VII. ASSERTION: LiF has less covalent character than LiI

REASON: Halogen molecule are short of one electron to complete the octet.

VIII. ASSERTION: LiCl is more covalent than KCl

REASON: The polarising power of K is more than Li

ANS: V-A ,VI-A, VII-B, VIII-C

MULTIPLE CHOICE QUESTIONS (MCQ)

1. Which of the following molecules has both covalent and ionic bond

   (a) CH_3Cl (b) NH_4Cl (c) HCl (d) $BeCl_2$

2. What is the maximum number of water molecules that can attach with one water molecule through intermolecular hydrogen bonds?

   (a) 2 (b) 3 (c) 4 (d) 1

3. Which of the following molecules has maximum bond angle

   (a) NH_3 (b) CH_4 (c) H_2O (d) CO_2

4. Identify correct statement regarding NH_3 and BF_3

   (a) Both are Lewis acid

   (b) Both are iso structural

   (c) Both are Lewis base

   (d) Have different values of dipole moment

5. Identify the molecule having sideways overlapping of atomic orbitals

   (a) CH_4 (b) CO_2 (c) NH_3 (d) H_2O

6. Which of the following chemical species is most stable?

   (a) O_2 (b) O_2^+ (c) O_2^- (d) O_2^{2-}

7. Which of the following d orbitals involved in sp^3d hybridization?

   (a) d_{xy} (b) d_{xz} (c) $d_{x^2-y^2}$ (d) d_{z^2}

8. Which of the following molecule has net dipole moment?

   (a) CO_2 (b) H_2O (c) BF_3 (d) CH_4

9. Which of the following compound has highest covalent character

   (a) LiCl (b) LiBr (c) LiF (d) LiI

10. The shape of XeF_4 molecule according to VSEPR theory is

    (a) Square planar (b) Square pyramid

    (c) Tetrahedral (d) Pyramidal

Ans. 1.(b) 2.(c) 3.(d) 4.(d) 5.(b) 6.(b) 7.(d) 8.(b) 9.(d) 10.(a)

FILL IN THE BLANKS

(i) The energy required to completely separate one mole of solid ionic compound into gaseous constituent ions is called……………………..

(ii) Among alkali metal ions ………..ion has highest polarizing power.

(iii) According to molecular orbital theory molecules are said to be stable if the number of electrons in bonding molecular orbitals is …………… the number of electrons in antibonding molecular orbitals.

(iv) Isoelectronic molecules and ions have identical…………………..

(v) In PCl_5 molecule the two equivalent axial P – Cl bonds are..............than three equivalent equatorial P – Cl bonds.

(vi) The state of hybridization of sulphur in SF_6 is……………………..

(vii) The maximum number of Hydrogen bonds formed by a single H_2O molecule is ....

(viii) A triple covalent bond consists of……sigma and…….pi bonds.

(ix) ………..bond is directional in nature.

(x) Atomic orbitals are……….centric and molecular orbitals are……….. centric.

Ans. (i) Lattice enthalpy (ii) Li^+ (iii) more (iv) bond order (v) longer (vi) sp^3d^2 (vii) 4 (viii) 1, 2 (ix) covalent (x) mono, poly

TRUE AND FALSE TYPE QUESTIONS

Write true or false for following statements:

(i) Energy of resonance hybrid is less as compared to the contributing canonical structures.

(ii) BeF_2 has more dipole moment than $BeCl_2$.

(iii) In water two O–H bond dissociation enthalpies are not identical.

(ix) Only the half filled orbitals of nearly same energy can participate in hybridization.

(v) No bond is purely ionic or purely covalent.

(vi) Chemical species having identical bond order have same bond dissociation enthalpies.

(vii) BF_3 is stronger Lewis acid than BCl_3.

(viii) Among alkali metal halides LiI has highest covalent character.

(ix) Resonating structures of a chemical species have no real existence.

(x) XeF_2 and ICl_2^- are iso structural.

Ans. (i) True (ii) False (iii) True (iv) False (v) True
(vi) False (vii) False (viii) True (ix) True (x) True

MATCH THE COLUMNS

I. Match the species in Column I with the geometry/shape in Column II and Hybridisation in Column III

S.N.	Column I	Column II	Column III
1.	BF_3	(a) Tetrahedral	(p) sp^3d^2
2.	ClF_3	(b) Trigonal Planer	(q) sp^3
3	NH_4^+	(c) Octahedral	(r) sp^3d
4.	SF_6	(d) Bent T-Shape	(s) sp^2

II. Match the species in Column I with the hybridsation in Column II and geometry/shape in Column III

S.N.	Column I	Column II	Column III
1.	BBr_3	(a) sp^3	(p) Square Planer
2.	H_2O	(b) sp^3d	(q) Trigonal Planer
3	PCl_5	(c) sp^2	(r) V-shape
4.	XeF_4	(d) sp^3d^2	(s) Trigonal Bipyramidal

ANS : MATCH-I

1. b, s 2. d, r 3. a, q 4. c, p

MATCH-II

1. c, q 2. a, r 3. b, s 4. d, p

ASSERTION AND REASON TYPE QUESTIONS

In the following questions a statement of assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below for each question:

(i) A and R both are correct, and R is correct explanation of A.

(ii) A and R both are correct, but R is not the correct explanation of A.

(iii) A is true but R is false.

(iv) A and R both are false.

1. Assertion (A): Among the two O–H bonds in H_2O molecule, the energy required to break the first O–H bond and the other O–H bond is the same.

   Reason (R): This is because the electronic environment around the oxygen is same after breakage of one O–H bond.

2. Assertion (A): Though the central atom of both NH_3 and H_2O molecules are sp^3 hybridised, yet H–N–H bond angle is greater than that of H–O–H.

   Reason (R): This is because nitrogen atom has one lone pair and oxygen atom has two lone pairs.

3. Assertion (A): SF_6 molecule is unstable.

   Reason (R): A stable molecule must have 8 electrons around the central atom. i.e. octet rule should be satisfied.

4. Assertion (A): Pi bond is never formed alone. It is formed along with a sigma bond

   Reason (R): Pi bond is formed by sideway overlap of p- orbitals only.

5. Assertion (A): Ionic compounds tend to be non-volatile.

   Reason (R): Ionic compounds are solid.

6. ASSERTION : Bonding molecular orbital are more stable than Antibonding Molecular orbital

   REASON : Electrons placed in Bonding molecular orbitals tend to hold the nuclei more together as compared to electrons placed in Antibonding molecular orbitals.

7. ASSERTION : Ortho-Nitrophenol has higher boiling point than Para-Nitrophenol

   REASON : Intramolecular Hydrogen bonding occur in Ortho-Nitrophenol as compare to intermolecular hydrogen bonding in Para-Nitro Phenol.

8. ASSERTION :When p_x orbital combine with p_y orbital than a sigma bond is produced.

   REASON : Atomic orbitals of similar symmetry can results positive and negative overlap.

9. ASSERTION : BF_3 molecule has zero dipole moment.

   REASON : BF_3 molecule shape is trigonal planer and symmetrical.

10. ASSERTION : O-O bond length in O3 molecule is identical.

    REASON : Ozone molecule is angular in shape

Ans. 1. (iv) 2. (i) 3. (iv) 4. (iv) 5. (ii) 6.(i) 7. (iv) 8. (iv) 9. (i) 10. (iv)

ONE WORD ANSWER TYPE QUESTIONS

1. Write the formal charge on central oxygen atom in O_3 molecule?
2. Write the shape of AB_2E_3 type molecule.
3. Name the property used to measure the degree of polarity.
4. Name the covalent bond formed by axial overlapping of atomic orbitals.
5. Out of p_x, p_y, p_z orbitals which p orbital takes part in sp hybridization?
6. Name the molecular orbital having energy greater than that of combining atomic orbitals.
7. Name the intermolecular forces responsible for liquid state of water.
8. Name the phenomenon used to describe a molecule whose single Lewis structure cannot describe it.
9. Name the geometry involved in sp^3d hybridization.
10. Name the molecular theory that can explain magnetic character of molecules.

Ans. 1. +1, 2. Linear, 3. Dipole moment, 4. Sigma bond, 5. p_z
6. Antibonding molecular orbital, 7. Hydrogen bond, 8. Resonance,
9. Trigonal bipyramid, 10. Molecular orbital theory

1-MARK QUESTIONS

1. Why noble gases exist in mono atomic form?
2. Write the Lewis structure of NO_2^-.
3. Why NH_3 and BF_3 have different shapes?
4. How many sigma and pi bonds are present in HCN molecule?
5. Why sigma bond is stronger than pi bond?
6. Explain why BeH_2 molecule has zero dipole moment although the Be–H bonds are polar?
7. Which has highest bond angle? NO_2, NO_2^-, NO_2^+
8. What is magnetic character of anion of KO_2?
9. Why do atoms combine?
10. What is the significance of Lewis Symbols?
11. Why density of water is maximum at 277K?
12. Give structure of BrF_5 according to VSEPR theory.
13. Why NH_3 is liquid and PH_3 is a gas?
14. Why KHF_2 exist but $KHCl_2$ and $KHBr_2$ does not?

    [**Ans.** HF…HF hydrogen bonding].
15. Boiling point of p-nitrophenol is more than O-nitrophenol why?
16. How paramagnetic character of a compound is related to the no. of unpaired electrons?
17. Define the term bond length.
18. He_2 molecule does not exist. Give reason.
19. Why PCl_5 dissociates to give PCl_3 and Cl_2?
20. Write the state of hybridization of O in H_2O.
21. Predict the shape of ClF_3 according to VSEPR theory.
22. Why ice has less density than water?
23. Why the H–P–H bond angle in PH_3 is less than H–N–H bond angle in NH_3?
24. At room temperature H_2O exist as liquid while H_2S exist as gas. Give reason.
25. NH_3 has higher boiling point than PH_3. Give reason.
26. Identify the chemical species having identical bond order: O_2^{2+}, N_2, O_2, O_2^{2-}.

2-MARKS QUESTIONS

1. What is an Octet rule? What are its limitations?
2. The enthalpy needed to break the two O–H bonds in water are as follows:

   $H_2O\ (g) \rightarrow H\ (g) + O{-}H(g) \qquad \Delta_a H_1^0 = 493\ kJ\ mol^{-1}$

   $O{-}H\ (g) \rightarrow H\ (g) + O(g) \qquad \Delta_a H_1^0 = 424\ kJ\ mol^{-1}$

   What is the average bond enthalpy of H_2O?
3. Write two points of difference between sigma and pi bond.
4. Define Hydrogen bond. Is it weaker or stronger than van der Waal forces?
5. Define dipole moment. Give its significance.
6. Give applications of dipole moment.
7. Which is more polar and why, CO_2 or N_2O?
8. Discuss the partial ionic character of covalent bond by taking an example.
9. Draw the resonating structures of O_3 and calculate formal charges on each O atom.
10. O-Nitrophenol is steam volatile while p-Nitrophenol is not. Give reason.
11. Define bond enthalpy. Why the bond enthalpy of F_2 is less than that of Cl_2?
12. Define resonance. Draw resonating structures of CO_2.
13. Assign reason for the following;
    (i) NH_3 is freely soluble in water while PH_3 is not.
    (ii) B_2 is paramagnetic while C_2 is not.
14. Out of NH_3 and NF_3 which is more polar. Explain with the help of dipole moment.
15. N_2 is diamagnetic while O_2 is paramagnetic. Explain on the basis of Molecular orbital theory.
16. H_2^+ and H_2^- have same bond order. Which is more stable?
17. Differentiate between bonding and anti bonding molecular orbitals.
18. Discuss the conditions for the combination of atomic orbitals to form molecular orbitals.

19. Although Chlorine (EN = 3.2) is more electronegative than Nitrogen (EN = 3.0), yet chlorine does not form hydrogen bond while nitrogen does. Give reason. (Ans: larger atomic size of Cl).

20. ClF_3 is T shaped but BF_3 is planar. Explain.

21. $N(SiH_3)_3$ and $N(CH_3)_3$ are not isostructural. Give reason.

22. Draw molecular orbital diagram for N_2^+ molecule.

23. HCl is a covalent compound but it ionises in the solution?

24. The molecule of CO_2 is linear whereas that of $SnCl_2$ is angular why?

25. Arrange the following in the order of property indicated for each set:

    (i) O_2, O_2^+, O_2^-, O_2^{2-} (increasing stability)

    (ii) LiCl, NaCl, KCl, RbCl (increasing covalent character)

    (iii) NO_2, NO_2^+, NO_2^- (decreasing bond angle)

    (iv) H−F, H−Cl, H−Br, H−I (increasing bond dissociation enthalpy)

26. Arrange the following in the order of property indicated for each set:

    (i) H_2O, NH_3, H_2S, HF (increasing polar character)

    (ii) HF, HCl, HBr, HI (decreasing dipole moment)

    (iii) NO_3^-, NO_2^-, NO (decreasing 's' character of hybridization)

    (iv) $BeCl_2$, BCl_3, CCl_4, PCl_3 (increasing bond angle)

3-MARKS QUESTIONS

1. How is ionic bond formed? On what factors it depends?
2. Calculate the lattice enthalpy of KCl from the following data by Born-Haber's Cycle.
   Enthalpy of sublimation of K = 89 kJ mol^{-1}
   Enthalpy of dissociation of Cl_2 = 244 kJ mol^{-1}
   Ionization enthalpy of potassium = 425 kJ mol^{-1}
   Electron gain enthalpy of chlorine = –355 kJ mol^{-1}
   Enthalpy of formation of KCl = –438 kJ mol-1
3. What is meant by hybridization? Describe the shape of sp, sp^2 and sp^3 hybridised orbitals.

4. Define bond order. Calculate the bond order in N_2 and O_2 molecules.
5. Give molecular orbital energy level diagram of O_2^{2-}. Write its electronic configuration,magnetic behaviour and bond order.
6. Which of the following in each pair has larger bond angle
   (i) CO_2 , BF_3 (ii) H_2O, H_2S (iii) CH_4, C_2H_2
7. What is meant by resonance? Draw the resonating structures of carbonate ion and explain why all the C–O bond lengths are identical in carbonate ion?
8. Compare relative stability of following species and predict their magnetic properties:
   O_2, O_2^+, O_2^- (superoxide), O_2^{2-} (peroxide)
9. Draw the Lewis structure of the species as mentioned BF_3, SF_6, NO_2:
   (i) In which the central atom has incomplete octet.
   (ii) In which the central atom has an expanded octet,
   (iii) An odd electron molecule is formed.
10. Explain the structure of PCl_5 according to hybridization. Why all P–Cl bonds lengths are not equivalent in PCl_5?

5-MARKS QUESTIONS

1. Give reasons for the following:
   (a) NH_3 has higher boiling point than PH_3.
   (b) Ionic compounds do not conduct electricity in solid state.
   (c) LiCl is more covalent than KCl.
   (d) NH_3 is more polar than NF_3.
   (e) H_2O has bent structure.
2. (a) Define the term bond dissociation enthalpy. How is it related to bond order?
   (b) Explain why N_2 has greater bond dissociation enthalpy than N_2^+ while O_2 has lesser bond dissociation enthalpy than O_2^+?
3. Draw the shape of following molecules according to VSEPR theory;
   XeO_3, XeF_2, $XeOF_4$, SF_4, XeF_4

HOTS QUESTIONS

1. The bond angle of H_2O is 104.5° while that of F_2O is 102°. Explain why?

   Solution: The bond pair of electrons are drawn more towards F in F_2O, whereas in H_2O it is drawn towards O. So bp – bp repulsion in H_2O is greater than that in F_2O.

2. Anhydrous $AlCl_3$ is covalent. From the data given below, predict whether it would remain covalent or become ionic in aqueous solution.

   $\Delta_i H\ (AlCl_3) = 5137\ kJ\ mol^{-1}$, $\Delta_{hyd}\ H(Al^{3+}) = -4665\ kJ\ mol^{-1}$,

   $\Delta_{hyd}\ H(Cl^-) = -381\ kJ\ mol^{-1}$.

   Solution: Total energy released = $1\Delta_{hyd}\ H(Al^{3+}) + 3\Delta_{hyd}\ H(Cl^-)$

   $$= [(-4665) + (3 \times -381)]\ kJ\ mol^{-1} = -5808\ kJ\ mol^{-1}$$

   Total energy required = $\Delta_i\ H(AlCl_3) = 5137\ kJ\ mol^{-1}$

   Since energy released is greater than the energy required, the compound will ionize in aqueous solution.

3. The dipole moment of HCl is 1.03 D, and the bond length is 127 pm. Calculate the percent ionic character of HCl molecule.

   Solution: $\mu_{cal} = Q \times r = (1.6\times10^{-19}C) \times (127\times10^{-12}m) = 2.032\times10^{-29}C\ m$

   $$= (2.032 \times 10^{-29}C\ m) \times \frac{1D}{3.336\times10^{-30}Cm} = 6.09\ D$$

   $$\%\ \text{ionic character} = \frac{\mu_{obs.}}{\mu_{cal}} \times 100 = \frac{1.03D}{6.09D} \times 100 = 16.9\%$$

UNIT TEST-I

Time Allowed: 1 Hr. **Maximum Marks : 20**

General Instructions:

(i) All questions are compulsory.
(ii) Maximum marks carried by each question are indicated against it.

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1. Identify the molecule having sideways overlapping of atomic orbitals [1]
   (a) CH_4 (b) CO_2 (c) NH_3 (d) H_2O
2. The shape of XeF_4 molecule according to VSEPR theory is [1]
   (a) Square planar (b) Square pyramid
   (c) Tetrahedral (d) Pyramidal
3. Write the Lewis structure of NO_2^-. [1]
4. Which has highest bond angle? NO_2, NO_2^-, NO_2^+ [1]
5. Draw the resonating structures of CO_2. [1]
6. The enthalpy needed to break the two O–H bonds in water are as follows:
   $$H_2O(g) \longrightarrow H(g) + O{-}H(g) \qquad \Delta_aH_1^0 = 493 \text{ kJ mol}^{-1}$$
   $$O{-}H\,(g) \longrightarrow H(g) + O(g) \qquad \Delta_aH_2^0 = 424 \text{ kJ mol}^{-1}$$
   What is the average bond enthalpy of H_2O? [2]
7. Out of NH_3 and NF_3 which is more polar. Explain with the help of dipole moment. [2]
8. Compare relative stability of following species and predict their magnetic properties: O_2, O_2^+, O_2^- (superoxide), O_2^{2-} (peroxide) [3]
9. Explain the structure of PCl_5 according to hybridization. Why all P–Cl bonds lengths are not equivalent in PCl_5? [3]
10. (i) N_2 is diamagnetic while O_2 is paramagnetic. Explain on the basis of Molecular orbital theory. [2]

    (ii) Give reasons for the following: [3]
    (a) NH_3 has higher boiling point than PH_3.
    (b) Ionic compounds do not conduct electricity in solid state.
    (c) LiCl is more covalent than KCl.

UNIT TEST-II

Time Allowed: 1 HR. **Maximum Marks : 20**

General Instructions:

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

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1. Identify the molecule in which carbon has 'sp' hybridisation. [1]

   (a) CO_2 (b) CH_4 (c) C_2H_4 (d) C_2H_2

2. The shape of the molecule SF_4 is [1]

   (a) Bent (b) See-saw

   (c) Tetrahedral (d) Square Planer

3. Write the Lewis structure of CO_3^{2-} [1]

In following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices:

(a) Assertion and Reason both are correct statements and Reason is correct explanation for assertion.

(b) Assertion and Reason both are correct statement but Reason is not correct explanation for assertion.

(c) Assertion is correct statement but Reason is wrong statement.

(d) Assertion is wrong statement but Reason is correct statement.

4. **Assertion :** Pie (π) bond are directional in nature. [1]

   Reason : Sigma bond are formed by axial approach of atomic orbitals.

5. **Assertion :** Boiling point of water is higher than H_2S. [1]

   Reason : Hydrogen bonding is feasible in Water but in H_2S there is no Hydrogen bonding.

6. Why dipole moment of BF_3 is zero but for PCl_3 it is non zero? [2]

7. Which one LiF or LiI is more ionic and why? [2]

8. Explain with the help of labeled diagram the Valence Bond Theory for formation of H_2 molecule. [3]

9. Explain the Octet rule with relevant example. Write two limitation of Octet rule also. [3]

10. Define Hybridisation. Write the salient features of hybridisation. Explain the hybridisation in SF_6 molecule with relevant diagram. [5]

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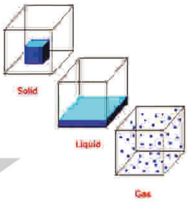


Chapter - 5

States of Matter : Gases, Liquids and Solids

FAST TRACK : QUICK REVISION

- **Magnitude of Intermolecular Forces**: Hydrogen bonds > van der Waal forces (dipole-dipole > dipole-induced dipole > Dispersion forces)
- **Gas Laws:**
  (i) **Boyle's Law:** $V \propto 1/P$ or $PV = \text{constant}$
  or $P_1V_1 = P_2V_2$ (at constant n, T)
  (ii) **Charles' Law:** $V \propto T$ or $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ (at constant n, P)
  (iii) **Avogadro's Law:** $V \propto n$ (at constant T, P)
  (iv) **Gay Lussac's Law:** $P \propto T$ (at constant n, V)
- **Combined Gas Law:** $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$
- **Ideal Gas Equation**: $PV = nRT$
- **Values of gas constant R:**
  (i) 0.0821 L atm K^{-1} mol^{-1}
  (ii) 0.083 L bar K^{-1} mol^{-1}
  (iii) 8.314 J K^{-1} mol^{-1}
  (iv) 1.99 Cal K^{-1} mol^{-1}
- **Density of gas (d)**: $d = PM/RT$ (M = molar mass of gas)
- **Absolute zero or lowest possible temperature:** –273°C or zero Kelvin, because at this temperature volume of gas becomes zero.

- **Dalton's Law of partial pressure**: $P_{total} = p_1 + p_2 + p_3 + \ldots$ (at constant T&V) for non reacting gases.
- **Ideal Gas**: A gas which obeys ideal gas equation at all temperature and pressure.
- **Boyle's temperature**: Temperature at which a real gas behaves like an ideal gas over an appreciable range of pressure.
- **Compressibility factor (Z):** $Z = PV/nRT$
  - (i) For ideal gas Z =1
  - (ii) For non ideal gas $Z \neq 1$
    - (a) ***Positive deviation (Z > 1) :*** shows dominance of repulsive forces and hence less compressibility e.g. H_2, He etc.
    - (b) ***Negative deviation (Z < 1) :*** shows dominance of attractive forces and hence more compressibility e.g. CH_4, CO_2 etc.
- **Conditions under which real gases deviates from ideal behavior**: Low T and high P.
- **Cause of deviation from ideal behavior**: At low T and high P gas molecules are close enough and hence volume occupied by the gas molecules and attractive forces between them cannot be negligible.
- **Conditions under which real gases behaves ideally**: High T and low P.
- **Van der Waals' gas equation:** $\left(P + \frac{an^2}{v^2}\right)(v - nb) = nRT$
- **Van der Waals' constant 'a':**
  - (i) It represents magnitude of attractive forces between gas molecules.
  - (ii) Ease of liquefaction of gas α T_c = critical temperature
    and Ease of liquefaction of gas αa
  - (iii) Unit of 'a' is L^2 atm mol^{-2}
- **Van der Waals' constant** 'b':
  - (i) It represents co-volume or excluded volume i.e. effective volume of gas molecules.
  - (ii) It is four times of actual volume of 1 mol, $b = 4N_A v$ gas
  - (iii) Unit of 'b' is L^2 mol^{-1}

- **Critical temperature**: It is the temperature above which a gas can not be liquefied however large the pressure may be.
- **Total Kinetic Energy of Gas** = $\frac{3}{2}$ nRT
- **Average Kinetic Energy of Gas** = $\frac{3}{2}$ RT mol^{-1} or $\frac{3}{2}$ kT molecule^{-1}

  (k = Boltzmann constant = R/N_A)
- **Different types of Molecular speeds:**

  (i) Most probable speed: Ump= $\sqrt{(2RT/M)}$

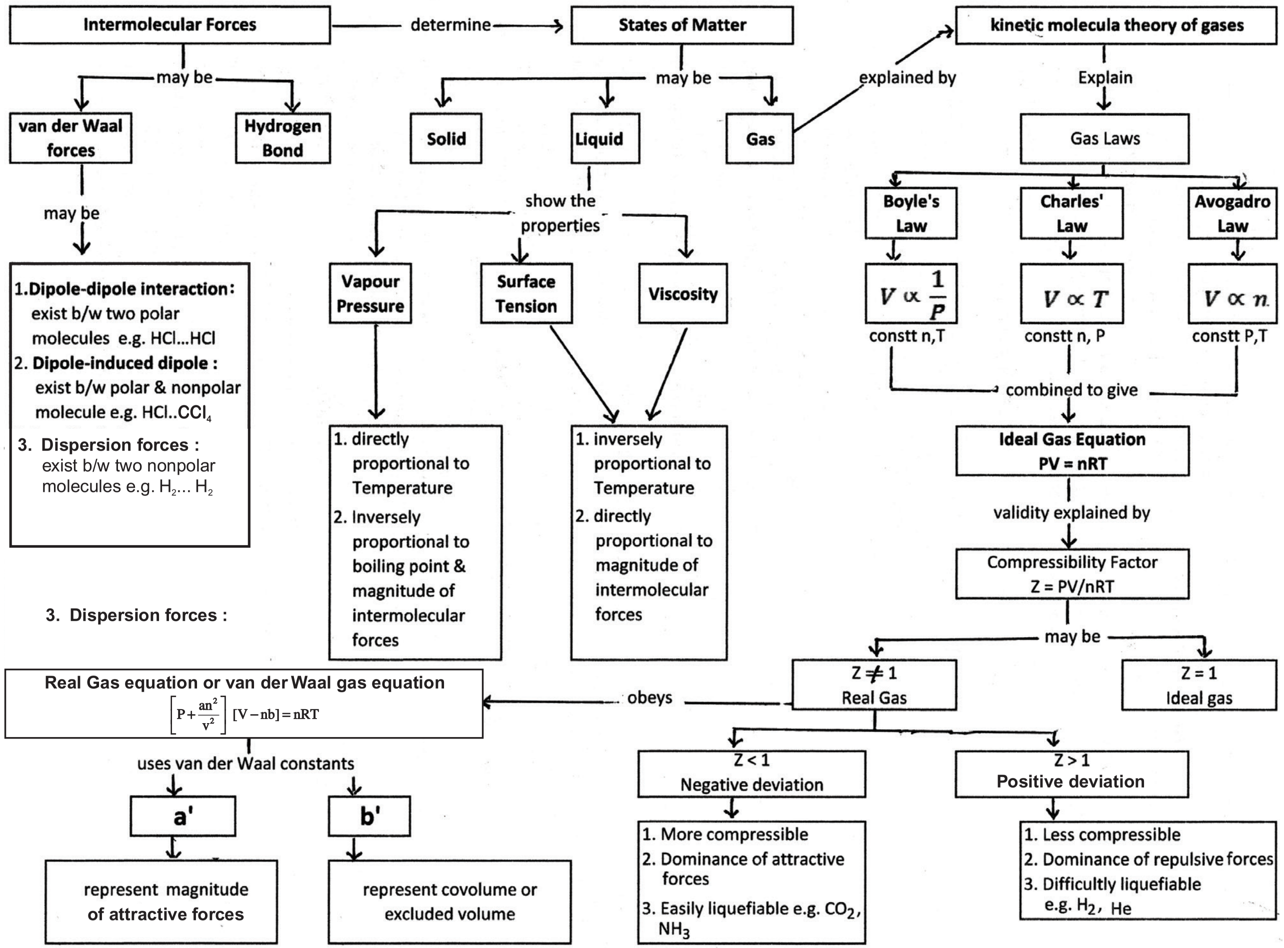
  (ii) Average speed: Uav = $\sqrt{(8RT/\pi M)}$

  (iii) Root mean square speed: Urms = $\sqrt{(3RT/M)}$ or $\sqrt{(3PV/M)}$
- (i) Vapour pressure α T

  (ii) Vapour pressure α $\frac{1}{\text{Magnitude of intermolecular forces}}$

  (iii) Vapour pressure α $\frac{1}{\text{Boiling point}}$
- **Surface tension**: It is tangential force acting along the surface of a liquid perpendicularly on one centimeter length of it.
- **Viscosity**: It is internal resistance to the flow possessed by a liquid.
- Increase in temperature decreases surface tension and viscosity of liquid.

MIND MAP : STATES OF MATTER



CASE BASED STUDY - QUESTIONS

PASSAGE -1

Consider a gas 'X' behaves as ideal under certain temperature and pressure. Based on the Kinetic theory of gas the ideal gas will follows PV=nRT. However due to two false assumption namely , there is no intermolecular forces among gases particles and gas particles do not occupies appreciable volume, the behaviour of gas 'X' is not ideal under certain conditions .When the correction factor for pressure and volume is applied on gas 'X' then ideal gas equation is modified into Vanderwaal's equation which is as follows

$[P + (an^2/V^2)]\ [V - nb] = n.R.T$

Where a = measure of intermolecular forces

n.b = Volume occupied by n moles of gas

The following questions are multiple choice questions. Choose the most appropriate answer:

I. For the gas 'X' at relatively high pressure, the Vander Waal's equation reduces to

(A) $PV = RT - a/V$ (B) $PV = a.R.T/V^2$

(C) $P = RT - a/V^2$ (D) $PV = RT + Pb$

II. For large volume and non-zero value of force of attraction between gas molecules, gas 'X' equation is

(A) $PV = n.R.T - (a.n^2)/V$ (B) $PV = n.R.T + n.b.P$

(C) $P = [n.R.T] / [V-b]$ (D) $PV = n.R.T$

III. The Vander Waal's constant for 'X' gas is greater than that of gas 'Y'. It mean that the

(A) Strength of Vander Waal's force for gas 'X' is less than that of gas 'Y'

(B) Strength of Vander Waal's force for gas 'X' is equal than that of gas 'Y'

(C) 'X' gas can be more easily liquefied than gas 'Y'

(D) 'Y' gas can be more easily liquefied than gas 'X'

IV. The unit of constant 'b' is

(A) Litre (B) atm

(C) Litre mol^{-1} (D) mol.L

Ans : I-D, II-A, III-C, IV-C

PASSAGE -2

According to Grahm's Law of Diffusion the rate of diffusion of gas is given by the expression as shown below :

Rate of Diffusion α $1/[M]^{1/2}$

Where M is molar mass of the gas. Lighter gas is easy to diffuse more than heavier gas. It is also observed the gas diffusion rate is also directly proportional to the Partial pressure of the gas.

According to Dalton law of partial pressure the total pressure of the system containing X,Y,Z ...gas is the sum of individual partial pressure.

In these questions (Q. No V-VIII , a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement

V. ASSERTION : Rate of Diffusion of He is more than that of Nitrogen gas.

REASON: He is lighter than Nitrogen gas.

VI. ASSERTION : In a mixture of H_2, D_2, T_2, all the three isotopes will come out with equal rate.

REASON : Tritium is radioactive element

VII. ASSERTION : For a mixture of NH_3 and HCl the Dalton Law of partial pressure is applicable.

REASON : When Ammonia reacts with HCl , NH_4Cl will produced.

VIII. ASSERTION : For Xe and N_2 at room temperature , Dalton Law of Partial pressure is applicable.

REASON : Xe and N_2 will react at room temperature.

ANS : V-A, VI-D, VII-D, VIII-C

MULTIPLE CHOICE QUESTIONS (MCQ)

1. Which of the following property explains the spherical shape of rain droplets:
   (a) Viscosity (b) Critical phenomena
   (c) Surface tension (d) Pressure
2. A gas would be most likely to obey the ideal gas law at
   (a) Low T and high P (b) High T and high P
   (c) Low T and low P (d) High T and low P
3. If P is the pressure and d is the density of gas, then P and d are related as:
   (a) $P \alpha 1/d$ (b) $P \alpha d$ (c) $P \alpha d^2$ (d) $P \alpha 1/d^2$
4. A gas can be liquefied
   (a) above its critical temperature (b) at its critical temperature
   (c) below its critical temperature (d) at any temperature
5. Which of the following gas is expected to have highest value of Van der Waal's constant 'a'
   (a) NH_3 (b) H_2 (c) N_2 (d) He
6. The compressibility factor (Z) for an ideal gas is:
   (a) 1.5 (b) 1.0 (c) 2.0 (d) zero
7. Two separate bulbs contain ideal gas A and B. The density of A is twice that of B.The molecular mass of A is half that of B. If the two gases are at the same temperature, the ratio of pressure of A to that of B is:
   (a) 2 (b) 1/2 (c) 4 (d) 1/4
8. At which temperature the volume of a gas is expected to be zero.
   (a) 0 °C (b) 273 K (c) –273°C (d) 273°C
9. Dominance of strong attractive forces among the molecules of the gas:
   (a) Depends on Z and indicates that $Z=1$
   (b) Depends on Z and indicates that $Z >1$
   (c) Depends on Z and indicates that $Z < 1$
   (d) Is independent of Z
10. Which of the following properties of liquid increases on increasing temperature:
    (a) Vapour pressure (b) Viscosity
    (c) Surface tension (d) Boiling Point

Ans. 1.(c), 2.(d), 3.(b), 4.(c), 5.(a), 6.(b), 7.(c), 8.(c), 9.(c), 10.(a)

FILL IN THE BLANKS

1. Pressure vs volume graph at constant temperature is known as…………
2. Surface tension of a liquid ……………with increase in magnitude of intermolecular forces.
3. …………. is the temperature at which a real gas behave like an ideal gas over appreciable range of pressure.
4. $Z > 1$ indicates that the gas is ………….. compressible than expected from ideal gas behavior.
5. The average kinetic energy of gas molecules is directly proportional to the……….
6. Internal resistance in flow of liquids is called…………………
7. ……………… is the temperature above which a gas cannot be liquefied however large the pressure may be.
8. Poise (P) is the unit of ……………..
9. The vapour pressure of any liquid is ……………. proportional to the magnitude of the intermolecular forces and is ………….. proportional to the temperature employed.
10. Van der Waal constant………… represent co-volume and ……….. represent magnitude of attractive forces.

Ans. 1. Isotherm 2. increases 3. Boyle's temperature 4. less
5. Kelvin temperature 6. viscosity 7. critical temperature
8. viscosity 9. inversely, directly 10. 'b', 'a'

TRUE AND FALSE TYPE QUESTIONS

Write true or false for following statements:

1. At a given temperature and pressure the density of N_2 is more than that of O_2.
2. Liquid at higher altitudes boil at a lower temperature.
3. Gases having $Z < 1$ cannot be liquefied easily.

4. According to the kinetic molecular theory, the collision between gas molecules is perfectly elastic.
5. Real gases deviate from ideal behavior at low temperature and high pressure.
6. A gas can be liquified above its critical temperature by applying high pressure.
7. Mosquito cannot walk on kerosene oil because its surface tension is less than that of water.
8. No gas is ideal gas, all gases are real gases.
9. Surface tension increases on increasing temperature.
10. 0°C is known as absolute zero temperature.

Ans. 1. False 2. True 3. False 4. True 5. True
6. False 7. True 8. True 9. False 10. False

MATCH THE COLUMNS

I. Match the Law in Column I with the relation in Column II and Variables in Column III

S.N.	Column I	Column II	Column III
1.	Boyles Law	(a) $V \alpha n$	(p) Constant T, P
2.	Charles Law	(b) $P=P_1+P_2$...	(q) Constant P, n
3.	Dalton Law	(c) $V \alpha T$	(r) Constant n, T
4.	Avogadro Law	(d) $P \alpha [1/V]$	(s) Only Non reacting gases

II. Match the parameter in Column I with the concern properties in Column II and unit in Column III

S.N.	Column I	Column II	Column III
1.	T_c	(a) Boiling Point	(p) atm
2.	Vapour Pressure	(b) Spherical shape H_2O	(q) Poise
3.	Viscosity	(c) Liquefaction of Gases	(r) N/m
4.	Surface Tension	(d) Flow of Liquids	(s) Kelvin

ANS. :

MATCH-I

1. d, r 2. c, q 3. b, s 4. a, p

MATCH-II

1. c, s 2. a, p 3. d, q 4. b, r

ASSERTION AND REASON TYPE QUESTIONS

In the following questions a statement of assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below for each question.

(i) A and R both are correct, and R is correct explanation of A.

(ii) A and R both are correct, but R is not the correct explanation of A.

(iii) A is true but R is false.

(iv) A is false but R is true.

1. Assertion (A): Gases do not liquefy above their critical temperature even on applying high pressure.

   Reason (R): Above critical temperature, the molecular speed is high and intermolecular attractions can not hold the molecules together because of high speed.

2. Assertion (A): At constant temperature, pV vs V plot for real gases is not a straight line.

   Reason (R) : At high pressure all gases have $Z > 1$ but at intermediate pressure most gases have $Z < 1$.

3. Assertion (A): At zero degree Kelvin,the volume occupied by a gas is negligible.

   Reason (R): All molecular motion ceases at 0 K.

4. Assertion (A): CO_2 has stronger intermolecular forces than CH_4.

   Reason (R): Critical temperature of CO_2 is more.

5. Assertion (A) : Lower the critical temperature of the gas, more easily can it be liquefied.

   Reason (R) : Critical temperature is the temperature above which a gas can not be liquefied by applying any pressure.

6. Assertion (A) : A lighter gas diffuses more rapidly than a heavier gas.

   Reason (R) : At a given temperature, the rate of diffusion of a gas is inversely proportional to the square root of density.

7. Assertion (A) : The value of the Vanderwaal constant ‘a’ is larger for Ammonia than for Nitrogen

REASON: Hydrogen bonding is present in ammonia

8. Assertion (A) : CH_4,CO_2 has value of Z(Compressibility factor) less than one at zero degree celcius.

   Reason (R) : Z<1 is due to the attractive forces dominates among the molecules.

9. Assertion (A) : Most probable velocity is the velocity possessed by maximum fraction of molecules at the same temperature

   Reason (R) : On collision, more and more molecules acquire higher velocity at the same temperature

10. Assertion (A) : 'He' shows only positive deviation from ideal behaviour at room temperature

    Reason (R) : Helium is an inert gas.

Ans. 1. (i) 2. (ii) 3. (iii) 4. (i) 5. (iv) 6. (i) 7. (i) 8. (i) 9. (iii) 10. (ii)

ONE WORD ANSWER TYPE QUESTIONS

1. Write SI unit of pressure.
2. Write the value of lowest possible temperature.
3. Write the value of compressibility factor Z for ideal gas.
4. Write the unit of van der Waal constant which represent the magnitude of attractive forces between gas molecules.
5. Name the gas law which relates volume and pressure of gas at constant temperature.
6. Name the property responsible for spherical shape of water droplets.
7. Name the property which opposes the flow of liquids.
8. Two liquids A and B have vapour pressures 400 mm Hg and 450 mm Hg respectively at a given temperature. Which liquid has higher boiling point?
9. Critical temperature of N_2 and O_2 are 126 K and 154.3 K respectively. Which gas has greater magnitude of attractive forces?

10 Mention the volume occupied by one mole of an ideal gas at STP.

Ans. 1. Pascal 2. –273°C 3. Z = 1 4. L^2 atm mol^{-2} 5. Boyle's law

6. Surface tension 7. Viscosity 8. Liquid A 9. O_2 10. 22.7 L

1-MARK QUESTIONS

1. Define Dalton's law of partial pressure of gases.
2. State Boyle's law.
3. Write van der Waal equation for n mol of gas.
4. Write the conditions in terms of temperature and pressure under which gases deviate from ideal behavior.
5. Write the relation between pressure and density of gas.
6. Write relation between average kinetic energy and temperature of a gas.
7. Define the term absolute zero.
8. In terms of Charles' law explain why –273°C is known as lowest temperature?
9. Write SI unit for quantity $(PV^2 T^2)/n^2$.
10. Define the term Critical temperature.
11. Define Boyle's temperature.
12. Define surface tension.
13. What is the value of normal boiling point and standard boiling point of water?
14 At a particular temperature vapour pressure of ethanol is more than that of water. Give reason.
15 Why vegetables are cooked with difficulty at a hill station?

2-MARKS QUESTIONS

1. Name the intermolecular forces present in: (i) H_2O (ii) HCl
2. Critical temperature for carbon dioxide and methane are 31.1°C and –81.9°C respectively. Which of these has stronger intermolecular forces and why?
3. Explain the significance of van der Waal parameters.
4. A gas occupies 300 ml at 27°C and 730 mm pressure what would be its volume at STP. [**Ans.** 262.2 L]
5. Calculate the temperature at which 28g N_2 occupies a volume of 10 litre at 2.46 atm. [**Ans.** 299.6 K]

6. Compressibility factor, Z of a gas is given as Z = PV/nRT
   (i) What is the value of Z for an ideal gas?
   (ii) For real gas, what is the value of Z above Boyle's temperature?

[**Ans.** (i) Z = 1 (ii) Z > 1]

7. What will be the minimum pressure required to compress 500 dm^3 of air at 1 bar to 200 dm^3 at 30°C. [**Ans.** 2.5 bar]

8. Calculate the volume occupied by 8.8 g of CO_2 at 31.1°C and 1 bar pressure. R = 0.083 L bar K^{-1} mol^{-1}. [**Ans.** 5.05 L]

9. Calculate the temperature of 4 mol of a gas occupying in 5 dm^3 at 3.32 bar. R = 0.083 bar dm^3 K^{-1} mol^{-1}. [**Ans.** 50K]

10 The pressure of the atmosphere is 2×10^{-6} mm at about 100 mile from the earth and temperature is – 180°C. How many moles are there in 1 mL gas at this attitude? [**Ans.** 3.45×10^{-13} mol]

11. Calculate average kinetic energy of CO_2 molecules at 27°C.

[**Ans.** 3741.3 J mol^{-1}]

12. Calculate root mean square speed of methane molecules at 27°C.

[**Ans.** 6.84×10^4 cm s^{-1}]

13. Name two phenomena that can be explained on the basis of surface tension.

14. The van der Waal constants of two gases are as follows:

Gas	*a (atm L mol^{-1})*	*b (L mol^{-1})*
A	1.39	0.0391
B	3.59	0.0427

Which of them is more easily liquefiable and which has greater molecular size?

15. Critical temperatures of NH_3 and SO_2 are 405.0 and 430.3 K respectively:
   (i) Which one is easily liquefiable?
   (ii) Which has higher value of van der Waal constant 'a'?

16. Arrange the following in the order of property indicated for each set:
   (i) H_2O, NH_3, HCl, H_2 (increasing magnitude of intermolecular forces)
   (ii) O_2, H_2, CO_2, SO_2 (ease of liquefaction)
   (iii) O_2, He, CO_2, NH_3 (decreasing critical temperature)
   (iv) O_2, He, CO_2, CH_4 (increasing value of van der Waal constant 'a')

17. Arrange Water, ethanol, ether and glycerine in the order of property given below:
    (i) increasing order of vapour pressure
    (ii) increasing order of boiling point
    (iii) decreasing order of surface tension
    (iv) increasing order of viscosity

3-MARKS QUESTIONS

1. Explain the terms:

   (i) Viscosity (ii) Vapour pressure (iii) Boiling point temperature

2. Calculate the total pressure in a mixture of 8 g of dioxygen and 4 g of dihydrogen confined in a vessel of 1 dm^3 at 27°C. [**Ans.** 56.025 bar]

3. What will be the pressure exerted by a mixture of 3.2 g of methane and 4.4 g of carbon dioxide contained in a 9 dm^3 flask at 27°C . [**Ans.** 0.82 atm]

4. Pressure of one gram of an ideal gas A at 27°C is found to be 2 bar. When 2 g of another ideal gas B is introduced in the same flask at same temperature, the pressure becomes 3 bar. Find the relationship between their molar masses. [**Ans.** $M_B = 4M_A$]

5. A 20g chunk of dry ice is placed in an empty 0.75 litre wire bottle tightly closed what would be the final pressure in the bottle after all CO_2 has been evaporated and temperature reaches to 25°C?

   [**Ans.** Pressure inside the bottle = P + atm pressure = 14.828 + 1 = 15.828 atm]

6. A gas at a pressure of 5 atm is heated from 0°C to 546°C and is simultaneously compressed to one third of its original volume. Find the final pressure of the gas. [**Ans.** 45 atm]

7. Calculate the compressibility factor for CO_2, if one mole of it occupies 0.4 litre at 300K and 40 atm. Comment on the result.

   [**Ans.** 0.65, since $Z < 1$, CO_2 is more compressible than ideal gas]

8. Find the pressure of 4 g of O_2 and 2 g of H_2 confined in a bulb of 1 L at 0°C. [**Ans.** 25.215 atm]

5-MARKS QUESTIONS

1. Mention the intermolecular forces present between:
   (i) H_2O and C_2H_5OH
   (ii) Cl_2 and CCl_4
   (iii) He and He atoms
   (iv) Na^+ ion and H_2O
   (v) HBr and HBr

2. (i) For Dalton's law of partial pressure derive the expression
   $$P_{gas} = X_{gas} \cdot P_{total}$$
   (ii) A 2L flask contains 1.6 g of methane and 0.5 g of hydrogen at 27 °C. Calculate the partial pressure of each gas the mixture and calculate the total pressure.
   [**Ans.** $P_{CH_4} = 1.23$ atm, $P_{H_2} = 3.079$ atm, $P_{total} = 4.31$ atm]

3. Using van der Waal's equation calculate the constant 'a' when 2 mole of a gas confined in a 4 L flask exerts a pressure of 11.0 atm at a temperature of 300K. The value of 'b' is 0.05 L mol^{-1}. [**Ans.** 6.49 atm L^2 mol^{-2}]

HOTS QUESTIONS

1. A mixture of CO and CO_2 is found to have density of 1.50 g L^{-1} at 20 °C and 730 mm pressure. Calculate the composition of mixture.

Solution:

Let the mol of CO in mixture = x

$\therefore$ mol of CO_2 = (100 – x)

$$\therefore \; M = \frac{dRT}{P}$$

$$28 \times + (1–\times)\ 44 = m$$

$$\frac{M = 1.5 \times 0.08214 \times 360}{2720 \div 760}$$

= 38.85 – (2) From (1) & (2)

x = 0.3218

mole % CO = 32.18

mole % CO_2 = 67.82

2. A cylindrical balloon of 21 cm diameter is to be filled up with H_2 at NTP from a cylinder containing the gas at 20 atm at 27°C. The cylinder can hold 2.82 litre of water at NTP. Calculate the number of balloons that can be filled up.

Solution:

Volume of 1 balloon which has to be filled = $4/3\ \pi\ (21/2)^3$

$= 4851$ mL $= 4.851$ litre

Let n balloons be filled, then volume of H_2 occupied by balloons = $4.851 \times n$

Also, cylinder will not be empty and it will occupy volume of $H_2 = 2.82$ litre.

$\therefore$ Total volume occupied by H_2 at NTP = $4.851 \times n + 2.82$ litre

$\therefore$ At STP

$P_2 = 1$ atm	Available H_2
$V_1 = 4.851 \times n + 2.82$	$P_2 = 20$ atm
$T_1 = 273$ K	$T_2 = 300$K
$P_1V_1 / T_2 = P_2V_2 / T_2$	$V_2 = 2.82$ litre

or $1 \times (4.85\ 1n + 2.82 / 273) = 20 \times 2.82 / 300$ $\quad \therefore n = 10$

3. Calculate the temperature at which CO_2 has the same rms speed to that of O_2 at STP.

Solution:

Urms of $O_2 = \sqrt{3RT / M}$ at STP, urms of $O_2 = \sqrt{(3R \times 273 / 32)}$

For CO_2 urms $CO_2 = \sqrt{3RT / 44}$

Given both are same; $3R \times 273 / 32 = 2RT / 44$

$\therefore$ T =375.38 K = 102.38°C

4. 50 litre of dry N_2 is passed through 36g of H_2O at 27°C. After passage of gas, there is a loss of 1.20g in water. Calculate vapour pressure of water.

Solution

The water vapours occupies the volume of N_2 gas i.e. 50 litre

$\therefore$ For H_2O vapour V = 50 litre, w = 1.20g, T = 300K, m = 18 g mol^{-1}

$PV = w / m\ RT$ or $P \times 50 = 1.2 / 18 \times 0.0821 \times 300$

$\therefore$ P = 0.03284 atm $\quad$ = 24.95 mm

UNIT TEST-I

Time Allowed: 1 Hr. **Maximum Marks : 20**

General Instructions:

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

---

1. If P is the pressure and d is the density of gas, then P and d are related as: [1]
   (a) $P \alpha 1/d$ (b) $P \alpha d$
   (c) $P \alpha d^2$ (d) $P \alpha 1/d^2$

2. At which temperature the volume of a gas is expected to be zero. [1]
   (a) 0°C (b) 273 K
   (c) –273 °C (d) 273°C

3. Define Boyle's temperature. [1]

4. Write van der Waal equation for n mol of gas. [1]

5. Why vegetables are cooked with difficulty at a hill station? [1]

6. A gas occupies 300 ml at 27°C and 730 mm pressure what would be its volume at STP. [2]

7. Compressibility factor, Z of a gas is given as Z = PV/nRT [2]
   (i) What is the value of Z for an ideal gas?
   (ii) For real gas, what is the value of Z above Boyle's temperature?

8. Pressure of one gram of an ideal gas A at 27°C is found to be 2 bar. When 2 g of another ideal gas B is introduced in the same flask at same temperature, the pressure becomes 3 bar. Find the relationship between their molar masses. [3]

9. Calculate the total pressure in a mixture of 8 g of dioxygen and 4 g of dihydrogen confined in a vessel of 1 dm^3 at 27°C . [3]
   $R = 0.083$ bar dm^3 K^{-1} mol^{-1}

10. (a) Critical temperatures of NH_3 and SO_2 are 405.0 and 430.3 K respectively: [2]
    (i) Which one is easily liquefiable?
    (ii) Which has higher value of van der Waal constant 'a'?

    (b) Explain the terms: [3]
    (i) Viscosity (ii) Vapour pressure (iii) Boiling point temperature

UNIT TEST-II

Time Allowed: 1 Hr. **Maximum Marks : 20**

General Instructions:

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

---

1. If a ideal gas is confined in a closed vessel then which of the following points is correct. [1]

   (a) The particles of gas occupy appreciable volume of the container.

   (b) The collision among gas particles are not elastic.

   (c) The particles of gas do not exert any kind of intermolecular forces among themselves.

   (d) The temperature of the as keep changing after each collision.

2. Dalton law of Partial pressure is not applicable to following mixture? [1]

   (a) $He + N_2$ (b) $Xe + N_2$

   (c) $He + Xe$ (d) $NH_3 + HCl$

3. Define Critical Temperature. [1]

   In following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choice.

   (a) Assertion and Reason both are correct statements and reason is correct explanation for assertion.

   (b) Assertion and Reason both are correct statements but reason is not correct explanation for assertion.

   (c) Assertion is correct statement but Reason is wrong statement.

   (d) Assertion is wrong statement but Reason is correct statement.

4. Assertion : Vapour Pressure of Ethyl alcohol is less than Water. [1]

   Reason : In water molecule strong hydrogen bonding is present as compare to Ethyl alcohol.

5. Assertion : Increase in Temperature leads to decrease in surface tension of the liquid. [1]

   Reason : At higher temperature the molecules has higher kinetic energy.

6. Critical Temperature for carbon dioxide and methan are 31.1°C and -81.9°C respectively. Which of these has stronger intermolecular forces and why? [2]

7. 2.9 g of gas at 95°C occupied the same volume as 0.184g of dihydrogen at 17°C, at the same pressure. What is the molar mass of the gas? [2]

8. The drain cleaner, Drainex contains small bits of aluminium which react with caustic soda to produce dihydrogen. What volume of dihydrogen at 20°C and one bar will be released when 0.15 g of aluminium reacts? [3]

9. Oxygen is present in a 2 litre flask at a pressure of 7.6×10^{-10} mm of Hg. Calculate the number of oxygen molecules in the flask at 0°C. [3]

10. (i) Define the compressibility factor and Boyle temperature.

    (ii) Calculate the compressibility factor for 1.0 mole NH_3 gas in a 500ml vessel at -10.0°C at a pressure of 30.0 atm.

    (iii) Derive the Vanderwaal gas equation for 'n' moles of a real gas. [5]

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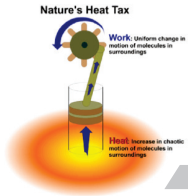


Chapter - 6

Chemical Thermodynamics

FAST TRACK : QUICK REVISION

- **System:** Specific part of universe in which observations are made.
- **Surroundings**: Everything which surrounds the system.
- **Types of the System**:

  Open System: Exchange both matter and energy with the surroundings. For example – Reactant in an open test tube.

  Closed System: Exchange energy but not matter with the surroundings. For example – Reactants in a closed vessel.

  Isolated System: Neither exchange energy nor matter with the surroundings. For example – Reactants in a thermos flask.

- **Thermodynamic Processes:**

  (i) Isothermal Process: $\Delta T = 0$

  (ii) Adiabatic process: $\Delta q = 0$

  (iii) Isobaric process: $\Delta P = 0$

  (iv) Isochoric process: $\Delta V = 0$

  (v) Cyclic process: $\Delta U = 0$

  (vi) Reversible process: Process which proceeds infinitely slowly by a series of equilibrium steps.

  (vii) Irreversible process: Process which proceeds rapidly and the system does not have chance to achieve equilibrium.

- **Extensive Properties:** Properties which depend upon the quantity or size of matter present in the system. For example – mass, volume, internal energy, enthalpy, heat capacity, work etc.

- **Intensive Properties**: Properties which do not depend upon the quantity or size of matter present in the system. For example – temperature, density, pressure, surface tension, viscosity, refractive index, boiling point, melting point etc.
- **State Functions**: The variables of functions whose value depend only on the state of a system or they are path independent.

  For example – pressure (P), volume (V), temperature (T), enthalpy (H), free energy (G), internal energy (U), entropy (S), amount (n) etc.
- **Internal Energy**: It is the sum of all kind of energies possessed by the system.
- First Law of Thermodynamics: "The energy of an isolated system is constant."

  Mathematical Form: $\Delta U = q + w$
- **Sign Conventions for Heat (q) and Work (w):**
  (i) $W = +$ ve , if work is done on system
  (ii) $W = -$ ve , if work is done by system
  (iii) $q = +$ ve , if heat is absorbed by the system
  (iv) $q = -$ ve , if heat is evolved by the system
- **Work of Expansion/ compression:** $\omega = -P_{ext}(V_f - V_i)$
- **Work done in Isothermal Reversible Expansion of an Ideal Gas**:

  $$\omega_{rev} = -2.303\ nRT \log V_f / V_i$$

  or $$\omega_{rev} = -2.303\ nRT \log P_i / P_f$$
- **Significance of ΔH & ΔU**: $\Delta H = q_p$ and $\Delta U = q_v$
- **Relation between ΔH & ΔU**: $\Delta H = \Delta U + (n_p - n_r)RT$ for gaseous reaction
  (i) $\Delta H = \Delta U$ if $(n_p - n_r)$ is zero; *e.g.* $H_2(g) + I_2(g) \longrightarrow 2HI(g)$
  (ii) $\Delta H > \Delta U$ if $(n_p - n_r)$ is positive; *e.g.* $PCl_5(g) \longrightarrow PCl_3(g) + Cl_2(g)$
  (iii) $\Delta H < \Delta U$ if $(n_p - n_r)$ is negative; *e.g.* $N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$
- **Heat Capacity (C):** Amount of heat required to raise the temperature of a substance by 1°C or 1 K.

  $$q = C\,\Delta T$$

- **Specific Heat Capacity (C_s)**: Amount of heat required to raise the temperature of 1 g of a substance by 1°C or 1 K.

$$q = C_s \times m \times \Delta T$$

- **Molar Heat Capacity (C_m):** Amount of heat required to raise the temperature of 1 mole of a substance by 1°C or 1 K.

$$q = C_m \times n \times \Delta T$$

- **Standard State of a Substance:** The standard state of a substance at a specified temperature is its pure form at 1 bar.

- **Standard Enthalpy of Formation($\Delta_f H^o$):** Enthalpy change accompanying the formation of one mole of a substance from its constituent elements under standard condition of temperature (normally 298 K) and pressure (1bar).
  - $\Delta_f H^0$ of an element in standard state is taken as zero.
  - Compounds with –ve value of $\Delta_f H^0$ more stable than their constituents.
  - $\Delta_r H^0 = \sum a_i \Delta_f H^0$ (products) – $\sum b_i \Delta_f H^0$ (reactants) ; Where 'a' and 'b' are coefficients of products and reactants in balanced equation.

- **Standard Enthalpy of Combustion($\Delta_c H^0$):** Enthalpy change accompanying the complete combustion of one mole of a substance under standard conditions (298 K, 1bar)

- **Hess's Law of Constant Heat Summation:** The total enthalpy change of a reaction remains same whether it takes place in one step or in several steps.

- **Bond Dissociation Enthalpy:** Enthalpy change when one mole of a gaseous covalent bond is broken to form products in gas phase.

  For example, $Cl_2\,(g) \longrightarrow 2Cl(g); \quad \Delta_{Cl-Cl} H^0 = 242 \text{ kJ mol}^{-1}$

  - For diatomic gaseous molecules; Bond enthalpy = Bond dissociation Enthalpy = Atomization Enthalpy

- For Polyatomic gaseous molecules; Bond Enthalpy = Average of the bond dissociation enthalpies of the bonds of the same type.
- $\Delta_r H^0 = \sum\Delta_{bond} H^0$ (Reactants) – $\sum\Delta_{bond} H^0$ (Products)

◆ **Spontaneous Reaction:** A reaction which can take place either an its own or under some initiation.

◆ **Entropy(S):** It is measure of degree of randomness or disorder of a system.

- $\Delta S_{sys} = \dfrac{(q_{rev})_{sys}}{\Delta T} = \dfrac{\Delta H_{sys}}{\Delta T}$
- Unit of Entropy = $JK^{-1}\ mol^{-1}$

◆ **Second Law of Thermodynamics:** For all the spontaneous processes totally entropy change must positive.

$$\Delta S_{total} = \Delta S_{sys} + \Delta S_{surr} > 0$$

◆ **Gibbs Helmholtz Equation for determination of Spontaneity:**

$$\Delta G = \Delta H - T\Delta S$$

(i) If ΔG = –ve, the process is spontaneous

(ii) If ΔG = +ve, the process is non-spontaneous

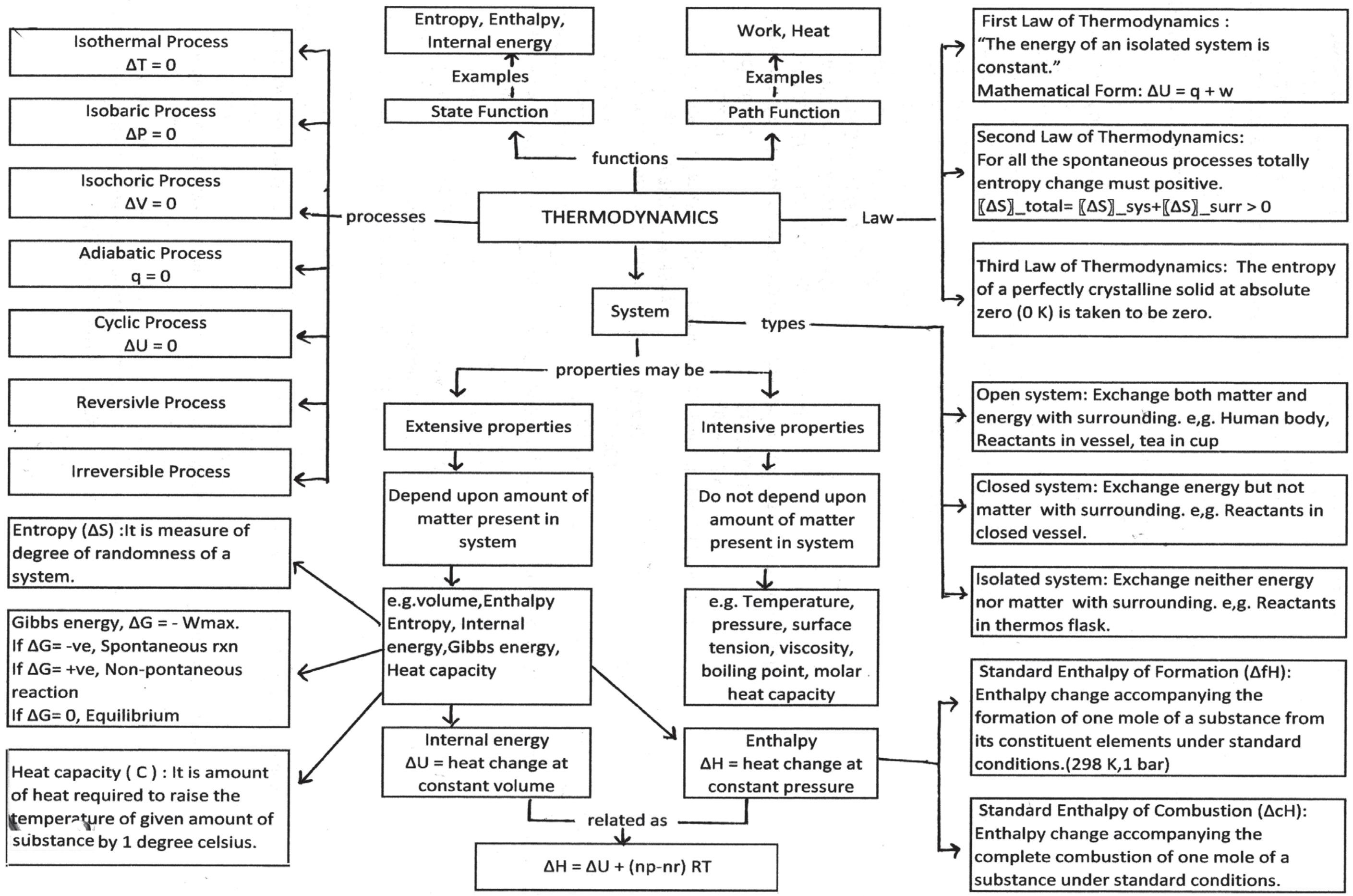
(iii) If $\Delta G = 0$, the process is in equilibrium

◆ **Relation between Gibbs Energy Change and Equilibrium Constant:**

$$\Delta G^o = -2.303\ RT \log K_c$$

◆ **Third Law of Thermodynamics:** The entropy of a perfectly crystalline solid at absolute zero (0 K) is taken to be zero.

MIND MAP : CHEMICAL THERMODYNAMICS



CASE BASED STUDIES - QUESTIONS

PASSAGE -1

Heat of neutralization is defined as amount of heat released when one gram equivalent of a strong base reacts with one gram equivalent of strong acid. The heat of neutralization is come out to be as follows

H^+ (aq.) + OH^- (aq.) $\rightarrow$ H_2O(aq.) , ΔH(Neu.) = 'X'

The following questions are multiple choice questions. Choose the most appropriate answer:

I. If enthalpy of neutralization of CH_3COOH by HCl is 'Y' then enthalpy of ionization of CH_3COOH acid will be(Magnitude only)

(A) Y/mol (B) X/mol

(C) (X-Y)/mol (D) (X+Y)/mol

II. What is the enthalpy change for a complete neutralization reaction of strong base $R(OH)_2$ by HCl

(A) X (B) 3X

(C) 2X (D) 4X

III. When the conditions are identical how many ml of 0.1 M of strong base AOH and 0.05 M strong H_2A acid solution should be mixed for a total volume of 100 ml produce the highest rise in temperature.

(A) 10:90 (B) 90:10

(C) 25:75 (D) 50:50

IV. If heat of neturalization of HA, HB, HC, HD acid follows the order HA>HB>HC>HD , then among the given acid which one is strongest acid.

(A) HA (B) HB

(C) HC (D) HD

ANS: I. C, II. C, III. D, IV. A

PASSAGE -2

According to first law of thermodynamics, the mathematical expression is as follows :

$$\Delta U = Q + W$$

Where ΔU is the change in internal energy observed when a 'Q' amount of heat is involved and 'W' amount of work is associated when the system moves from state 'A' to state 'B'. The sign of 'Q' and 'W' is taken such that ΔU is measures accurately .

In these questions (Q. No V-VIII , a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement

V. ASSERTION : For Isothermal reversible expansion of gas heat is absorbed by the gas.

REASON : The sign of 'W' is negative which makes 'Q' overall positive.

VI. ASSERTION : For Isochoric process , if heat absorb by the system, then temperature increases.

REASON : For Isochoric process the work done is either positive or negative.

VII. ASSERTION : For Adiabatic process , if expansion occur then temperature of the system rises.

REASON : For Adiabatic process , heat change is zero during process.

VIII. ASSERTION : Internal energy can be increase by decreasing temperature.

REASON : Kinetic energy of the particles can be increased as the temperature increases.

ANS: V. A, VI. C, VII. D, VIII. D

MULTIPLE CHOICE QUESTIONS (MCQ)

1. Which one of the following thermodynamic quantities is not a state function?
   (a) Gibbs free energy (b) Enthalpy
   (c) Entropy (d) Work

2. All of the following have a standard heat of formation value of zero at 25°C and 1.0 atm except:
   (a) N_2 (g) (b) Fe(s)
   (c) Ne (g) (d) H(g)

3. For the following reaction at 25°C, $\Delta H° = +115$ kJ and $\Delta S° = +125$ J/K. Calculate $\Delta G°$ for the reaction at 25°C :

   $$SBr_4(g) \longrightarrow S(g) + 2Br_2(l)$$

   (a) +152 kJ (b) –56.7 kJ
   (c) +77.8 kJ. (d) +37.1 kJ

4. Calculate $\Delta_r H^0$ for the following reaction at 25°C :

	$Fe_3O_4(s)$	$+ CO(g)$	$\longrightarrow 3FeO(s)$	$+ CO_2(g)$
ΔH_f^o (kJ/mol)	–1118	–110.5	–272	–393.5

   (a) –263 kJ (b) 54 kJ
   (c) 19 kJ. (d) –50 kJ

5. A system suffers an increase in internal energy of 80 J and at the same time has 50 J of work done on it. What is the heat change of the system?
   (a) +130 J (b) +30 J
   (c) –130 J (d) –30 J

6. The ΔH^0 for the following reaction at 298 K is –36.4 kJ.

   $$1/2\ H_2\ (g) + 1/2\ Br_2\ (l) \longrightarrow HBr(g)$$

   Calculate ΔU^0 at 298 K. The universal gas constant, R, is 8.314 J/mol K.
   (a) –35.2 kJ (b) +35.2 kJ
   (c) –36.4 kJ (d) –37.6 kJ.

7. For which of the following reactions would the ΔH^o for the reaction be labeled ΔH_f^0 ?
   (a) $Al(s) + 3/2\ H_2\ (g) + 3/2\ O_2\ (g) \longrightarrow Al(OH)_3(s)$
   (b) $PCl_3\ (g) + 1/2\ O_2\ (g) \longrightarrow POCl_3\ (g)$

(c) 1/2 N_2O (g) + 1/4 O_2 (g) $\longrightarrow$ NO (g)

(d) CaO(s) + SO_2 (g) $\longrightarrow$ $CaSO_3$(s)

8. Which statement is ture for reaction? $2H_2$ (g) + O_2 (g) $\longrightarrow$ $2H_2O$ (g)

(a) $\Delta S = +ve$ (b) $\Delta H > U$

(c) $\Delta H < U$ (d) $\Delta H = U$

9. The heat of combustion of yellow phosphorous is –9.91 KJ and the red phosphorous is –8.78 KJ. The heat of transition of yellow phosphorous to red phosphorous is :

(a) –9.91 kJ (b) –8.78 kJ

(c) –9.34 kJ (d) –1.13 kJ

10. Entropy of universe is :

(a) Increasing (b) decreasing

(c) Constant (d) None of these

11. Which is state function?

(a) q (b) w

(c) q + w (d) None of these

12. According to second law of thermodynamics

(a) $\Delta S_{total} = +ve$ (b) $\Delta S_{total} = -ve$

(c) $\Delta S_{system} = +ve$ (d) $\Delta S_{system} = -ve$

Ans: 1.(d), 2.(d), 3.(c), 4.(c), 5.(b), 6.(d), 7.(a),
8. (c), 9.(a), 10.(c), 11.(c), 12.(a)

FILL IN THE BLANKS

(i) ……… is a measure of the degree of randomness or disorder of a system.

(ii) A process which can take place either of its own or under some initiation is known as ………………..

(iii) For evaporation of water the sign of ΔH is…….. and sign of ΔS is……..

(iv) The entropy of a perfectly crystalline solid is zero at ………..

(v) The heat energy exchanged between the system and surroundings at constant temperature and pressure is known as………..….

(vi) ………… is the quantity of heat needed to raise the temperature of one mole of a substance by 1°C

(vii) $C_p - C_v$ = ...

(viii) .... = $\Delta H - T\Delta S$.

(ix) According to .... law of thermodynamics, $\Delta S_{total} = +$ ve.

(x) If $\Delta H = +$ve and $\Delta S = +$ve, the reaction is spontaneous at .... temperature

Ans: (i) Entropy (ii) spontaneous (iii) +ve, +ve (iv) –273°C
(v) Enthalpy (vi) molar heat capacity (vii) R (viii) ΔG
(ix) second (x) high

TRUE AND FALSE TYPE QUESTIONS

Write true or false for following statements:

(i) For every chemical reaction at equilibrium ΔG^0 is zero.

(ii) Entropy is not a state function because its value depends upon the condition of temperature and pressure.

(iii) During isothermal expansion of an ideal gas, there is no change in internal energy.

(iv) q and w are not state function but q+w is a state function.

(v) The enthalpy of neutralization of a strong acid by a strong base is always constant.

(v) For a spontaneous process $\Delta S_{system} = +$ve.

(vi) ΔH is not a state function.

(vii) The energy of universe is conserved while its entropy is increasing.

(viii) Volume is extensive property while temperature is intensive property.

(ix) At 0°C the entropy of a perfectly crystalline solid is zero.

(x) Hess' law is a corollary of the first law of thermodynamics.

Ans: (i) False (ii) False (iii) True (iv) True (v) True
(vi) False (vii) True (viii) True (ix) False (x) True

MATCH THE COLUMNS

I. Match the sign of ΔH in Column I with the sign of ΔS Column II and sign of ΔG in Column III for a Spontaneous & Non spontaneous reaction.

S.N.	Column I-[ΔH]	Column II-[ΔS]	Column III-[ΔG]
1.	–Ve	(a) +Ve	(p) +Ve at low temperature
2.	+Ve	(b) +Ve	(q) -Ve at High Temperature
3	+Ve	(c) +Ve	(r) –Ve at all temperature
4.	+Ve	(d) -Ve	(s) +Ve at all Temperature

II. Match the Process in Column I with the parameters in Column II and parameters in Column III

S.N.	Column I	Column II	Column III
1.	Isochoric Process	(a) Temperature constant	(p) w is not zero
2.	Isothermal Process	(b) Volume Constant	(q) T not constant
3.	Adiabatic Process	(c) Pressure Constant	(r) $\Delta U=0$
4.	Isobaric Process	(d) Heat Constant	(s) Work is zero

ANS :

MATCH-I : 1. b, r   2. a, q   3. d, s   4. c, p

MATCH-II : 1. b, s   2. a, r   3. d, q   4. c, p

ASSERTION AND REASON TYPE QUESTIONS

In the following questions a statement of assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below for each question.

(i) A and R both are correct, and R is correct explanation of A.

(ii) A and R both are correct, but R is not the correct explanation of A.

(iii) A is true but R is false.

(iv) A and R both are false.

1. Assertion (A): Enthalpy of graphite is lower than that of diamond.
   Reason (R): Entropy of graphite is greater than that of diamond.
2. Assertion (A): Enthalpy of formation of $H_2O(l)$ is greater than that of $H_2O(g)$.
   Reason (R): Enthalpy change is negative for condensation reaction, $H_2O(g)$ $H_2O(l)$
3. Assertion (A): ΔH and ΔU are same for the reaction $N_2(g) + O_2(g) \longrightarrow 2NO(g)$
   Reason (R): All the reactants and products are gases.
4. Assertion (A): if both ΔH^0 and ΔS^0 are positive than the reaction will be spontaneous at high temperature
   Reason (R): All processes with positive entropy change are spontaneous.
5. Assertion (A): Enthalpy of formation of HCl is equal to bond energy of HCl.
   Reason (R): Enthalpy of formation and bond energy both involve the formation of one mole of HCl from the elements.

6. ASSERTION : The standard free energies changes for all the spontaneously occurring reaction are negative

   REASON: The standard free energies of the elements in their standard states at 1 bar and 298 K are taken as zero

7. ASSERTION: Enthalpy and Entropy of any elementary substances in the standard states are taken as zero.

   REASON: At absolute zero, particles of the perfectly crystalline substances become completely motionless.

8. ASSERTION : Enthalpy of Neutralization of CH_3COOH by NaOH is less than that of HCl by NaOH

   REASON : CH_3COOH is a weak acid hence need energy to ionize completely.

9. ASSERTION : The heat absorbed during the isothermal expansion of an ideal gas against vacuum is zero

   REASON: Internal energy of a gas depends upon Pressure of the gas.

10. ASSERTION : A reaction which is spontaneous and accompanied by decrease of randomness must be exothermic

    REASON : All exothermic reactions are accompanied by decrease of randomness.

Ans: 1. (ii) 2. (i) 3. (ii) 4. (iii) 5. (i) 6. (ii) 7. (iv) 8. (i) 9. (iii) 10. (iii)

ONE WORD ANSWER TYPE QUESTIONS

1. 'w' amount of work is done by the system and 'q' amount of heat is supplied to the system. What type of system would it be?
2. What is the work done in free expansion of an ideal gas?
3. What is the sign of ΔG^0 for spontaneous reaction?
4. Write the relation between ΔH and ΔU for $H_2\,(g) + I_2\,(g) \rightarrow 2HI\,(g)$.
5. Write the SI unit of entropy.
6. Name the calorimeter used to measureΔU.
7. What is the standard enthalpy of formation of graphite?
8. What is the sign of ΔH for $H_2\,(g) \longrightarrow 2H\,(g)$?
9. If $K_c = 1$, what will be the value of ΔG?
10. An exothermic reaction is spontaneous at all temperature. What is the sign of S?

Ans: 1. Closed system 2. W = 0 3. $\Delta G = -ve$ 4. $\Delta H = \Delta U$ 5. J K^{-1} mol^{-1}

6. Bomb calorimeter 7. Zero 8. $\Delta H = +ve$ 9. Zero 10. $\Delta S = +ve$

1-MARK QUESTIONS

1. Name the thermodynamic system to which following belong:

   (i) Human body (ii) Milk in Thermos flask (iii) Tea in steel kettle

2. Identify State functions out of the following: Enthalpy, Entropy, Heat, Temperature, Work, Gibb's free energy.

3. Give two examples of state functions.

4. Write the mathematical statement of first law of thermodynamics.

5. Predict the internal energy change for an isolated system? [**Ans.** Zero]

6. Why ΔH is more significant than ΔU?

7. Write one example each of extensive and intensive properties.

8. Write a chemical equation in which ΔH and ΔU are equal.

9 Write the relationship between ΔH and ΔU for the reaction:

$$C(s) + O_2(g) \longrightarrow CO_2(g)$$

10. Define standard enthalpy of formation.

11. Why is the standard enthalpy of formation of diamond not zero although it is an element?

12. The enthalpy of atomization of CH_4 is 1665 kJ mol^{-1}. What is the bond enthalpy of C – H bond? [**Ans.** 416.25 kJ]

13. Identify the species for which $\Delta_f H^\theta = O$, at 298 K; $O_3(g)$, $Br_2(g)$, $Cl_2(g)$ $CH_4(g)$.

14. For the reaction $2Cl(g) \longrightarrow Cl_2\ (g)$; what are the sign of ΔH and ΔS ?

15. For an isolated system $\Delta U = 0$, what will be ΔS ?

16. Why entropy of steam is more than that of water at its boiling point?

17. Out of Diamond and Graphite which has higher entropy?

18. Write an example of endothermic spontaneous reaction.

19. State second law of thermodynamics.

20. State third law of thermodynamics.

21. Which has more entropy? 1 mol $H_2\,O(l)$ at 25°C or 1 mol $H_2O(l)$ at35°C.

22. At what temperature the entropy of a perfectly crystalline solid is zero?

23. For a certain reaction $\Delta G^0 = 0$,what is the value of K_c?

24. How can a non spontaneous reaction be made spontaneous?

25. For a reaction both ΔH and ΔS are negative. Under what conditions does the reaction occur.

2-MARKS QUESTIONS

1. In a process 701 J of heat is absorbed by a system and 394 J work is done by the system. What is the change in internal energy for the process? [**Ans.** 307 J]

2. Neither 'q' nor 'w' is state functions but q + w is a state function. Explain.

3. Classify the following as extensive or intensive properties :-
   Heat capacity, Density, Temperature, Molar heat capacity.

4. Derive the relationship between ΔH and ΔU.

5. Derive the relationship $C_p - C_v = R$.

6. A 1.25g sample of octane (C_8H_{18}) is burnt in excess of oxygen in a bomb calorimeter. The temperature of the calorimeter rises from 294.05 to 300.78K.If heat capacity of the calorimeter is 8.93 kJ/gK. Find the heat transferred to calorimeter. [**Ans.** 0.075 kJ]

7. Show that for an ideal gas, the molar heat capacity under constant volume conditions is equal to 3/2 R.

8. Expansion of a gas in vacuum is called free expansion. Calculate the work done and change in internal energy when 1 mol of an ideal gas expands isothermally from I L to 5 L into vacuum.

9. State and explain Hess's Law of Constant Heat Summation with a suitable example.

10. Derive the relationship between ΔH and ΔU.
    Given, $N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$; $\Delta_r H^\theta = -92.4$ kJ mol^{-1};
    What is the standard enthalpy of formation of NH_3 gas?
    [**Ans.** –46.2 kJ mol^{-1}]

11. Calculate the enthalpy change for the reaction:
    $H_2(g) + Br_2(g) \longrightarrow 2\,HBr(g)$.
    Given the bond enthalpies H_2, Br_2 and HBr are 435 kJ mol^{-1}, 192 kJ mol^{-1} and 368 kJ mol^{-1} respectively. [**Ans.** –109 kJ mol^{-1}]

12. Is the bond dissociation enthalpy of all the four C – H bonds in CH_4 same? Give reason in support of your.

13. Define the term entropy. Write its unit. How does entropy of a system change on increasing temperature?

14. Dissolution of ammonium chloride in water is endothermic but still it dissolves in water readily. Why?

15. Calculate the entropy change in the surroundings when 1.00 mol of $H_2O(l)$ is formed under standard conditions; $\Delta_f H^\theta = -286$ kJ mol^{-1}.
[**Ans.** 959.7 J K^{-1} mol^{-1}]

16. The enthalpy of vaporization of a liquid is 30 kJ mol^{-1} and entropy of vaporization is 75 J K^{-1} mol^{-1}. Calculate the boiling point of liquid at 1 atm. [**Ans.** 400 K]

17. The equilibrium constant for a reaction is 10.What will be the value of ΔG^θ? R = 8.314J K^{-1} mol^{-1}, T = 300K. [**Ans.** –5.744 kJ mol^{-1}]

18. Derive the relationship, $\Delta G = -T\Delta S_{total}$ for a system.

19. The ΔH and ΔS for $2Ag_2O(s) \longrightarrow 4Ag(s) + O_2(g)$ are given + 61.17kJ mol^{-1} and +132 J $K^{-1}mol^{-1}$ respectively. Above what temperature will the reaction be spontaneous? [**Ans.** >463.4 K]

3-MARKS QUESTIONS

1. Differentiate between the following (with examples)
   (i) Open and Closed System.
   (ii) Adiabatic and Isothermal process.
   (iii) State function and path function

2. Calculate the maximum work obtained when 0.75 mole of an ideal gas expands isothermally and reversibly at 27°C from a volume of 15L to 25L. [**Ans.** –955.7 J]

3. Calculate the number of kJ necessary to raise the temperature of 60 g of aluminium from 35 to 55°C . Molar heat capacity of Al is 24 J mol^{-1} K^{-1}.
[**Ans.** 1.067 kJ]

4. The reaction of cyanamide, NH_2CN (s), with Dioxygen was carried out in a bomb calorimeter, and ΔU was found to be –742.7 kJ mol^{-1} at 298K. Calculate Enthalpy change for the reaction at 298K,

$NH_2CN (s) + 3/2\ O_2 (g) \longrightarrow N_2 (g) + CO_2 (g) + H_2O (l)$

[**Ans.** –741.5 kJ mol^{-1}]

5. The enthalpy of combustion of methane, graphite and dihydrogen at 298 K are –890.3 kJ mol^{-1}, –393.5 kJ mol^{-1} and –285.8 kJ mol^{-1} respectively. Calculate enthalpy of formation of methane gas. [**Ans.** –74.8 kJ mol^{-1}]

6. Explain the Born Haber Cycle to determine the lattice enthalpy of NaCl.

7. Enthalpies of formation of CO(g), CO_2(g), N_2O(g) and N_2O_4 (g) are –110, –393, 81 and 9.7 kJ mol-1 respectively. Find the value of $\Delta_r H$ for the reaction; $N_2O_4(g) + 3\ CO (g) \longrightarrow N_2O (g) + 3CO_2 (g)$

   [**Ans.** –777.7 kJ mol^{-1}]

8. The combustion of 1 mol of benzene takes place at 298K .After combustionCO_2 and H_2O are formed and 3267 kJ mol^{-1} of heat is liberated. Calculate $\Delta_f H^0 (C_6H_6)$.

   Given: $\Delta_f H^0 (H_2O) = -286$ kJ mol^{-1}, $\Delta_f H^0(CO_2) = -393$ kJ mol^{-1}

   [**Ans.** 48.51 kJ mol^{-1}]

9. Calculate the standard enthalpy of formation of CH_3OH(l) from the following data:

   $CH_3OH (l) + 3/2\ O_2 (g) \longrightarrow CO_2 (g) + 2H_2O (l); \Delta_c H^\theta = -726$ kJ mol^{-1}

   $C (g) + O_2 (g) \longrightarrow CO_2 (g); \Delta_f H^\theta = -393$ kJ mol^{-1}

   $H_2(g) + 1/2\ O_2 (g) \longrightarrow H_2O (l); \Delta_f H^\ominus - 286$ kJ mol^{-1}

   [**Ans.** –239 kJ mol^{-1}]

10. For oxidation of iron, $4\ Fe(s) + 3\ O_2(g) \rightarrow 2\ Fe_2O_3(s)$ entropy change is –549.4 J K^{-1} mol^{-1} at 298 K. In spite of negative entropy change of this reaction, why is the reaction spontaneous? ($\Delta_r H^\theta$ for this reaction is –1648 kJ mol^{-1}) [**Ans.** $\Delta S_{total} = +4980.6$ J K^{-1} mol^{-1}]

11. Give reasons:
    (i) Evaporation of water is endothermic process but it is spontaneous.
    (ii) A real crystal has more entropy than an ideal crystal.
    (iii) Entropy of universe is increasing.

12. For the reaction at 298 K, $2A + B \longrightarrow C$; $\Delta H = 400$ kJ mol^{-1}, $\Delta S = 0.2$ kJ K^{-1} mol^{-1}. At what temperature will the reaction become spontaneous considering ΔH and ΔS to be constant over the temperature range.

    [**Ans.** T > 2000 K]

13. Reaction $X(s) \rightarrow Y(g)$ $\Delta H = +ve$ is spontaneous at temperature 'T'. Determine

(i) Sign of ΔS for this reaction.

(ii) Sign of ΔG for $Y \longrightarrow X$

(iii) Sign of ΔG at a temperature $< T$

5-MARKS QUESTIONS

1. (a) What is reversible process in Thermodynamics?

(b) Name the thermodynamic processes for which : (i) $q = 0$ (ii) $\Delta U = 0$ (iii) $\Delta V = 0$ (iv) $\Delta P = 0$

(c) Water decomposes by absorbing 286.2 kJ of electrical energy per mole. When H_2 and O_2 combine to form one mole of H_2O, 286.2 kJ of heat is produced. Which thermodynamic law is proved? Write its statement.

2. (a) Although heat is a path function but heat absorbed by the system under certain specific conditions is independent of path. What are those conditions? Explain. [Hint: $q_v = \Delta U$ and $q_p = \Delta H$]

(b) It has been found that 221.4 J is needed to heat 30g of ethanol from 15°C to 18°C. Calculate (a) specific heat capacity, and (b) molar heat capacity of ethanol. [**Ans.** (a) 2.46 $Jg^{-1}\,°C^{-1}$, (b) 113.2 $J\,mol^{-1}\,°C^{-1}$]

3. (a) Differentiate the terms Bond dissociation enthalpy & Bond Enthalpy.

(b) Calculate enthalpy change for the process $CCl_4(g) \longrightarrow C(g) + 4Cl(g)$ and calculate Bond enthalpy of C–Cl bond in CCl_4.

Given: $\Delta_{vap} H^\theta = 30.5\ kJ\ mol^{-1}$; $\Delta_f H^\theta(CCl_4) = -135.5\ kJ\ mol^{-1}$;

$\Delta_a H^\theta(C) = 715\ kJ\ mol^{-1}$ and $\Delta_a H^\theta(Cl_2) = 242\ kJ\ mol^{-1}$

[**Ans.** 1304 $kJ\ mol^{-1}$, 326 $kJ\ mol^{-1}$]

4. Predict the sign of ΔS for the following changes:

(i) Freezing of water.

(ii) $C(graphite) \longrightarrow C(diamond)$

(iii) $H_2(g)$ at 298 k and 1 bar $\longrightarrow$ $H_2(g)$ at 298 k and 10 bar

(iv) $H_2(g) + I_2(g) \longrightarrow 2HI(g)$

(v) $2NaHCO_3(s) \longrightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$

5. (i) Define Gibbs Energy. Give its mathematical expression. What is Gibb's energy criteria of Spontaneity.

(ii) For the reaction:

$2A(g) + B(g) \rightarrow 2D(g)$, $\Delta U^{\theta} = -10.5$ kJ and $\Delta S^{\theta} = -44.1$ J K^{-1}.

Calculate $\Delta rG°$ for the reaction, and predict whether the reaction will occur spontaneously.

[**Ans.** $\Delta_r G^{\theta} = +0.16$ kJ, Non-spontaneous]

HOTS QUESTIONS

1. Does entropy increase or decrease when egg is boiled?

Ans.: On boiling egg, entropy decreases as due to denaturation, the helical structure of protein become more complicated and random coiled structure.

2. 10 g of argon is compressed isothermally and reversibly at a temperature of 27°C from 10 L to 5 L. Calculate q, w, ΔU and ,ΔH.

Solution: $q = -2.303\ nRT \log V_2 / V_1 = -2.303 \times 10/40$ mol $\times$ 2 Cal K^{-1} $mol^{-1} \times 300$ K $\times \log 5/10 = -103.635$ Cal

For isothermal compression $\Delta U = 0$

$W = \Delta U - q = 0 - (-103.635) = +103.635$ Cal

Also when temperature is constant,

PV = constant, $\Delta H = \Delta U + \Delta(PV) = 0 + 0 = 0$

3. 1 mole of an ideal gas expand isothermally and reversibly from a pressure of 10 atm to 1 atm at 300 K. Calculate the height to which an object of 50 kg can be lifted by this expansion.

Solution: $w_{(exp.)} = -[2.303\ nRT \log (P_i / P_f)]$

$= -2.303 \times 1$ mol $\times$ 8.314 J $K^{-1}mol^{-1} \times 300$ K $\times \log 10/1$

$= 5.74 \times 10^3$ J

Now, $mgh = 5.74 \times 10^3$ J or 50 kg $\times$ 9.81 m $s^{-2} \times h = 5.744 \times 10^3$ J

$\therefore h = 11.7$ m

UNIT TEST-I

Time Allowed: 1 Hr. **Maximum Marks : 20**

General Instructions:

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

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1. For the reaction $2Cl(g) \longrightarrow Cl_2\ (g)$; what are the sign of ΔH and ΔS? [1]
2. Write an example of endothermic spontaneous reaction. [1]
3. 'w' amount of work is done by the system and 'q' amount of heat is supplied to the system. What type of system would it be? [1]
4. In a process 701 J of heat is absorbed by a system and 394 J work is done by the system. What is the change in internal energy for the process? [2]
5. State and explain Hess's Law of Constant Heat Summation with a suitable example. [2]
6. Calculate the number of kJ necessary to raise the temperature of 60 g of aluminium from 35 to 55°C . Molar heat capacity of Al is 24 J mol^{-1} K^{-1}. [3]
7. Calculate the standard enthalpy of formation of CH_3OH (l) from the following data:

   $CH_3OH(l) + 3/2\ O_2\ (g) \longrightarrow CO_2\ (g) + 2H_2O\ (l);$
   $\Delta_c\ H^\theta = -726\ \text{kJ mol}^{-1}$

   $C\ (g) + O_2\ (g) \longrightarrow CO_2\ (g);\ \Delta_f\ H^\theta = -393\ \text{kJ mol}^{-1}$

   $H_2(g) + ½\ O_2\ (g) \longrightarrow H_2O\ (l);\ \Delta_f\ H^\theta = -286\ \text{kJ mol}^{-1}$

8. (a) For oxidation of iron, $4\ Fe(s) + 3\ O_2(g) \longrightarrow 2\ Fe_2O_3(s)$ entropy change is –549.4 J K^{-1} mol^{-1} at 298 K. In spite of negative entropy change of this reaction, why is the reaction spontaneous? ($\Delta r\ H°$ for this reaction is –1648 kJ mol^{-1}) [2]

   (b) For the reaction: $2A\ (g) + B\ (g) \longrightarrow 2D\ (g)$, $\Delta U° = -10.5$ kJ and $\Delta S° = -44.1$ J K^{-1}. Calculate ΔG^0 for the reaction, and predict whether the reaction will occur spontaneously. [3]

UNIT TEST-II

Time Allowed: 1 Hr. **Maximum Marks : 20**

General Instructions:

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

---

1. Among following the property which is intensive is [1]

   (a) Mass (b) Volume

   (c) Temperature (d) Length

2. Heat of formation is zero for which substance. [1]

   (a) $CaCO_3$ (b) HCl

   (c) Carbon (Diamond) (d) Carbon (Graphite)

3. What is an isochoric process and what is the work value associated with isochoric process? [1]

In following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and Reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and Reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

4. **Assertion :** Work is path function parameter. [1]

   Reason : Work asociated with Isobaric process is zero.

5. **Assertion :** Heat of atomisation is zero for H_2(gas). [1]

   Reason : Hydrogen element has three isotopes.

6. Derive the expression for work done in isothermal reversible expansion. [3]

7. Define standard enthalpy of combustion and standard enthalpy of formation taking C_2H_6 (gas) molecule in both case. [2]

8. State 'Hess law of Constant heat summation'. The molar heat of combustion of $C_2H_2(g)$, C(Graphite) and $H_2(g)$ are 310.62kcal, 94.05 kcal and 68.32 kcal respectively. Calculate the standard heat of formation of $C_2H_2(g)$. [3]

9. The reaction of Cyanamid, $NH_2CN(s)$, with dioxygen was carried out in a bomb calorimeter, and ΔU was found to be -742.7 $kJmol^{-1}$ at 298 K. Calculate enthalpy change for the reaction at 298 K.

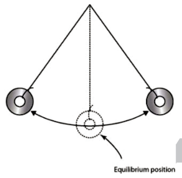
$$NH_2CN(s) + 1.5\ O_2(g) \rightarrow N_2(g) + CO_2(g) + H_2O(l)$$ [3]

10. (i) State the First Law of Thermodynamics.

(ii) Define Entropy. What is the effect of temperature on Entropy?

(iii) Two moles of an ideal gas are held by a piston under 5 atm pressure at 300 K. The pressure is suddenly released to 0.4 atm and the gas is allowed to expand isothermally. Calculate W, q, ΔE, ΔH. [5]

*****



Chapter - 7

Equilibrium

FAST TRACK : QUICK REVISION

- **Equilibrium :** It is a state in a process when two opposing processes (forward and reverse) occur simultaneously at the same rate. The free energy change at equilibrium state is zero *i.e.*, $\Delta G = 0$.

- **Equilibrium constant :** For a general reaction :

$$aA + bB \rightleftharpoons cC + dD$$

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b} \text{ and } K_p = \frac{P_C^c \times P_D^d}{P_A^a \times P_B^b}$$

- **Relationship between K_p and K_c :**

$$K_p = K_c (RT)^{\Delta n_g}$$

$$\Delta n_g = n_p(g) - n_r(g)$$

- Magnitude of equilibrium constant depends upon the way in which a reaction is written :

Chemical equation	Equilibrium constant
$aA + bB \rightleftharpoons cC + dD$	K
$cC + dD \rightleftharpoons aA + bB$	$K_1 = \frac{1}{K}$
$naA + nbB \rightleftharpoons ncC + ndD$	$K_2 = K^n$
$\frac{1}{n}aA + \frac{1}{n}bB \rightleftharpoons \frac{1}{n}cC + \frac{1}{n}dD$	$K_3 = K^{1/n}$

- **Predicting the direction of reaction :**

  If $Q_c = K_c \Rightarrow$ The reaction is in a state of equilibrium.

  $Q_c > K_c \Rightarrow$ The reaction proceeds in reverse direction.

  $Q_c < K_c \Rightarrow$ The reaction proceeds in forward direction.

- **Ostwald's dilution law :** Degree of dissociation of weak electrolyte, $\alpha = \sqrt{\frac{K}{C}}$

- **Ionic Product of water (K_w) = $[H_3O^+]$ $[OH^-]$ = 10^{-14} at 298K**

- **Le-Chatelier's Principle :** When a system of equilibrium is subjected to a change in temperature, pressure or concentration, the equilibrium shifts itself in such a way so as to undo or nullify the effect of change.

- **Outcomes of Le-Chatelier's Principle**

Change at equilibrium	Shift in equilibrium
Increase in temperature	Endothermic direction
Decrease in temperature	Exothermic direction
Increase in pressure	Towards lesser gaseous moles
Decrease in pressure	Towards greater gaseous moles
Increase in Conc. of reactants	Forward direction
Increase in Conc. of products	Reverse direction

- **Conjugate Acid or Base : Acid-base pair which differ by H^+ ion.**

  Species – H^+ = Conjugate base

  Species + H^+ = Conjugate acid

- **pH of solution :**

  $pH = -\log [H_3O^+]$ or $[H^+] = 10^{-pH}$, $pOH = -\log [OH^-]$

  $pH + pOH = pK_w = 14$ at 298K

- **Common ion effect** : The depression of ionisation of weak electrolyte by the presence of common ion from a strong electrolyte is called common ion effect. For example degree of dissociation of NH_4OH decreases in the presence of strong electrolyte NH_4Cl.

- **Hydrolysis of salts and pH of their solutions :** Hydrolysis of salt is defined as the reaction of cation or anion with water as a result of which the pH of water changes.

  1. Salts of strong and strong bases (*e.g.*, NaCl) do not hydrolyse. The solution pH will be 7.

  2. Salts of weak acids and strong bases (*e.g.*, CH_3COONa) hydrolyse, pH >7 (The anion acts as a base).

  $$X^- + H_2O \rightleftharpoons \underset{\text{(Weak acid)}}{HX} + \underset{\text{(Weak base)}}{OH^-}$$

  $$pH = 7 + \frac{1}{2}(pK_a + \log C)$$

  3. Salt of strong acids and weak bases (*e.g.*, NH_4Cl) hydrolyse, pH < 7. (The cation acts as an acid).

  $$M^+ + H_2O \rightleftharpoons MOH + H^+$$

  $$pH = 7 - \frac{1}{2}(pK_b + \log C)$$

  4. Salt of weak acids and weak base (*e.g.*, CH_3COONH_4) hydrolyse. The cation acts as an acid and anion as a base but whether the solution is acidic or basic depends upon the relative values of K_a and K_b for these **ions.**

  $$M^+ + X^- + H_2O \rightleftharpoons MOH + HX$$

  $$pH = 7 + \frac{1}{2}(pK_a - pK_b)$$

- **Buffer solutions :** The solutions, which resist the change in pH on dilution or addition of small amounts of acid or base, are called buffer solutions.

- **Basic buffer :** Solution of weak base and its salt with strong acid, For *e.g.*, $NH_4OH + NH_4Cl$

- **Acidic buffer :** Solution of weak acid and its salt with strong base, For *e.g.*, $CH_3COOH + CH_3COONa$.

- **Henderson Hasselbalch Equation for the pH of Buffer solution—**

$$pH = pK_a + \log\frac{[Salt]}{[Acid]} \qquad \text{(for acidic buffer)}$$

$$pOH = pK_a + \log\frac{[Salt]}{[Base]} \qquad \text{(for basic buffer)}$$

- **Solubility Product (K_{sp}) :** The equilibrium constant that represent the equilibrium between undissolved salt (solute) and its ions in a saturated solution is called solubility product constant (K_{sp}).

For $A_xB_y \overset{aq}{\rightleftharpoons} xA^{y+} + yB^{x-}$

$$K_{sp} = [A^{y+}]^x [B^{x-}]^y = (xs)^x (ys)^y = x^x.\ y^x.\ s^{(x+y)}$$

where s = Molar solubility

If ionic product < K_{sp} ; salt remain dissolve.

If ionic product > K_{sp} ; salt will be precipitated.

- **Relationship between solubility (s) and solubility product (K_{sp}).**

$$K_{sp} = x^x.y^y.\ s^{x+y}$$

For binary salts (*e.g.*, AgCl, AgBr, AgI) $\qquad K_{sp} = s^2$

For Ternary salts (*e.g.*, PbI_2) $\qquad K_{sp} = 4s^3$

MIND MAP : EQUILIBRIUM

EQUILIBRIUM

- Non Ionic Entities → **Chemical Equilibrium** → **Le-Chatlier Principle**
- Ionic Entities → Ionic Equilibrium

Equilibrium Constant

$aA + bB \rightleftharpoons cC + dD$

$$K_c = \frac{[C]^c\,[D]^d}{[A]^a\,[B]^b}$$

$$K_c = \frac{[P_C]^c\,[P_D]^d}{[P_A]^a\,[P_B]^b}$$

$K_p = K_c(R_5)$ and

$\Delta n_g = (c + d) + (a + b)$

Gaseous component A, B, C & D

Reaction Quotent

$$Q_c = \frac{[C]^c\,[D]^d}{[A]^a\,[B]^b}$$

$Q_c = K_c$ Reaction is at equilbrium

$Q_c < K_c$ Forward reaction favoured

$Q_c > K_c$ Backward reaction fovoured till new equilibrium is re-establish

Effect of Pressure

$\Delta n_g = 0$ No effect

$\Delta n_g > 0$ On increasing pressure backward reaction favoured and vice-versa

$\Delta n_g < 0$ On increasing pressure backward reaction favoured and vice-versa

Effect of Concentration

If reactant concentration increases or product decreases then forward reaction forward and vice-versa

Effect of Volume (Opposite 'P' Effect)

$\Delta n = 0$ No effect

$\Delta n > 0$ On increasing pressure backward reaction favoured and vice-versa

$\Delta n < 0$ On increasing pressure backward reaction favoured and vice-versa

Effect of Temperature

$$\log = \frac{K_2}{K_1} = \frac{\Delta H}{2.303} R\left(\frac{1}{T_1} - \frac{1}{T_1}\right)$$

For endothermic reaction ΔH is +

If T increases, forward reaction favoure and otherwise backward reaction

If T decreases, For Exothermic opposite effect

Effect of Inert Gas (N_2, Xe, Kr, etc.)

If inter gas is added at constant condition then no effect is observed

If inter gas is added at constant pressure then

at $\Delta n_g = 0$ No effect

$\Delta n_g > 0$ Forward reaction fovoured

$\Delta n_g < 0$ Forward reaction fovoured

IONIC EQUILIBRIUM

1 ACID / BASE

Arrhenius Concept

H^+ Donar – Acid (Hcl)

OH^- Donar – Base (NaOH)

Bronsted Lowry Concept

H^+ Donar (Acid)

H^+ Acceptor (Base)

Lewis Concept

Lone Pair Donar – Base (NH_3)

Lone Pair Acceptor – Acid ($AlCl_3$)

2 WEAK ACID / BASE

- $K = \frac{K\alpha^2}{C}$ $\qquad \alpha = \sqrt{\frac{K\alpha}{C}}$ (dilute sol.)
- $[H^+] = [c\alpha] = \sqrt{Ka.c}$
- $[OH^-] = [c\alpha]$
- $pH = \frac{1}{2}[pKa - logC]$

3 pH, pOH

- $pH = -\log [H_3O^+]_{total}$
- $[H_3O^+] = 10^{-pH}$
- $pOH = -\log [OH^-]_{total}$
- $pH + pOH = 14$ (298K)

4 SOLUBILITY PRODUCT

A_xB_y Salt solution has solubility 'S' M

$A_xBr \leftrightharpoons xA^{4-}_{(aq.)} + \gamma B^{x-}_{(aq.)}$

$K_{sp} = x^x.y^y [S]^{x+y}$

$A_xB_y = K_{sp} = 1^1.2^2.S^{1+2} = 4S^3$

$A_2b_3 = K_{sp} = 2^2.3^3.S^{2+3} = 108.S^3$

5 BUFFER SOLUTIONS

Acid Buffer ($CH_3COOH + CH_3COONa$)

$[H^+] = \frac{K_a.[Acid]}{[Salt]}$

$pH = pk_a + \log \frac{Salt}{Acid}$

Basic Buffer ($NH_4OH + NH_4Cl$)

$[OH^-] = \frac{K_b.[Acid]}{[Salt]}$

$pOH = pk_b + \log \frac{[Salt]}{[Acid]}$

6 SALT HYDROLYSIS

Acid Salt (NH_4Cl) : $K_H = \frac{K_w}{K_b}$ $\qquad pH = 7 - \frac{1}{2}[pk_a + logC]$

$h = \sqrt{K_w / K_b.c}$

Basic Salt (CH_3COONa) : $K_H = \frac{K_w}{K_a}$ $\qquad pH = 7 + \frac{1}{2}[pk_a + logC]$

$h = \sqrt{K_w / K_b.c}$

Mixed Salt (CH_3COONH_4) : $K_H = \frac{K_w}{K_a.K_b}, \frac{h}{1-h} = \sqrt{K_H}$

K_H = Hydrolysis constant $\qquad h = \sqrt{\frac{K_w}{K_aK_b}} = \sqrt{K_H}$

h = Degree of Hydrolysis $\qquad pH = 7 + \frac{1}{2}[pk_a - pk_b]$

CASE BASED STUDY QUESTIONS

PASSAGE -1

According to Arrehenius theory, acids are substances that dissociates in water to give hydrogen ions and bases are substances that produce hydroxyl ions.

Bronsted-Lowry gave a more general definition of acids and bases. According to Bronsted-Lowry theory , acid is a substance that is capable of donating a hydrogen ion and bases are substance which are capable of accepting of a hydrogen ion.

According to Lewis Acids and Bases , an acid is a species which accepts electron pair and base which donates an electron pair

The following questions are multiple choice questions. Choose the most appropriate answer:

I. Which among of the following can act as Lewis as well as Bronsted-Lowry base

(A) H_2O (B) HF

(C) NH_4^+ (D) CH_4

II. Among following the one pair that does not act as conjugate acid-base pair is

(A) H_2O, H_3O^+ (B) HCO_3^-, H_2CO_3

(C) HSO_4^-, H_2SO_4 (D) NH_4^+, NH_2^-

III. Which among the following is weakest base

(A) ClO_4^- (B) ClO_3^-

(C) ClO_2^- (D) ClO^-

IV. Which among the following is not Lewis acid

(A) $AlCl_3$ (B) Co^{3+}

(C) Mg^{2+} (D) NH_3

ANS: I. A, II. D, III. A , IV.D

PASSAGE -2

Common Ion effect is the phenomenon in which weak acid or weak base dissociation is suppressed due to the presence of the common ion provided by the strong electrolyte . For example the dissociation of CH_3COOH is suppressed by the addition of the CH_3COONa. Similarly the dissociation of NH_4OH is suppressed due to presence of NH_4Cl.This occurs due to the Le-Chatlier's principle .

In these questions (Q. No V-VIII , a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

V. ASSERTION : The dissociation of HCN is decreased when HNO_3 is added to solution.

REASON : HNO_3 is a strong acid which provides H^+ .

VI. ASSERTION : When NaOH (solid) is added to NH_4OH solution , then pH increases

REASON : NH_4OH dissociation decreases by addition of NaOH

VII. ASSERTION : A mixture of CH_3COOH and CH_3COONa act as buffer solution.

REASON : A buffer solution resist change in pH by addition of large amount of Base or Acid.

VIII. ASSERTION : NH_4Cl is basic salt

REASON : NH_4Cl is produced by adding weak base NH_4OH and strong acid HCl.

ANS: V. A, VI. B, VII. C, VIII. D

MULTIPLE CHOICE QUESTION (MCQ)

1. For the hypothetical reactions, the equilibrium constant (k) values are given

   $A \rightleftharpoons B : k_1 = 2$

   $B \rightleftharpoons C: K_2 = 4$

   $C \rightleftharpoons D : K_3 = 8$

   The equilibrium constant (K) for the reaction $A \rightleftharpoons D$ is

   (a) 48 (b) 24 (c) 12 (d) 64

2. The equilibrium constant for the reaction

   $SO_2(g) + \frac{1}{2} O_2(g) \rightleftharpoons SO_3(g)$ is 5×10^{-2} atm$^{-1/2}$

   The equilibrium constant for the reaction

   $2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$ would be

   (a) 100 atm (b) 25×10^{-4} atm (c) 400 atm (d) 125×19^{-6} atm$^{-3/2}$

3. $A(g) + 3B(g) \rightleftharpoons 4C(g)$ initial concentration of A is equal to that of B. The equilibrium concentrations of A and C are equal. What is the equilibrium constant for

   $4C(g) \rightleftharpoons A(g) + 3B(g)$

   (a) 4 (b) 1/8 (c) B (d) 16

4. The equilibrium reaction that is not affected by volume change at constant temperature is

   (a) $H_2(g) + Cl_2(g) \rightleftharpoons 2HCl(g)$ (b) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

   (c) $PCl_5(g) \rightleftharpoons PCl_3(g) + C1_2(g)$ (d) $H_2(l) + CO_2(g) \rightleftharpoons H_2CO_3(l)$

5. For the reaction $CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$, the value of K_c/K_p is equal to

   (a) RT (b) $(RT)^2$ (c) 1/RT (d) 1.0

6. At 90°C pure water has $K_w = 10^{-12}$. The solution with pH value 6.5 is

   (a) Acidic (b) Basic (c) Amphoteric (d) Data insufficient

7. 40 ml of 0.1 M NH_4OH is mixed with 20 mL of 0.1 M HCl. What is the pH of the mixture? (pK_b of ammonia solution = 4.74)

(a) 4.74 (b) 2.26 (c) 9.26 (d) 5

8. Identify Bronsted Lowry Acids in the reaction

$$\underset{(X)}{[Al(H_2O)_6]^{3+}} + \underset{(Y)}{HCO_3^-} \rightleftharpoons \underset{(P)}{[Al(H_2O)_5(OH)]^{2+}} + \underset{(Q)}{H_2CO_3}$$

(a) X, Y (b) Y, P (c) P, Q (d) X, Q

9. The pK_a of weak acid HA is 4.80 and pK_b of a weak base BOH is 4.78. The pH of an aqueous solutions of corresponding salt BA will be

(a) 7.01 (b) 4.79 (c) 9.22 (d) 10.0

10 If 'p' M is the solubility of $KAl(SO_4)_2$, then K_{sp} is equal to

(a) p^3 (b) $4p^4$ (c) p^4 (d) $4p^3$

TRUE AND FALSE TYPE QUESTIONS

1. Equilibrium state can be achieved if a reversible reaction is carried out in closed or open container.

2. For a reaction $2A(g) \rightleftharpoons B(g)$ $Q_c > K$ if 'A' is added maintaining $Q_c > K$, the reaction will move in backward direction.

3. For the reaction at equilibrium

   $CaCO_3 \rightleftharpoons CaO(s) + CO_2(g)$

   What CaO(s) is removed reaction moves in forward direction.

4. For a reaction $aA + bB \rightleftharpoons cC + dD$ at equilibrium $\Delta G^0 = 0$ always.

5. For a reaction at equilibrium $H_2(g) + Cl_2(g) \rightleftharpoons 2HCl(g)$

   K = 4, the value of $\dfrac{K_b[HCl]^2}{K_f[H_2][Cl_2]}$ is 1.

6. For the electrolyte A_2B if K_{sp} is solubility product then its solubling 'S' M is $[K_{sp}]^{1/3} \div 4$.

7. HCO_3^- is conjugate base of H_2CO_3.

8. H_2O can act as acid as well as base.

9. The pH of buffer solution remain same when any amount of dilution is done.

10. For a salt AB_2(s) solution if Ionic product (I.P) > K_{sp}, then precipitation will take place.

Ans. 1. False 2. True 3. False 4. False 5. True
6. True 7. True 8. True 9. False 10. True

FILL IN THE BLANKS

1. At equilibrium rate of forward reaction is always equal to ....
2. K_p & K_c are .... for reaction at equilibrium of type $H_2(g) + Br_2(g) \rightleftharpoons 2HBr(g)$.
3. If K_c for reaction $CH_3COOH(l) + C_2H_5OH \rightleftharpoons CH_3COOC_2H_5(l) + H_2O(l)$ is 4. Then Q_c and K_c are .... at equilibrium.
4. If A+B –70J/mol $\rightleftharpoons$ D, reaction temperature is increased then reaction moves in .... direction.
5. Presence of catalyst will ...... the equilibrium constant.
6. The conjugate acid of H_2O is ....
7. On dilution, the degree of dissociation of acetic acid will ....
8. The presence of NH_4Cl in NH_4OH solution will .... the degree of dissociation of NH_4OH.
9. If Ionic product (IP) < K_{sp} for a salt solution of AB, then addition of AB further .... lead to precipitation initially.
10. K_p is always equal to K_c if Δn_g is ....

Ans. 1. rate of backward reaction, 2. equal, 3. equal, 4. backward direction forward, 5. not change, 6. H_3O^+, 7. increase, 8. decrease, 9. will not, 10. zero.

MATCH THE COLUMNS

I. Match the reaction in Column I with the parameters in Column II and unit (M=Molarity) of K eq in Column III

S.N.	Column I	Column II	Column III
1.	$N_2(g)+3H_2(g) \rightleftharpoons 2NH_3(g)$, ΔH= -ve	(a) T increase then K increase	(p) M^0
2.	$2N_2(g)+2O_2(g) \rightleftharpoons 4NO(g)$, ΔH= +ve	(b) T increase then K decrease	(q) M^{2-}
3.	$2X(g) \rightleftharpoons Y(g)$, ΔH= +Ve	(c) P has not effect	(r) M^{-1}
4.	$PCl_5(g) \rightleftharpoons PCl_3(g)+Cl_2(g)$, ΔH= +ve	(d) Equilibrium move forward On addition of Xe Gas	(s) M

II. Match the parameter in Column I with the pH expression in Column II and examples in Column III

S.N.	Column I	Column II-pH	Column III
1.	Salt of weak acid and weak base	(a)7+ 0.5(pka +logC)	(p) NH_4Cl
2.	Salt of weak acid and strong base	(b) 7+ 0.5(pka -pkb)	(q) NaCl
3	Salt of strong acid and strong base	(c)7- 0.5(pkb +logC)	(r) CH_3COONa
4.	Salt of strong acid and weak base	(d) 0.5 (pkw)	(s) CH_3COONH_4

ANS. :

MATCH-I : 1. b, q 2. c, p 3. a, r 4. d, s

MATCH-II : 1. b, s 2. a, r 3. d, q 4. c, p

ASSERTION - REASON TYPE QUESTION

Each question contains statement-1 (assertion) and Statement-2 (Reason) Examine the statements carefully and mark the correct answer according to the instruction given below :

A. If both the statements are true and statement -2 is the correct explanation of statement-I
B. If both the statements are true but statement-2 is not the correct explanation of statement-I
C. If statement-I is true and statement-2 is false
D. If statement-I is false and statement-2 is true.

1. Statement-1 : The endothermic reactions are favoured at lower temperature and the exothermic reactions are favoured at higher temperature.
   Statement-2 : when a system in equilibrium is disturbed by changing the temperature, it will tend to adjust itself so as to overcome the effect of change.
2. Statement-1 : The melting point of ice decreases with increase of pressure
   Statement-2 : Ice contracts on melting.
3. Statement -1 : The gas phase reaction $PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$ shifts to the right on increasing pressure.
   Statement-2 : When pressure increase, equilibrium shifts towards more number of moles.

4. Statement-1 : The chemical equilibrium is not static but dynamic in nature.
Statement-2: The chemical equilibrium is a state in which two opposing process are proceeding at the same rate.

5. Statement-1 : The catalyst does not change the equilibrium constant.
Statement-2 : Because for the catalysed reaction and uncatalysed reaction ΔH remains same and equilibrium constant depends on ΔH.

6. Statement-1 : If water is heated to 59°C, the pH will increase.
Statement-2 : K_w increases with increase in temperature.

7. Statement-1: Addition of HCl(aq.) to CH_3COOH (aq.) decrease the ionisation of CH_3COOH (aq.).
Statement-2 : Due to common ion effect H^+, ionisation of CH_3COOH decreases.

8. Statement-1: Sparingly soluble salts AB and XY_2 with the same solubility product, will have different solubility.
Statement 2: Solubility of sparingly soluble salts depends upon solubility product.

9. Statement-1 : The ionisation constants of weak diprotic acid are in the order of $Ka_1 > Ka_2$.
Statement-2 : Removal of H^+ from anion is difficult as compared to neutral atom.

10. Statement-1 : In a titration of weak acid with strong base, the pH at the half equivalence point is pK_a.
Statement-2 : At half equivalence point, it will form acidic buffer at its maximum capacity where [Acid] = [Salt].

Ans.: 1. D, 2. A, 3. C, 4. A, 5. A, 6. D, 7. A, 8. B, 9. A, 10. A

ONE WORD ANSWER TYPE QUESTIONS

1. What is sum of pH + pOH at 25ºC? [**Ans.** 14]
2. Write the Henderson Hasselbalch equation for acidic buffer
Ans. $pH = pka + 10g \frac{[SALT]}{[ACID]}$
3. How is degree of dissociation related with concentration terms and Ka, for weak electrolyte. **Ans.** $\alpha = \sqrt{Ka / c}$
4. How NH_3 is defined as Lewis base?
[**Ans.** It contain Lone paid of electrons]
5. How are K_p and K_c related? [**Ans.** $K_p = K_c (RT)^{\Delta n}$]
6. How does K affected for endothermic reaction if temperature is increased?
[**Ans.** K get decreased]

7. What is the effect of catalyst on K? [**Ans.** K remains unaffected]

8. How is pH scale affected by increasing temperature? [**Ans.** pH scale gets contracted]

9. What is the conjugate base of HCO_3^-? [**Ans.** CO_3^{2-}]

10. What is the nature of CH_3COOH in conc. HCl solution? [**Ans.** Bronsted Base]

1-MARK QUESTIONS

1. Define physical equilibrium. Give an example also.

2. Fizz is observed when soda water bottle is opened. Why ?

3. Justify the statement : 'Both physical and chemical equilibrium are dynamic in nature'

4. State Law of Chemical equilibrium.

5. In a reversible reaction, the two substances are in equilibrium. If the concentration of each one is reduced to half, then what is the effect on the equilibrium constant ?

6. K_1 and K_2 are equilibrium constant for reactions (1) and (2)

(i) $N_2(g) + O_2(g) \rightleftharpoons 2\,NO(g)$

(ii) $NO(g) \rightleftharpoons 1/2\,N_2(g) + 1/2\,O_2(g)$

Calculate the relation between K_1 and K_2.

7. Write the equilibrium constant expression for the following reaction :

$3\,Fe(s) + 4\,H_2O(g) \rightleftharpoons Fe_3O_4(s) + 4\,H_2(g)$

8. Classify the equilibrium as homogeneous or heterogeneous :

$CH_3COOC_2H_5(aq.) + H_2O(1) \rightleftharpoons CH_3COOH(aq.) + C_2H_5OH\,(aq.)$

9. $K_p = \dfrac{(P_{NH_3})}{(P_{H_2})^{3/2}(P_{N_2})^{1/2}}$

Write the balanced chemical equation corresponding to the above expression.

10. Give the direction in which the reaction would proceed if $Q_c > K_c$.

11. $Hb(s) + O_2(g) \rightleftharpoons HbO_2(s)$

Predict the direction in which equilibrium gets shifted if partial pressure of $O_2(g)$ is lowered.

12. Discuss the position of equilibrium if the following reaction is carried out in the presence of catalyst.

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

13. Which of the following are Lewis acids ?

H_2O, BF_3, H^+, NH_4^+

14. Write the conjugate acids for the following Bronsted bases.

C_6H_5OH, H_2O

15. Write the conjugate bases for the following Bronsted acids.

H_2O, CH_3COOH.

16. Which of the following are Lewis acids ?

(a) H_2O (b) $AlCl_3$ (c) NH_4^+

17. Define Ostwald's dilution law.

18. SO_3^{2-} is Bronsted base or acid and why ?

19. Why pH of our blood remains almost constant at 7.4 though we quite often eat spicy food ?

20. pH of black coffee is 5.0 at 25ºC. Is black coffee acidic or basic ? [**Ans.** Acidic]

21. What will be the value of ($pK_a + pK_b$) at 25ºC.

22. What will be the pH of 1 M KNO_3 solutions at 25ºC?

23. $CaCl_2(s) + H_2O(l) \rightleftharpoons CaCl_2(aq.) + Heat$

Discuss the solubility of $CaCl_2$ if temperature is increased.

24. Why does the solubility of CO_2 decrease with rise in temperature ?

25. The solubility of A_2X_3 is y mol dm^{-3}. Calculate its solubility product.

26. Write the K_{sp} expression for $Al(OH)_3$.

27. What is the condition for precipitation of a salt ?

28. Pridict whether the solution is acidic, basic or natural when NH_4NO_3 undergo hydrolysis.

29. Explain why pure NaCl precipitates out when HCl gas is passed through the solution of NaCl ?

30. Give the Henderson's Hasselbalch equation for an acidic buffer solution.

31. On which of the factors the equilibrium depend : Temperature, nature of reactant and product, initial concentration and pressure of the reactants.

32. Arrange the following in increasing acidic strength HCl, HBr, HF, HI

[**Ans.** HF < HCl < HBr < HI]

33. Arrange the following in increasing Lewis base strength

NH_3, BiH_3, PH_3, AsH_3, SbH_3

[**Ans.** $BiH_3 < SbH_3 < ASH_3 < PH_3 < NH_3$]

34. Arrange following in increasing pH value

0.1M CH_3COOH, 0.1 M NaCl, 0.1MHCl, 0.1MNaOH, 0.1MNH_4OH

[**Ans.** 0.1MHCl < 0.1M CH_3COOH < 0.1M NaCl < 0.1 NH_4OH < 0.1M NaOH]

35. Arrange following in increasing order of degree of hydrolysis.

0.1M NH_4OH, 0.01 M NH_4OH, 10^{-5} M NH_4OH, 10^{-3} M NH_4OH, 10^{-6} M NH_4OH

[**Ans.** 0.1M NH_4OH < 10^{-2} M NH_4OH, 10^{-3}M NH_4OH< 10^{-5}MNH_4OH < 10^{-6} M NH_4OH]

36. Arrange following in increasing order of acidic strength

CH_3COOH, HCOOH, CH_3CH_2COOH, C_6H_5COOH, CH_2COOH

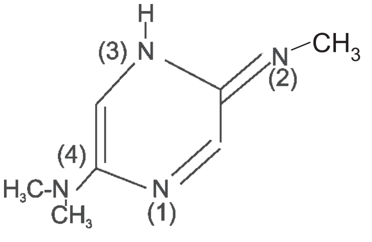
[**Ans.** $CH_3COOH < C_6H_5COOH < HCOOH < CH_2FCOOH$]

37. Arrange following in increasing order of basic strength in gas phase

NH_3, $(CH_3)_2NH$, $(CH_3)_3N$, CH_3NH_2

[**Ans**. $NH_3 < NH_3NH_2 < (CH_3)_2NH < (CH3)_3N$]

38. Arrange the following pkb in increasing order



[**Ans.** $pK_2 < pK_1 < pK_4 < pK_3$]

39. Arrange the basic strength of following

F^-, Br^-, Cl^-, I^-

[**Ans.** $I^- < Br^- < Cl^- < F^-$]

40. Arrange the following in increasing base strength

CH_3^-, NH_2^-, OH^-, F^-

[**Ans.** $F^- < OH^- < NH_2 < CH_3^-$]

2-MARKS QUESTIONS

1. The standard Gibbs energy change at 300 k for the reaction $2A \rightleftharpoons B + C$ is 2494. 2 J. At a given temperature, and time. the composition of the reaction mixture is [A] = ½, [B] = 2, [C] = ½. The reaction proceed in the (R = 8.314J/K/mo1, = 2.718) [**Ans.** Reverse direction]

2. The equilibrium constant for

   $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ is K, then calculate equilibrium constant for $\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons NO(g)$. [**Ans.** $\sqrt{K}$]

3. For the reversible reaction $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ at 500°C, the value of Kp is 1.44×10^{-5} atn^{-2}. Find the K_c value.

   [**Ans.** $1.44 \times 10^{-5} / (0.082 \times 773)^{-2}$]

4. The equilibrium constant at 298 K for the reaction $A + B \rightleftharpoons C + D$ is 100. If the initial concentration of all the four species were 1M each, then equilibrium concentration of D will be [**Ans.** 1.818]

5. For the reaction

   $NH_4COO\ NH_2(s) \rightleftharpoons 2NH_3(g) + CO_2(g)$

   If equilibrium pressure is 3 atm. Find the value of Kp [**Ans.** 4]

6. A buffer solution with pH 9 is to be prepared by mixing NH_4Cl that should be added to one litre of 1.0m NH_4OH kb 1.8×10^{-5}

   [**Ans.** $NH_4Cl = 1.8$ M]

7. Calculate the solubility of silver chloride in water at room temperature if the K_{sp} of AgCl is 1.6×10^{-10}. [**Ans.** 1.26×10^{-5}M]

8. Calculate the molar solubility of $Ni(OH)_2$ in 0.10m NaOH. The ionic product of $Ni(OH)_2$ is 2.0×10^{-15}. [**Ans.** 2.0×10^{-13}M]

9. Calculate the pH of 10^{-8} M HCl solution. [**Ans.** 6.96]

10. How many grams of NaOH must be dissolved in IL of the solution to give it a pH value of 12? [**Ans.** 0.4g]

3-MARKS QUESTIONS

1. The equilibrium constant for the reaction $H_2(g) + Br_2(g) \rightleftharpoons 2HBr(g)$ at 1024 K is 1.6×10^5. Find the equilibrium pressure of all gases if 10.0 bar of HBr is introduced into a sealed container at 1024K. [**Ans.** 10 bar]

2. For the reaction $2BrCl(g) \rightleftharpoons Br_2(g) + Cl_2(g)$ K_c is 32 at 500 K. If initially pure BrCl is present at a concentration of 3.30×10^{-3} M, what is its molar concentration in the mixture at equilibrium? [**Ans.** 3.0×10^{-4} M]

3. What is the equilibrium constant K_p and K_c for the reaction $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ if the pressure is 1.0 atm in 8.0L container at equilibrium.

   [**Ans.** $K_c = 0.04$ $K_p = 1.77$]

4. The K_p for the reaction, $N_2O_4(g) \rightleftharpoons NO_2(g)$ is 640 mm at 775 K. Calculate the percentage dissociation of N_2O_4 at equilibrium pressure of 160mm. At what pressure the dissociation will be 50%.

   [**Ans.** 70.7%, P = 480 mm]

5. Show that degree of dissociation (α) for the dissociation of PCl_5 into PCl_3 and Cl_2 at pressure P is given by $\alpha = \left[\dfrac{Kp}{P + kp}\right]^{1/2}$

6. How much of 0.3M NH_4OH should be mixed with 30 mL of 0.2m solution of NH_4Cl to give a buffer solution of pH 10. pk_b for NH_4OH is 4.75.

   [**Ans.** V = 112.5 mL]

7. Predict whether a precipitate will be formed or not on mixing 20 mL of 0.001 N NaCl solution with 80 mL of 0.01 M $AgNO_3$ solution. K_{sp} for AgCl is 1.5×10^{-10}. [**Ans.** Yes, ppt will formed.]

8. The values of Ksp of two sparingly soluble salts $Ni(OH)_2$ and AgCN are 2.0×10^{-15} and 6.0×10^{-17} respectively. Which salt is more soluble. Explain

[**Ans.** $S_{Ni(OH)_2} = 5.8 \times 10^{-5}M : S_{(Ag\ CN)} = 7.8{\times}10^{-9}M$. $Ni(OH)_2$ is more soluble]

9. The ionization constant of propanoic acid is $1.32{\times}10^{-15}$. Calculate the degree of ionization if its solution is 0.05 M. What will be its degree of ionization if the solution is 0.01 M in HCl solution.

[**Ans.** 1.62×10^{-2}, 1.32×10^{-3}]

10. Calculate the pH of a solution obtained by mixing 50ml of 0.2M HCl with 49.9 mL of 0.2m NaOH solution. [**Ans.** 3.699]

HOTS QUESTIONS

1. The molar solubility of $Cd(OH)_2$ is $1.84 \times 10^{-5}M$. Calculate the expected solubility of $Cd(OH)_2$ in a buffer solution of pH = 12.

Ans. $Cd(OH)_2 \rightleftharpoons Cd^{2+}_{(aq.)} + 2OH^{-}_{(aq.)}$

$$\quad\quad S \quad\quad\quad 10^{-2}$$

$2.49 \times 10^{-14} = S(10^{-2})^2$ $\quad\therefore S = 2.49 \times 10^{-10M}$

2. An aqueous solution contains an unknown concentration of Ba^{2+}. When 50 ml of a 1M solution of Na_2SO_4 is added. $BaSO_4$ just begins to precipitate. The final volume is 500ml. The solubility product of $BaSO_4$ is $1{\times}10^{-10}$. Find the original concentration.

Ans. $K_{sp} = \left[Ba^{2+}\right]\left[SO_4^{2-}\right] = \left[Ba^{2+}\right]\left[\frac{50 \times 1}{500}\right] = 10^{-9} \times 500$

$Ba^{2+} = 10^{-9}$ M

$10^{-9} \times 500 = 450 \times M$ $\quad\therefore M = 1.11 \times 10^{-9}M$

3. An aqueous solution contains 0.10 M H_2S and 0.20 M HCl. If the equilibrium constants for the formation of HS^- from H_2S is 1.0×10^{-7} and that of S^{2-} from $4S^-$ ions is $1.2{\times}10^{-13}$, then find the concentration of S^{-2} ions in aqueous solution.

Ans. $H_2S(aq.) \rightleftharpoons 2H^+ + S^{2-}$

$(0.1 - x) \quad (2x + 0.29) \quad x$

$$K_a = K_{a_1} \times K_{a_2} = 1.2 \times 10^{-20}$$

$$1.2 \times 10^{-20} = \frac{(0.2)^2[S^{2-}]}{0.1}, \ [S^{2-}] = 3 \times 10^{-20}$$

4. How many litres of water must be added to 1 litre of an aqueous solution of HCl with a pH of 1 to create an aqueous solution with pH of 2?

Ans. $0.1 \times 1 = (1 + v)(0.01) \Rightarrow v = 9L$

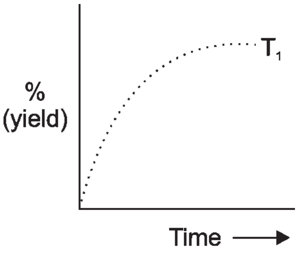
5. A certain buffer solution contains equal concentration of X^- and HX. The K_b for X^- is 10^{-10}. Find the pH of the buffer .

Ans. $k_a.k_b = 10^{-14} \quad \therefore k_a = \frac{10^{-14}}{10^{-10}} = 10^{-4}$

$$pH = pka + \log\frac{[x^-]}{[Hx]}$$

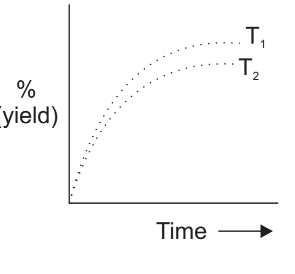
$$\therefore pH = 4 + \log\frac{1}{1} = 4 \quad \therefore pH = 4$$

6. The % yield of Ammonia as a function of time in the reaction $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, $\Delta H < O$ at (P, T) is given below:



If this reaction is conducted at $T_2 > T_1$, then plot the % yield of NH_3 as a function of time on same graph

Ans. Initially on increasing temperature the rate of reaction increases, however since the reaction is exothermic therefore % yield of NH_3 get decreased overall after a certain interval of time.



7. Consider the reaction $NH_4COONH_2(s) \rightleftharpoons 2NH_3(g) + CO_2(g)$ at a certain temperature, the equilibrium pressure of the system is 0.318 atm. Find K_p of the decomposition of ammonium carbonate.

Ans. $P_{total} = 3P \qquad \therefore P = 0.318/3 = 0.106$

$Kp = 4P^3 = 4.76 \times 10^{-3}$

8. The equilibrium constant for the reaction $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$ is 5. How many moles of CO_2 must be added to 1 litre container already containing 3 moles each of CO and H_2O to make 2M equilibrium concentration of CO?

Ans.

	CO	+ H_2O	$\rightleftharpoons$ CO_2	+ H_2
t = 0	3	2	x	0
At equilibrium	2	2	x+1	1

$$\therefore \ S = \frac{x+1}{4} \Rightarrow x = 19$$

9. At constant temperature, the equilibrium constant K_p

$N_2O_4 \rightleftharpoons 2NO_2$ is given by

$k_p = \dfrac{4x^2P}{1-x}$ where, P = Pressure and X = Extent of reaction

How does the value of K_p change on following changes

(a) ‘P’ increases

(b) X changes

(c) ‘P’ decreases

Ans. K_p is equilibrium constant which does not change on changing the P, x.K_p depends on temperature.

10. When two reactants A and B are mixed to give product 'c' and 'p' the reaction quotient 'Q' at the initial stages of the reaction will be?

Ans. In the beginning of the reaction Q = 0. As the reaction proceeds in the forward direction Q starts increasing.

At chemical equilibrium Q = K

UNIT TEST-I

Time Allowed: 1 Hr. **Maximum Marks : 20**

General Instructions:

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

---

1. What is the pH 10^{-3} M HCl solution ? [1]

   (a) 1 (b) 11 (c) 3 (d) 14

2. Which one can act as Arrhenius Acid ? [1]

   (a) NH_3 (b) H_2O (c) HCl (d) C_6H_5OH

3. Write the conjugate base of CH_3COOH, H_2O. [1]

4. Write the relation between K_p and K_c. [1]

5. What is the nature of following reaction [1]

   Exothermic or endothermic

   $A + B - 70J \longrightarrow C$

6. The pka of CH_3COOH and pkb of NH_4OH are 4.76 and 4.75 respectively. Calculate the pH of CH_3COONH_4. [2]

7. What is a buffer solution. Calculate the pH of the solution obtained by adding 4mol of CH_3COOH with 3 mol of NaOH in 1 litre container. [2]

   pka, $CH_3COOH = 4.74$ log2 = 0.3010 log3 = 0.4771

8. Calculate the molar solubility of $Ni(OH)_2$ in 0.1M KOH solution. The K_{sp} for $Ni(OH)_2$ is 2.0×10^{-15}. [3]

9. $K_p = 0.04$ atm at 899 K for the equilibrium shown below. What is the equilibrium concentration of H_2 when it is placed in a flask at 4.0 atm pressure and allowed to come to equilibrium. [3]

   $C_2H_6(g) \rightleftharpoons C_2H_4(g) + H_2(g)$

10. The first ionization constant of H_2S is 9.1×10^{-4}. Calculate the concentration of HS^{-1} in its 0.1 M solution. How will this concentration be effected if the solution is 0.1 M HCl also? If the second dissociation constant of H_2S is 1.2×10^{-12}. Calculate the concentration of S^{2-} in both conditions. [5]

UNIT TEST-II

Time Allowed: 1 Hr. **Maximum Marks : 20**

General Instructions:

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

---

1. What is the pH 10^{-8} MHCl solution ? [1]

   (a) pH>7 (b) pH<7

   (c) pH=7 (d) Cannot be defined

2. What is the conjugate acid for the NH_3? [1]

   (a) NH_2^- (b) NH^{2-}

   (c) N^{3-} (d) NH_4^+

3. Define Lewis acid and base with one example each. [1]

In following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and Reason both are correct statement and reason is correct explanation for assertion.

(b) Assertion and Reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

4. **Assertion :** HI is stronger acid than HCl [1]

   Reason : Size of I is more than Cl and hence H-I bond strength is less than HCl.

5. **Assertion :** BF_3 is Lewis acid and NH_3 is Lewis base. [1]

   Reason : NH_3 is short of octet and BF_3 molecule contain lone pair of electron.

6. Arrange the following in increasing acidic strength. Give reason also

   CH_4, NH_3, H_2O, HF [2]

7. K_c for the reaction $SO_2 + 0.5O_2 \rightarrow SO_3$ at 600°C is 61.7. Calculate K_p. [2]

8. 25.4 ml of hydrogen and 20.4 ml of iodine when heated in a closed container, produced 30.8 mL of HI at equilibrium. Calculate the degree of dissociation of HI at same temperature. [3]

9. Define common ion effect. The solubility of CaF_2 in water at T K is $2x10^{-4}$ moles/L. Calculate (i) K_{sp}, and (ii) Solubility in 0.01 M NaF solution. [3]

10. (i) What is a buffer solution? What are its types?

    (ii) Derive the Henderson-Hasselbalch equation for an Acidic buffer with the help of relevant example.

    (ii) 8g of NaOH was dissolved in one litre of a solution containing one mole of CH_3COOH and one mole of CH_3COONa. Find the pH of the resulting solution. (The pK_a of CH_3COOH is 4.74). [5]

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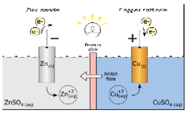


Chapter - 8

Redox Reactions

FAST TRACK : QUICK REVISION

Oxidation and Reduction :

	Oxidation		Reduction
1.	Addition of oxygen.	1.	Removal of oxygen.
2.	Removal an Hydrogen.	2.	Addition of Hydrogen.
3.	Addition of an electronegative element.	3.	Removal of an electronegative element.
4.	Removal of an electropositive element.	4.	Addition of an electropositive element.
5.	Loss of electron(s).	5.	Gain of electron(s).
6.	Increase in oxidation number.	6.	Decrease in oxidation number.

- **Reducing Agent :** Reduce other substance and oxidise itself.
- **Oxidising Agent :** Oxidise other substance but reduce itself.
- **Redox Reaction :** Reactions in which oxidation and reduction takes place simultaneously.
- **Oxidation Number :** It is charge that an atom appears to have in a given species when the bonding electron are counted towards more electro-negative atom.
- **Calculation of Oxidation Number :**

  (a) Oxidation number of all the elements in their elemental form (in standard state) is taken as zero. Oxidation number of element in a molecule Cl_2, F_2, O_2, P_4, O_3, Fe, H_2, N_2, C (graphite) is zero.

  (b) Common Oxidation number of elements of first group is +1. Common Oxidation number of elements of second group + 2.

  (c) For ions composed of only one atom, the oxidation number is equal to the charge on the ion.

(d) The oxidation number of oxygen in most compounds is – 2. While in peroxides (*e.g.*, H_2O_2, Na_2O_2), each oxygen atom is assigned an oxidation number of – 1, in super oxides (*e.g.*, KO_2, RbO_2) each oxygen atom is assigned an oxidation number of – (½).

(e) In oxygen difluoride (OF_2) and dioxygen difluoride (O_2F_2), the oxygen is assigned an oxidation number of + 2 and + 1, respectively.

(f) The oxidation number of hydrogen is + 1 but in metal hydride its oxidation no. is – 1.

(g) In all its compounds, fluorine has an oxidation number of – 1.

(h) The algebraic sum of the oxidation number of all the atoms in a compound must be zero.

(i) In polyatomic ion, the algebraic sum of all the oxidation numbers of atoms of the ion must equal the charge on the ion.

- **Types of Redox Reactions:**

(i) Combination Reaction :

$$\overset{0}{3\,Mg}\,(s) + \overset{0}{N_2}\,(g) \xrightarrow{\Delta} \overset{+2}{Mg_3}\overset{-3}{N_2}\,(s)$$

(ii) Decomposition Reaction :

$$2\overset{+1}{K}\overset{+5}{Cl}\overset{-2}{O_3}(s) \xrightarrow{\Delta} 2\,\overset{+1}{K}\overset{-1}{Cl}(s) + 3\overset{0}{O_2}\,(g)$$

(iii) Metal Displacement :

$$\overset{+2}{Cu}\overset{+6}{S}\overset{-2}{O_4}\,(aq) + \overset{0}{Zn}(s) \rightarrow \overset{+2}{Zn}\overset{+6}{S}\overset{-2}{O_4}\,(aq) + \overset{0}{Cu}\,(s)$$

(iv) Non-metal displacement :

$$\overset{0}{Ca}\,(s) + 2\,\overset{+1}{H_2}\overset{-2}{O}\,(l) \rightarrow \overset{+2}{Ca}\,(\overset{-2}{O}\overset{+1}{H})_2 + \overset{0}{H_2}\,(g)$$

(v) Disproportionation reactions : It is a reaction in which same element is reduced and oxidized simultaneously.

$$\overset{0}{Cl_2}\,(g) + 2\,OH^-\,(aq) \rightarrow \overset{-1}{Cl^-}\,(aq) + \overset{+1}{Cl}O^-\,(aq) + H_2O\,(l)$$

- **Stock Notation :** Representing oxidation number of metal in Roman numerals within parenthesis after the symbol or name of metal in the molecular formula or name of a compound. For *e.g.*, Stock Notation of Ferric oxide is $Fe_2(III)O_3$ or Iron (III) oxide.

- **Fractional Oxidation Number :** When two or more atoms of an element are present in different oxidation states, then calculated oxidation number may comes out as fractional due to average of all the different oxidation states.

In reality no element can have a fractional oxidation state.

- **Balancing of Redox Reactions :**

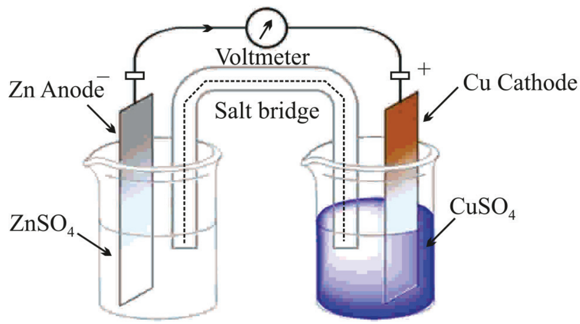
  (A) Oxidation number method

  (B) Half reaction method

- **Electrode Potential (E) :** Potential difference between electrode and electrolytic solution due to charge separation.

- **Standard Electrode Potential (E^{θ}) :** Electrode Potential measured at 298 K and 1M concentration of metal ions (or 1 bar pressure of gas).

- **Electrochemical Cell :** A device in which chemical energy of a spontaneous redox reaction is converted into electrical energy.



Cell diagram: Zn | Zn^{2+} || Cu^{2+} | Cu

LHS oxidation, $Zn \rightarrow Zn^{2+} + 2e^-$

RHS reduction $Cu^{2+} + 2e^- \rightarrow Cu$

Overall reaction $Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$

- Representation of an Electrochemical cell :

$$\xrightarrow{\text{Flow of electrons}}$$

$$\xleftarrow{\text{Flow of current}}$$

$$Zn(s) \mid Zn^{2+}(aq) \parallel Cu^{2+}(aq) \mid Cu(s)$$

	Left Electrode	Salt Bridge	**R**ight Electrode
LOAN	**O**xidation		**R**eduction
	Anode		**C**athode
	Negative		**P**ositive

- **Functions of Salt Bridge :** (i) To complete inner circuit. (ii) To maintain electrical neutrality around electrodes.

MIND MAP : REDOX REACTIONS

REDOX REACTION

REDUCTION

- Addition of Hydrogen
  $Na + H_2 \longrightarrow NaH$
- Addition of electropositive element
  $2HgCl_2 + SnCl_2 \longrightarrow Hg_2Cl_2 + SnCl_4$
- Removal of Oxygen
  $2HgO \longrightarrow 2Hg(l) + O_2(g)$
- Removal of electronegative element
  $2FeCl_3 + H_2 \longrightarrow 2FeCl_2 + 2HCl$
- Gain of electron or decrease in oxidation number
  $2Na + Cl_2 \longrightarrow 2\overset{+}{Na}Cl^-$
  Cl get reduced

Oxidant or Oxidising Agents
Substance which get reduced and help to oxidise other substance.

OXIDATION

- Addition of oxygen
  $Mg + O_2 \longrightarrow MgO$
- Addition of electronegative element
  $Mg + F_2 \longrightarrow MgF_2$
- Removal of Hydrogen
  $2H_2S + O_2 \longrightarrow 2S + 2H_2O$
- Removal of electronegative element
  $2K_4[Fe(CN)_6] + H_2O_2 \longrightarrow 2K_3[Fe(CN)_6] + 2KOH$
- Loss of electron or increase in oxidation number
  $2Na + Cl_2 \longrightarrow Na^+Cl^-$
  Na — oxidise

Reduction / Reducing Agent
Substance which get oxidised itself but help to reduce others substance is called Reducing Agent / Reductant.

Types of Redox Reaction

- Combination Reactioin
  $\overset{0}{C} + \overset{0}{O}_2 \longrightarrow C^{+4}O_2^{-2}$
- Decomposition Reaction
  $2K\overset{+5}{Cl}O_3^{-2} \longrightarrow 2KCl^{-1} + 3\overset{0}{O}_2$
- Displacement Reaction
  a) Metal Displacement
  $Cr_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Cr$
  b) Non-Metal Displacement
  $2Na + 2H_2O \longrightarrow 2NaOH + H_2$
- Disproportionation Reaction
  $H_2O_2 \longrightarrow 2H_2O + O_2$

ELECTROCHEMICAL

$Zn\,|Zn^{2+}|\,|Cu^{2+}|Cu$

$E^\circ_{Cell} = E - E^\circ_L = E^\circ_{Cathode} - E^\circ_{Anode}$

$Zn + Cu^{2+} \longrightarrow Zn^{2+} + Cu$

$E_{Cell} = E^\circ_{Cell} - \frac{0.0591}{2} \log \frac{[Zn^{2+}]}{[Cu^{2+}]}$

E°_{Cell} = 0 At equilibrium

E_{Cell} < 0 Non spontaneous reaction

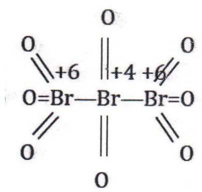
E_{Cell} > 0 Spontaneous reaction

CASE BASED STUDY - QUESTIONS

1. Read the given passage and answer the questions.

Redox reactions are reactions in which oxidation and reduction takes place simultaneously. Oxidation number are assigned in accordance with the set of rules. Oxidation number and ion electron methods both are used in balancing ionic equations. Redox reactions are classified as combination, decomposition, displacement and disproportionation reactions. The concept of redox couple and electrode processes is basis of electrolysis and electrochemical cells.

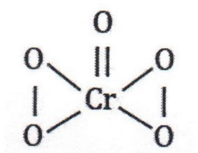
(a) What are oxidation number of each individual Br in $Br_3O_8^{2-}$?

Ans. +6, +4, +6 

(b) If electrolysis of $CuSO_4$, solution is carried out using Cu electrodes, what will be reaction taking place at anode.

Ans. $Cu \rightarrow Cu^{2+} + 2e^-$

(c) What is oxidation number of Cr in CrOs?

Ans. +6 

∵ It has peroxide linkage.

(d) Give one example of disproportionation reaction.

Ans. $2Cu^+ \rightarrow Cu^{2+} + Cu$

(e) $MnO_4^{2-} + H^+ \rightarrow MnO_4^- + MnO_2 + H_2O$ [Balance this reaction]

Ans. $MnO_4^{2-} \rightarrow MnO_4^- + e^-$ ....(i)×2

$2e^- + 4H^+ + MnO_4^{2-} \rightarrow MnO_2 + 2H_2O$ ....(ii)

$3MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O$

2. **Redox Reactions : Passage Based Question (Assertion and Reason)**

Passage : Redox reactions are those reactions in which, there is a simultaneous oxidation and reduction taking place. There is an addition of oxygen and removal of hydrogen taking place in oxidation reactions. In Reduction, hydrogen gets added and oxygen gets removed. Redox reactions are also used to determine the strength of reductant/oxidant. In oxidation, there is a decrease in electron density while in reduction, there is an increase in electron density around the atom.

(Q1-Q4) There are assertion and reason which have been put forward. Read the given statement and choose correct alternative from the following :

(Note : A-Assertion & R-Reason)

(a) Both A and R are true and R is the correct explanation of A.

(b) Both A and R are true but R is not the correct explanation of A.

(c) A is true but R is false.

(d) A is false but R is true.

Q1. **A :** Oxidation-Reduction (Redox) couple is the combination of oxidized and reduced form of a substance that is involved in Oxidation-Reduction half cell.

R: As in representation E° Fe^{3+}/Fe^{2+} and E° Cu^{2+}/Cu^{+} are two Redox couples.

Q2. **A :** In Formaldehyde (HCHO) oxidation no. of carbon is 0.

R: Formaldehyde is a covalent compound.

Q3. **A :** Oxidation state of hydrogen is water is +1 and CaH_2 is -1.

R: CaH_2 is metal hydride and for hydrogen, it assigned the oxidation state of -1.

Q4. **A :** Redox reactions are also called neutralization reactions.

R: As the number of electron gained/lost in the reaction are balanced.

Or

A : Substances which get reduced an act as reducing agent.

R: Oxidizing agent itself gets reduced.

Ans. : Q1. (c), Q2. (b), Q3. (a), Q4. (d) or (d)

MULTIPLE CHOICE QUESTIONS (MCQ)

1. The oxidation state of Fe in Fe_3O_4 is

(a) +2 (b) + 3

(c) $\frac{8}{3}$ (d) + 2, + 3

2. The oxidation state of 'S' in $KAl(SO_4)_2 .12H_2O$ is

(a) –2 (b) – 1

(c) 2 (d) + 6

3. Oxidation state carbon in C_3O_2 is

(a) $\frac{4}{3}$ (b) 0

(c) 2 (d) 0, 2

4. The reaction $S_8 + 12OH^- \longrightarrow 4S^{2-} + 2S_2O_3^{2-} + 6H_2O$ is

(a) Combination reaction (b) Decomposition reaction

(c) Non-metal displacement (d) Disproportionation reaction

5. E^0 for H^+/H_2 is

(a) 0 (b) +1V

(c) –1.0V (d) –2.0V

6. Which one act as strong oxidising agent

$K^+/K = -2.9\ 3V$, $Ag^+/Ag = 0.80$, $Hg^{2+}/Hg = 0.79V$

(a) K^+ (b) K

(c) Hg^{2+} (d) Ag^+

7. The coefficient of HCl in balance reaction is

$Pb_3O_4 + HCl \longrightarrow PbCl_2 + Cl_2 + H_2O$

(a) 1 (b) 8

(c) 3 (d) 4

8. Sum of oxidation numbers of all Bromine atoms in Br_3O_8 is

(a) 6 (b) 4

(c) 16 (d) 20

9. In the reaction $6ClO_2^- \longrightarrow 4ClO_3^- + 2Cl^-$, Cl^- ion is

(a) Oxidised Reduced (b) Reduced

(c) Odixised and (d) Neither Oxidised nor reduced

10. 'I' can not act as reducing agent in following state

(a) -1 (b) $+1$

(c) $+7$ (d) $+5$

Ans: 1. (d) 2. (d) 3. (d) 4. (d) 5. (a) 6. (d) 7. (b) 8. (c) 9. (c) 10. (d)

FILL IN THE BLANKS

(i) Oxidation is __________ of electrons.

(ii) S.H.E. stands for __________.

(iii) Oxidation state of Oxygen in O_2F_2 is __________.

(iv) Disproportionation is a type of __________ reaction.

(v) Oxidant is one which __________ electron..

(vi) $Cl_2 + 2OH^- \longrightarrow ClO^- + Cl^-$ is a __________ type of reaction.

(vii) Oxidation state of F is always either ______ or _____ .

(viii) Oxidation state of Oxygen in O_3 is __________ .

(ix) Reducing agent are also called __________.

(x) Hydrogen economy is use of Hydrogen as _________.

Ans: (i) loss, (ii) standard hydrogen electrode, (iii) +1, (iv) redox, (v) gain, (vi) disproportionation, (vii) 0, –1, (viii) zero, (ix) reductant, (x) fuel

TRUE AND FALSE TYPE QUESTIONS

(i) In Redox reaction first oxidation take place.

(ii) Oxidising agents are also called reductant.

(iii) Fluorine cannot have +1 oxidation state.

(iv) O_2^+ has oxidation state of oxygen as +½.

(v) If for the reaction $Ca^{2+} + 2e^- \longrightarrow Ca(s)$; $E^\ominus = -2.87$

Then for the reaction $2Ca^{2+} + 4e^- \longrightarrow 2Ca(s)$; $E^\ominus = 2(-2.87)V$

(vi) Salt bridge is used for enhancing E° values of individual half reaction.

(vii) Anode is –ve charged in Galvanic cell.

(viii) KCl can be use in salt bridge.

(ix) Current flows in galvanic cell from Anode to cathode.

(x) MnO_4^- is colourless in basic medium.

Ans: (i) False (ii) False (iii) True (iv) True (v) False (vi) False (vii) True (viii) True (ix) False (x) False

MATCH THE COLUMNS

1. **Column-I** — **Column-II**

Column-I	Column-II
(a) $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$	(p) Disproportionation
(b) $Cr_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Cr$	(q) Non-metal displacement
(c) $Fe + 2HCl \longrightarrow FeCl_2 + H_2$	(r) Metal displacement
(d) $P_4 + 3OH^- + 3H_2O \rightarrow PH_3 + 3H_2PO_2^-$	(s) Metal displacement

Ans. (a) – (s) (b) – (r) (c) – (q) (d) – (p)

2.

Column-I	Column-II (Oxidation sate of N)
(a) NO	(p) + 5
(b) NO_2	(q) + 3
(c) NO_2^-	(r) + 4
(d) NO_3^-	(s) + 2

Ans. (a) – (s) (b) – (r) (c) – (q) (d) – (p)

3.

Column-I	Column-II
(A) Increase in oxidation number	(a) Loss of electron
(B) Reducing agent	(b) Oxidation
(C) $MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + H_2O$	(c) Natural redox reaction
(D) Photosynthesis	(d) Redox reaction

Ans. (A) – (b) (B) – (a) (C) – (d) (D) – (c)

4.

Column-I	Column-II
(A) Decrease in oxidation number	(a) Disproportionation
(B) Oxidizing agent	(b) Fractional oxidation number
(C) $2Cu^+ \rightarrow Cu^{2+} + Cu$	(c) Reduction
(D) Mn_3O_4	(d) Gain of electron

Ans. (A) – (c) (B) – (d) (C) – (a) (D) – (b)

5.

Column-I	Column-II
(A) H_2O_2	(a) –1
(B) $MnSO_4$	(b) +3
(C) $AlCl_3$	(c) +5
(D) P_2O_5	(d) +6

Ans. (A) – (a) (B) – (d) (C) – (b) (D) – (c)

ASSERTION AND REASON TYPE QUESTIONS

Each question contain statement-1 (Assertion) and statement-2 (Reason)

Examine the statements carefully and work the correct answer according to the instruction given below :

(a) If both the statements are True and Statement-2 is the correct explanation of the statement-1

(b) If both the statements are True and statement-2 is not the correct explanation of statement-1

(c) If statement-1 is true and statement-2 is False.

(d) If statement-1 is false and statement-2 is True.

1. Statement - 1 : In HF, the oxidation state of 'F' is –1
   Statement - 2 : 'F' being most electronegative, will have -1 oxidation in its compound.

2. Statement - 1 : Oxygen has zero oxidation state in O_2.
   Statement - 2 : Element in their elemental form have zero oxidation state.

3. Statement - 1 : Oxidation state of Oxygen in H_2O_2 is –1.
   Statement - 2 : H_2O_2 has peroxide linkage.

4. Statement - 1 : For the reaction $Zn + Cu^{2+} \longrightarrow Zn^{2+} + Cu$; E_{cell} is +ve.
   Statement - 2 : For standard Hydrogen electrode $E^\circ = 0$

5. Statement - 1 : $2H_2O_2 \longrightarrow 2H_2O + O_2$ is Decomposition reaction (Redox).
   Statement - 2 : Oxygen has -2 oxidation state in H_2O.

6. Statement - 1 : $C + O_2 \longrightarrow CO_2$; carbon get oxidised.
   Statement - 2 : Gain of Hydrogen is reduction.

7. Statement - 1 : $CaCO_3 \longrightarrow CaO + CO_2$ is not redox reaction.
   Statement - 2 : C, Ca, O do not change their oxidation number in the reaction.

8. Statement - 1 : Oxidation also occurs when decrease in electron density is observed.
   Statement - 2 : Oxidation is gain of electro-positive element.

9. Statement - 1 : $Cr_2O_7^{2-}$ is a self indicator.
   Statement - 2 : MnO_4^- acts as a self indicator.

10. Statement - 1 : Equivalence point comes first before end point.

Statement - 2 : Equivalence point cannot be obtained even by graphical method.

Ans: 1. (a) 2. (a) 3. (a) 4. (b) 5. (d) 6. (b) 7. (a) 8. (c) 9. (d) 10. (d)

ONE WORD ANSWER TYPE QUESTIONS

1. What is the oxidation number of S in S_8.
2. What is the oxidation state of Oxygen in H_2O_2.
3. Name the substance used in salt-bridge.
4. Name an indicator which can act as self-indicator.
5. When a substance gains electron, it is called :
6. Name the ion which is used for balancing the hydrogen atom in acidic medium.
7. In the reaction $3Mg + N_2 \longrightarrow Mg_3N_2$, Nitrogen is oxidised or reduced.

Ans: 1. zero 2. 1 3. NH_4Cl or KCl 4. $KMnO_4$

5. Reduction 6. H^+ 7. Reduced

1-MARK QUESTIONS

1. Define oxidation and reduction according to electronic concept.
2. Define oxidation and reduction according to oxidation number.
3. A freshly cut apple is almost white but it turns reddish brown after sometime. Give reason.
4. Define oxidation number.
5. Write oxidation number of Mn in $KMnO_4$.
6. Write oxidation number of Cr in $Cr_2O_7^{2-}$.
7. Write Stock notation of MnO_2 and $AuCl_3$.
8. Define redox reaction with example.
9. Define disproportionation reaction. Give one example.
10. Define the term redox titration.

11. Name the indicator used in redox titration involving $K_2Cr_2O_7$ as an oxidizing agent.

12. At what concentration of Cu^{2+} (aq.) will electrode potential become equal to its standard electrode potential ? [**Ans.** 1 M]

13. The standard reduction potentials of three metals cations X, Y and Z are + 0.52, – 3.03 and – 1.18 V respectively. Arrange X, Y and Z in order of increasing reducing power. [**Ans.** X < Z < Y]

14. An electrochemical cell consists of two electrodes *i.e.*, Anode and Cathode. What is the direction of flow of electrons in this cell ?

15. Why anode is negatively charged in an electrochemical cell?

16. Out of Zn and Cu vessel one will be more suitable to store 1 M HCl? [**Ans.** Cu]

Given $E^{\theta}_{Zn^{2+}/Zn} = -0.76$ V, $E^{\theta}_{Cu^{2+}/Cu} = +0.34$ V.

15. Is it safe to stir 1 M $AgNO_3$ solution with copper spoon ?

Given $E^{\theta}_{Ag^{+}/Ag} = +0.80$ V, $E^{\theta}_{Cu^{2+}/Cu} = +0.34$ V. [**Ans.** No]

2-MARKS QUESTIONS

1. Identify oxidant and reductant in the reaction :

$$I_2\,(aq) + 2S_2O_3^{2-}\,(aq) \longrightarrow 2\,I^-\,(aq) + S_4O_6^{2-}(aq).$$

2. Calculate oxidation number of Fe in Fe_3O_4 and write a suitable justification of your answer.

3. Oxidation-reduction reactions are complementary. Explain.

4. Write formula for the following compounds :

(i) Mercury (II) chloride

(ii) Nickel (II) sulphate

(iii) Iron (III) sulphate

(iv) Chromium (III) oxide

5. Justify that the reaction : $H_2O(s) + F_2 \longrightarrow HF + HOF$ is a redox reaction.

6. A decomposition reaction may or may not be a redox reaction. Write two decomposition reactions in support of the statement.

7. Split the reaction $2\ K\ (s) + Cl_2\ (g) \longrightarrow 2\ KCl\ (s)$ into oxidation and reduction half reactions.

8. Calculate the oxidation number of underlined elements in following compounds :

   (i) $Ca\underline{O}_2$ (ii) $H_2\underline{S}_2O_7$ (iii) $K_2\underline{Mn}O_4$ (iv) $K\underline{I}_3$

9. Write the functions of salt bridge in an electrochemical cell.

10. Define the term redox couple. Write the practical application of redox couple.

11. The standard reduction potentials of two metals A and B are – 0.76 V and + 0.34 V respectively. An electrochemical cell is formed using electrodes of these metals.

    (i) Identify the cathode and anode.

    (ii) Write the direction of flow of electron.

3-MARKS QUESTIONS

1. Calculate oxidation number of :

   (i) Cr in $Cr_2O_4^{2-}$

   (ii) O in KO_2

   (iii) Na in Na_2O_2.

2. Account for the following :

   (i) HNO_3 acts as oxidizing agent while HNO_2 can act both as reducing and oxidizing agent.

   (ii) AgF_2 is unstable compound and act as a strong oxidizing agent.

   (iii) Ozone acts as an oxidising agent.

3. Permanent ion (MnO_4^-) reacts with sulfur dioxide gas in acidic medium to produce Mn^{2+} ion and hydrogen sulphate ion. Write ionic equation and balance by ion electron method.

4. Balance the following equation by oxidation number method :

   $P_4(s) + OH^-(aq) \longrightarrow PH_3 + H_2PO_2^-(aq)$ [*Basic Medium*]

5. Balance the following equation by ion electron method :

   $C1_2O_7(g) + H_2O_2(1) \longrightarrow ClO_2^-(aq) + O_2(g)$ [*Basic medium*]

6. Depict the galvanic cell in which the reaction

   $Zn(s) + 2Ag^+(aq) \longrightarrow Zn^{2+}(aq) + 2Ag(s)$ takes place. Further show :

   (i) Which electrode is negatively charged ?

   (ii) The carriers of the current in the cell

   (iii) Individual reaction at each electrode.

7. Explain with suitable reasons :

   (i) Reaction $FeSO_4(aq) + Cu(s) \longrightarrow CuSO_4(aq) + Fe$ does not occur.

   (ii) Zinc can displace copper from aqueous $CuSO_4$ solution but Ag cannot.

   (iii) Solution of $AgNO_3$ turns blue when copper rod is immersed in it.

5-MARKS QUESTIONS

1. (i) MnO_4^{2-} undergoes disproportionation reaction in acidic medium but MnO_4^- does not. Give reason.

   (ii) Give one example each of the following redox reactions:

   (a) Combination reaction

   (b) Decomposition reaction

   (c) Metal displacement reaction

2. Consider the cell reaction of an electrochemical cell : $Ni(s) + 2Ag^+(aq) \rightarrow Ni^{2+}(aq) + 2Ag(s)$ and answer the following questions :

   (i) Write anode and cathode half reactions.

   (ii) Mention the direction of flow of electrons.

(iii) How is the electrical neutrality maintained in the solutions of the two half cells ?

(iv) Write the formula for calculating standard emf of this cell.

(v) How does the emf change when the concentration of silver ions is decreased ?

3. Justify the reason that following reactions are redox reactions.

(a) $CuO\ (s) + H_2\ (g) \longrightarrow Cu\ (s) + H_2O\ (g)$

(b) $Fe_2O_3 + 3CO\ (g) \longrightarrow 2\ Fe\ (g) + 3CO_2\ (g)$

(c) $NH_3\ (g)\ 5O_2\ (g) \longrightarrow 4NO\ (g) + 5H_2O\ (g)$

(d) $BCl_3\ (g) + 3\ LiAlH_4 \longrightarrow B_2H_6 + LiCl + AlCl_3$

(e) $2K + F_2 \longrightarrow 2KF$

[**Hints:**– CuO is oxidizing agent, H_2 is acting as reducing agent because Cu (II) is changing to Cu (0) by gain of e^- H_2 is getting oxidised to H_2O (g), its oxidations sate is changing from 0 to +1, by loss of electrons.

(ii) It is redox reaction: Fe_2O_3 is getting reduced to fe. CO is getting oxidised to CO_2.]

4. Using standard electrode : Predict if the reaction between as the following is feasible.

(i) Fe^{3+} (aq) and I^- (aq)

(ii) Ag^+ and Cu

(iii) Fe^{3+} and Br^- (aq)

(iv) Ag and Fe^{3+} (aq)

(iv) Br_2 (aq) and Fe^{2+} (aq)

Hint:– $E^\theta_{I_2/I^-} = 0.541$ V, $E^\theta_{Cu^{2+}/Cu}$, $= 0.34$V, $E^\theta_{Br_2/Br^-} = 1.09$V, $E^\theta_{Ag^+/Ag} = 0.80$V, $E^\theta_{Fe^{3+}/Fe^{2+}} = 0.77$V.

5. Draw the diagram for the galvanic cell which would have overall chemical reaction as

$$Zn + 2Ag^+ \longrightarrow Zn^{2+} + 2Ag.$$

Answer the following :

(i) Write the reactions occurring at each electrode.

(ii) In which directions do the electrons flow in the external circuit?

(iii)Name the salt to be taken in salt bridge.

(iv)Label the anode and cathode.

(v) How does the EMF change when the concentration of solvers ions is decreased?

HOTS QUESTIONS

1. 6×10^{-3} mole $K_2Cr_2O_7$ reacts completely with 9×10^{-3} mole X^{n+} to give XO_3^- and Cr^{3+}. Find the value of X.

Ans. $K_2Cr_2O_7 + X^{n+} \longrightarrow \overset{+5}{X}O_3^- + Cr^{3+}$

$6\times10^{-3} \times 6 = (5\text{-}n) \times 9 \times 10^{-3} \longrightarrow n = 1$

2. For the redox reaction

$K_2Cr_2O_7 + X\ H_2SO_4 + Y\ SO_2 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + ZH_2O$

What is the sum of $x + y + z$

Ans. $K_2Cr_2O_7 + H_2SO_4 + 3SO_2 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + H_2O$

$\therefore x = 1 \quad y = 3 \quad z = 1 \quad \therefore x + y + z = 5$

3. An aqueous solution containing 1M each of Au^{+3}, Cu^{+2}, Ag^+, Li^+ is being electrolysed using inert electrodes the value of standard potentials are

$E^\theta_{Ag^+/Ag} = 0.80\ V,\quad E^\theta_{Cu^2+Cu} = 0.34\ V,\quad E^\theta_{Au^{3+}/Au} = 1.50\ V,\quad E^\theta_{Li^+/Li} = -3.03V$

With increasing voltage, find the sequence of deposition of metals on the cathode.

Ans. Only Au^{3+}, Ag^+ and Cu^{2+} will deposit at cathode.

Li^+ will not deposit at cathode be cause SRP of water is -0.8274V

So after Cu^{2+} ; H_2 will evolve at cathode.

4. E^θ for $Cl_2\ (g) + 2I^- \longrightarrow 2Cl^-\ (aq.)$ is 1.36 V, then calculate.

E^θ for $4C1^-\ (aq.) \longrightarrow 2Cl_2(g) + 4e^-$

Ans. $E^\theta_{Cl^-/Cl_2} = -1.36$ E^θ is independent of amount of substance

5. Why salt bridge is made up of saturated solution of KNO_3 in agar–agar.

Ans. Velocities of both K^+ and NO_3^- are nearly the same.

UNIT TEST-I

Time Allowed: 1 hr **Maximum Marks : 20**

General Instructions:

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

---

1. Identify the oxidised and Reduced species in the following reaction [1]

$$H_2S + Cl_2 \longrightarrow 2HCl + S$$

(a) H_2S (b) Cl_2 (c) Both H_2, Cl_2 (d) None of these

2. What is the oxidation state of Br in BrO_3^-? [1]

(a) +1 (b) +3 (c) +4 (d) +5

3. Classify the type of reaction in Redox Reaction form : [1]

$$3H_2O + P_4 + 3OH^- \longrightarrow PH_3 + 3H_2PO_2^-$$

4. What is a redox couple? Give one example.

5. Identify oxidant in reaction given below : [1]

$$CuO(s) + H_2\,(g) \longrightarrow Cu(s) + H_2O(g)$$

6. Assign oxidation number to the underlined elements [2]

(a) $NaH_2\underline{P}O_4$ (b) $H_4\underline{P_2}O_7$ (c) $K_2\underline{Mn}O_4$ (d) $H_2\underline{S_2}O_7$

7. Predict product of electrolysis in following case [2]

- An aqueous solution of $CuCl_2$ with platinum electrodes.

8. Consider the reaction $Zn(s) + 2Ag^+\,(aq.) \longrightarrow Zn^{2+}\,(aq.) + 2Ag(s)$

Answer following : [3]

(i) Which electrode is negatively charged ?

(ii) What are carrier of current in the cell ?

(iii) Individual reaction at each electrode.

9. E^θ values are given : $K^+/K = -2.93V$, $Ag^+/Ag = 0.80V$ [3]

$Hg^{2+}/Hg = 0.79V$ $Mg^{2+}/Mg = -2.37V$, $Cr^{3+}/Cr = -0.74V$

(i) Which one is strong reducing agent ?

(ii) Which one is strong oxidising agent ?

(iii) Which redox couple is a stronger reducing agent than H^+/H_2 ?

10. Balance the reaction (ion-electron or oxidation number) [5]

$$P_4(s) + OH^-(aq.) \longrightarrow PH_3\,(g) + H_2PO_2^-\,(aq.) \quad \text{[Basic medium]}$$

UNIT TEST-II

Time Allowed: 1 Hr. (REDOX REACTIONS) Maximum Marks : 20

General Instructions:

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

---

1. The average oxidation No. of Iodine is I_3^- ion is. [1]

2. What is oxidation state of Cr in $K_2Cr_2O_7$? [1]

3. Write the name of cell in which chemical energy is converted into Electrical energy. [1]

4. Why is anode negatively charged in an electrochemical cell? [1]

5. Identify the oxidised and Reduced species in the following reaction

   $H_2S + Cl_2 \longrightarrow 2HCl + S$ [1]

6. A decomposition reaction may or may not be a redox Reaction. Write two decomposition reactions in support of the statement. [2]

7. Write the functions of salt bridge in a electrochemical cell. [2]

8. Account for the following : [3]

   (i) HNO_3 acts as oxidizing agent while HNO_2 can act both as Reducing and oxidizing agent.

   (ii) AgF_2 is unstable compound and act as a strong oxidizing agent.

   (iii) Ozone acts as an oxidizing agent.

9. Explain with suitable reasons : [3]

   (i) Reaction $FeSO_4$ (aq) + Cu(s) $\rightarrow$ $CuSO_4$ (aq) + Fe does not occur.

   (ii) Zinc can displace copper from aqueous $CuSO_4$ solution but Ag cannot.

   (iii) Solution of $AgNO_3$ turns blue when copper rod is immersed in it.

10. (i) Give one example each of the following redox reactions : [3]

   (a) Combination Reaction

(b) Decomposition Reaction

(c) Metal displacement Reaction

(ii) Remaining two are Assertion and Reason. Read the statement carefully and choose the correct alternative : [2]

(a) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.

(b) Both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

(c) Assertion is true but Reason is false.

(d) Both Assertion and Reason are false.

(I) **Assertion :** Redox couple is the combination of oxidised and Reduced from of a substance involved in an oxidation or reduction half cell.

Reason : In the Representation E^{θ} Fe^{3+}/Fe^{2+} and E^{θ} Cu^{2+}/Cu, Fe^{3+}/Fe^{2+} and Cu^{2+}/Cu are Redox couples.

(II) **Assertion :** Oxidation no. of C in HCHO is zero.

Reason : Formaldehyde is covalent compound.

*****

Chapter - 9

Hydrogen

FAST TRACK : QUICK REVISION

- Hydrogen is the first element in the periodic table and also the lightest element known. Electronic configuration of Hydrogen is $1s^1$.
- **Isotopes of hydrogen :**

  (i) Protium ($_1^1H$)

  (ii) Deuterium ($_1^2H$ or $_1^2D$)

  (iii) Tritium ($_1^3H$ or $_1^3T$)
- **Preparation of Dihydrogen :**

  (i) **Laboratory preparation :** $Zn + 2H^+ \rightarrow Zn^{2+} + H_2$.

  (ii) **Commercial preparation :** By electrolysis of acidified water.

  (iii) High purity dihydrogen is obtained by electrolysing warm aqueous barium hydroxide.
- **Properties :**

  * Reaction with halogen: $H_2 + X_2 \longrightarrow 2HX$ [X = F, Cl, Br, I]
  * Reaction with oxygen: $H_2(g) + O_2(g) \xrightarrow{\Delta} 2H_2O(l)$;

  $$\Delta H^{ø} = -285.9 \text{ kJ mol}^{-1}$$

  * Reaction with nitrogen: $3H_2(g) + N_2(g) \xrightarrow{\Delta} 2NH_3(g)$;

  $$\Delta H^{ø} = -92 \text{ kJ mol}^{-1}$$

  * Reaction with alkali metals: $H_2(g) + 2M(g) \xrightarrow{\Delta} 2MH(s)$

  It is relatively inert at room temperature due to the high H-H bond enthalpy.
- **Uses of Dihydrogen :**

  (i) For synthesis of Ammonia (NH_3)

(ii) For production of Methanol (CH_3OH)

(iii) In oxyhydrogen torches

(iv) In a fuel cell.

- **Hydrides**

  (i) **Ionic or salt like or saline hydrides** are formed with most of the *s*-block elements. Significant covalent character is found in LiH, BeH_2 and MgH_2.

  (ii) **Covalent or Molecular hydrides** are formed with most of the *p*-block elements. There are further classified as :

  (a) **Electron deficient hydrides** are formed by group 13 elements *e.g.*, B_2H_6. They acts as Lewis acid.

  (b) **Electron Precise hydrides** are formed by group 14 elements *e.g.*, CH_4.

  (c) **Electron rich hydrides** have lone pair of electrons on central atoms of the molecules. Elements of group 15-17 form these types of hydrides.

  NH_3, HF has high m.p./b.p. due to presence of intermolecular hydrogen bonding.

  (iii) **Metallic or Non-stoichiometric or Interstitial hydrides** are formed by *d* and *f* -block elements. For example La $H_{2.87}$ or $NiH_{0.6-0.7}$.

- **Water :** (H_2O)

  Hard water : Hard water contains calcium and magnesium salts in the form of hydrogencarbonate, chloride and sulphate. Hard water does not give lathers with soap.

  Soft water : Water free from soluble salts of calcium and magnesium is soft water.

  Types of Hardness :

  Temporary hardness is due to presence of calcium or magnesium hydrogen carbonate in water. Temporary hardness can be removed by :

  (i) Boiling

  (ii) Clark's Method

  Permanent hardness :

  Such hardness is due to presence of calcium or magnesium chlorides and sulphates.

Permanent hardness can be removed by :

(i) Treatment with washing soda

(ii) Calgon's method

(iii) Ion exchange method.

Demineralised or Deionised water : Water free from all soluble mineral salts is known as **demineralised water.**

- **Hydrogen Peroxide (H_2O_2)**

  Preperation :

  (i) By electrolytic oxidation of acidified sulphate solutions at high current density.

  (ii) 2-Ethylanthraquinol $\underset{H_2/Pd}{\overset{O_2\text{ (air)}}{\rightleftharpoons}}$ H_2O_2 + (Oxidised product)

- **Physical Properties**

  (i) Miscible with water in all proportions.

  (ii) A 30% of H_2O_2 solution is marked as **'100 volume' hydrogen peroxide.**

- **Chemical Properties :**

  (i) It acts as an oxidising as well as reducing agent.

  (ii) **Oxidising action in acidic medium :**

  $$2Fe^{2+}(aq) + 2H^+(aq) + H_2O_2(aq) \longrightarrow 2Fe^{3+}(aq) + 2H_2O(l)$$

  (iii) **Reducing action in acidic medium :**

  $$2MnO_4^- + 6H^+ + 5H_2O_2 \longrightarrow 2Mn^{2+} + 8H_2O + SO_2$$

- **Storage of H_2O_2 :**

  (i) Stored in wax-linked glass or plastic vessels in dark. Urea can be added as a stabiliser.

  (ii) It is kept away from dust because dust can induce explosive decomposition of the compound.

- **Uses of H_2O_2 :**

  (i) As an antiseptic it is sold in the market name **perhydrol**.

  (ii) In synthesis of hydroquinone.

  (iii) As a bleaching agent.

1. **Auto–protolysis of water:** Water accepts a proton from other water molecule to from H_3O^+ and OH^- this porous is called auto – protolysis of water

$$H_2O(l) + H_2O(l) \rightleftharpoons H_3O^+ (aq) + OH^- (aq)$$

Its significance is that water can act as acid as well as base i.e. it is amphoteric in nature.

2. **Hydrogen economy:** It is transportation and storage of energy in the form of liquid or gaseous hydrogen. Advantage of hydrogen economy is that energy is transmitted in the form of dihydrogen and not as electric power

3. **Hydrogenation:** It is a process of converting polyunsaturated oils in edible fats.

$$\text{Vegetable oil} + H_2 \xrightarrow[473K]{Ni} \text{Vanaspati ghee (fat).}$$

4. **Syngas:** It is a mixture of CO and H_2 in 1:1 ratio and also known as water gas or syntnesis gas.

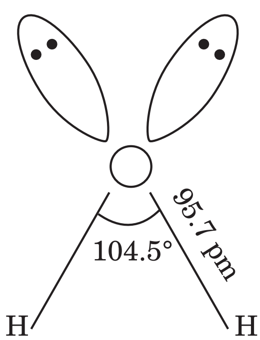
$$\underset{\text{Carbon}}{C(s)} + H_2O(g) \xrightarrow[Ni]{1270\ K} \underset{\text{Carbon monoxide}}{CO_2 + H_2(g)}$$

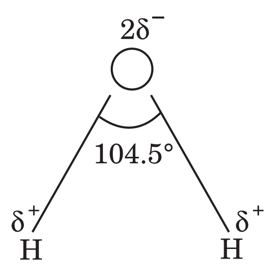
5. Water gas shift reaction.

$$CO + H_2O \xrightarrow[\text{iron chromate as catalyst}]{673\ K} CO_2 + H_2$$

6. **Fuel-cell:**– Fuel cell is a cell in which chemical energy of fuel is converted into electrical energy.

7. **Structure of water:** It is bent molecule in gas phase with HOH bond angle 104.5° and O–H bond length of 95.7 pm as shown if figure





8. **Calgon:–** It is sodium polymetaphosphate $(NaPO_3)_n$ it is used to remove. Permanent hardness of water.

9. **De-ionized water:–** Pure di-mineralised (ionized water) free from all soluble mineral matter is obtained by passing water successively through a cation exchanger (in the H^+ form) and an anion exchanger for removal by cation and anions

$$2RH + M^{2+} \rightleftharpoons MR_2 + 2H^+$$

(R is the resin anion M^{2+} is cation)

$$RNH_2 + H_2O \rightleftharpoons RNH_3^+ \ OH^-$$

$$RNH_3^+ + OH^- + X^- \rightleftharpoons RNH_3^+ . X^- + OH^-$$

$$H^+ + OH^- \longrightarrow H_2O$$

MIND MAP : HYDROGEN

HYDROGEN

Preparation

- Lab Preparation
  $Zn + 2H^+ \longrightarrow Zn^{2+} + H_2$
  $Zn + 2NaOH \longrightarrow Na_2ZnO_2 + H_2$
- Commercial Production
  $2H_2O \xrightarrow[\text{electrolysis}]{} 2H_2 + O_2$
- Electrolysis of brine solution
- Reaction of steam on hydro-carbons or coke.

Reaction

- $H_2 + X_2 \longrightarrow 2Hx$
- $2H_2 + O_2 \longrightarrow 2H_2O$
- $3H_2 + N_2 \xrightarrow[673K,\ 200\ atm,\ Fe]{} 2NH_3$
- $H_2 + 2M \longrightarrow 2MH$
- $H_2 + Pd^{2+} \longrightarrow Pd + 2H^+$
- $yH_2 + MxOy \longrightarrow xM + yH_2O$
- $H_2 + CO + RCH = CH_2 \longrightarrow RCH_2CH_2CH_2CHO$
- $H_2 + RCH_2CH_2CHO \longrightarrow RCH_2CH_2CH_2OH$

Hydrides

- Ionic or Saline or Salt like Hydride
  LiH, BeH_2, MgH_2
- Covalent or Molecular Hydride
- (a) Electron deficient : Group-13 hydride e.g., B_2H_6
  (b) Electron Rich : Group-14 hydride e.g., CH_4
  (c) Electron Rich-Group-15, 16, 17 e.g., NH_3, H_2O
- Metallic or Non-Stoichiometric (or Interstitial) Hydrides
  - Formed by many d and f block element) $LaH_{2.87}$, $YbH_{2.55}$
- Group-7, 8, 9 do not from hybride - Hydribe Cap

H_2O

- Amphoteric Nature
  $H_2O + NH_3 \rightleftharpoons OH^- + Nh_4^+$
  $H_2O + H_2S \rightleftharpoons H_3O^+ + HS^-$
- Redox Reaction
  $2H_2O + Na \longrightarrow 2NaOH + H_2$
- Hydrolysis Reaction
  $P_4O_{10} + 6H_2O \longrightarrow 4H_3PO_4$
- Hydrates Formation
  $[Cr(H_2O)_6]_3^{3+}\ Cl^-$
  $BaCl_2 \cdot 2H_2O$
  $CuSO_4 \cdot 5H_2O$
- Two types of hardness
  Temporary – HCO_3^-, Mg^{2+}, Ca^{2+}
  Permanent – Cl^-, SO_4^{2-} of Ca, Mg^{2+}
  Temporary hardness is removed by boiling and Clarck's method.
  Permanent hardness is removed by Washing Soda, Calgon method, ion-exchange and synthetic resin method.

H_2O_2

- Preparation
- Acidifying Barium per Oxide
- Peroxodisulphate on hydrolysis
- Industrially by auto oxidation of 2-alkylanthraquinds.
- Volume Strength (V)
  V = 5.6 × N
  V = 11.2 × M
  g/L = 3.03 V
  % m/v = 0.303 V
- H_2O_2 act as oxsiding agent as well as
- Reducing agent in acidic and basic medium

CASE BASE STUDY - QUESTION

PASSAGE-I

Hydrogen is an enormously attractive fuel because it is environmental clean 'Hydrogen economy' is a new field in which it is thought that our energy needs can be met by gaseous liquids and solid Hydrogen. Since hydrogen is not a naturally occurring substance like coal oil or natural gas energy must be expended to produce hydrogen before it can be used. Current researchers are therefore on finding cheaper methods for extracting hydrogen.

1. Which fuel does produce least environmental pollution?

   (a) Kerosene oil (b) Hydrogen

   (c) Wood (d) Coal

2. If an isotope of hydrogen has two neutrons in its atom its atomic number and atomic mass number will respectively be :

   (a) 2 and 1 (b) 3 and 1

   (c) 1 and 1 (d) 1 and 3

3. Which of the following gas is lightest?

   (a) Oxygen (b) Ammonia

   (c) Hydrogen (d) Helium

4. Which isotope of Hydrogen is radioactive in nature?

   (a) Protium only (b) Deuterium only

   (c) Deuterium and tritium (d) Tritium only

5. Liquid H_2 has been used as a rocket fuel because of :

   (a) High thrust

   (b) Its reaction with oxygen is highly exothermic

   (c) Small space it occupies

   (d) All these are correct

PASSAGE-II

H_2O_2 is a powerful oxidizing agent it is an electron acceptor in acidic as well as in alkaline medium. It can also act as reducing agent towards powerful oxidizing agent. In alkaline medium the reducing nature of H_2O_2 is even more effective Answer the following questions :

1. H_2O_2 can be prepared when the following react with H_2SO_4 except with

   (a) BaO_2 (b) PbO_2

   (c) Na_2O_2 (d) SrO_2

2. In which of the following reaction H_2O_2 acts as a reducing agent?

   (a) $H_2O_2 + 2H^+ + 2e^- \rightarrow 2H_2O$ (b) $H_2O_2 - 2e^- \rightarrow O_2 + 2H^+$

   (c) $H_2O_2 + 2e^- \rightarrow 2OH^-$ (d) $H_2O_2 + 2OH^- - 2e^- \rightarrow O_2 + H_2O$

3. The oxidant an state of oxygen in H_2O_2 is

   (a) $+2$ (b) -2

   (c) $+1$ (d) -1

4. The bleaching properties of H_2O_2 are due to its :

   (a) Unstable nature (b) Acidic nature

   (c) Reducing nature (d) Oxidising nature

5. Decolorization of acidified $KMnO_4$ occurs when H_2O_2 is added to it. This is due to :

   (a) Oxidation of $KMnO_4$

   (b) Reduction of $KMnO_4$

   (c) Both oxidation and reduction of $KMnO_4$

   (d) None of the above

Ans. Passage-I : 1. (b), 2. (d), 3. (c), 4. (d), 5. (d)

Ans. Passage-II : 1. (c), 2. (b), 3. (d), 4. (d), 5. (b)

MULTIPLE CHOICE QUESTIONS (MCQ)

1. The reagent commonly used to determine the hardness of water titrimetrically is :

(a) Oxalic acid (b) Di sodium salt of EDTA

(c) Sodium citrate (d) Sodium thiosulphate

2. The number of H_2O molecules which are involve in Hydrogen bonding in $CuSO_4 \cdot 5H_2O$ molecule itself is

(a) H_3PO_2 (b) H_3PO_3 (c) H_3PO_4 (d) PH_3

3. The reagent used for softening temporary hardness of water is

(a) $Ca_3(PO_4)_2$ (b) $Ca(OH)_2$ (c) Na_2CO_3 (d) NaOH

4. D_2O has higher value of following physical parameters than H_2O, except

(a) Molecular Mass (b) Melting Point

(c) Density (d) Dielectric Constant

5. Hydrogen peroxide oxidises $[Fe(CN)_6]^{4-}$ to $[Fe(CN)_6]^{3-}$ in acidic medium but reduces $[Fe(CN)_6]^{3-}$ to $[Fe(CN)_6]^{4-}$ in alkaline medium the other products formed are respectively.

(a) $(H_2O + O_2)$ and $(H_2O + OH^-)$ (b) H_2O and $(H_2O + O_2)$

(c) H_2O and $(H_2O + OH^-)$ (d) $(H_2O + O_2)$ and H_2O

6. Syn-gas is a mixture of

(a) $CO+N_2$ (b) O_3 (c) $CO + H_2$ (d) $CO + H_2CO_3$

7. The electronic conguration of 'D' (Isotope of Hydrogen)

(a) $1s^2$ (b) $1s^2 2s^1$ (c) $1s^1$ (d) $1s^2 2s^2 2p^1$

8. Pure water is obtained from sea water by :

(a) Centrifugation (b) Plasmolysis

(c) Reverse Osmosis (d) Sedimentation

9. When MnO_4^- reacts with H_2O_2 in basic medium then following species are involved, except

(a) MnO_2 (b) O_2 (c) OH^- (d) Mn^{2+}

10. Select the incorrect statement for H_2O_2 structure

(a) It is non planar

(b) O–O bond length is more in gaseous state than in solid phase

(c) Both OH bond are in different plane

(d) O–O–H bond angle in gas phase is more than in solid phase

Ans: 1. (d) 2. (d) 3. (b) 4. (d) 5. (b) 6. (c) 7. (c) 8. (c) 9. (d) 10. (d)

TRUE AND FALSE TYPE QUESTIONSE

1. H_2O_2 decomposes slowly on exposure to light.
2. H_2O_2 on reaction with Pbs convert Pbs into Pb.
3. Chemically calgon is sodium hexametaphosphate $Na_6P_6O_{18}$.
4. NH_3 is electron rich hydride.
5. Phosphorus form PH_5.
6. H_2 gas cannot reduce Pb^{2+} ion.
7. Hydroformylation of olefins yields aldehydes which futher undergoes reduction to give alcohols.
8. Hydrogenation of vegetable oils using nickel as catalyst gives edible fats.
9. Ice has cage like structure with air spaces.
10. Soft water gives lather with Soap.

Ans: 1. True 2. False 3. True 4. True 5. False
6. False 7. True 8. True 9. True 10. True

FILL IN THE BLANKS

1. Cation exchange resin contain large organic molecule with _____ group.
2. At atmospheric pressure ice crystallises in __________ for.
3. Due to high _______ of H_2O, H_2O has a very strong hydrating tendency.
4. Water is present in $[Cr(H_2O)_6]^{3+}.3Cl^-$ in the form of _________.
5. The H-H bond dissociation enthalpy of H_2 is _________, is the highest for a single bond between two atoms of any elements.
6. In the Clark's method for softening compound _________ is used.
7. During photosynthesis H_2O is __________.
8. BeH_2 and MgH_2 are ionic and _________ in nature.
9. When NaH is electrolysed, then _________ is released at anode.
10. Hydrated sodium aluminium silicate is ___________.

Ans: 1. SO_3H 2. Hexagonal 3. Dielectric 4. Coordinated water
5. 435.88 kj mol^{-1} 6. $Ca(HCO_3)_2$ 7. Oxidised 8. Polymeric
9. H_2 10. Zeolite/Permutit

MATCH THE COLUMNS

1.

	Column -I		Column-II		Column-III
A.	Boiling	p.	$CaCO_3$	1.	CaZ
B.	Clark's Method	q.	$Mg(OH)_2$	2.	$Ca(OH)_2$
C.	Washing soda	r.	$NaAISiO_4$	3.	CO_2
D.	Ion-exchange method	s.	NaCl	4.	Na_2SO_4

2.

	Column -I		Column-II
A.	$H_2O + NH_3 \rightleftharpoons OH + NH_4^+$	p.	Hydroformylation
B.	$2H_2O + 2Na \longrightarrow 2NaOH + H_2$	q.	Acid base reaction
C.	$P_4O_{10} + 6H_2O \longrightarrow 4H_3PO_4$	r.	Redox Reaction
D.	$2H_2 + CO + RCH = CH_2 \longrightarrow RCH_2CH_2CH_2O_4$	s.	Hydrolysis reaction

Ans. 1. A $\rightarrow$ q, 3. B $\rightarrow$ p, 2. C $\rightarrow$ s, 4 D $\rightarrow$ r, 1

2. A $\rightarrow$ q, B $\rightarrow$ r, C $\rightarrow$ s, D $\rightarrow$ p

ONE WORD ANSWER TYPE QUESTIONS

1. Name the gas release when zinc reacts with NaOH.
2. When brine solution is electrolysed then nature of solution will be?
3. What happens when Al_4C_3 reacts with D_2O?
4. In which medium H_2O_2 act as reducing agent?
5. What is the chemical name of calgon's?
6. What happens when LiH reacts with Al_2C_{16}?
7. What happens when warm aqueous Barium hydroxide solution is electrolysed?
8. What type of particles are emitted by Tritium?
9. What is the name for the following chemical reaction?

$$CO(g) + H_2O(g) \longrightarrow CO_2(g) + H_2(g)$$

10. What is the term used to refer "Transportation and storage of energy in the form of liquid or gaseous dihydrogen"

Ans: 1. H_2 2. Basic 3. $Al_4C_3 + 12D_2O \longrightarrow 3CD_4 + 4Al(OD)_3$
4. Acidic, Basic
5. Sodium hexameter phosphate ($Na_6P_6O_{18}$)
6. $8LiH + Al_2Cl_6 \longrightarrow 2LiAlH_4 + 6\ LiCl$
7. H_2 gas is produced 8. β^- (beta negative)
9. Water gas shift reaction 10. Hydrogen economy

ASSERTION AND REASON TYPE QUESTIONS

The questions given below consist of Assertion (A) and Reason (R). Use the following key to select the correct answer :

(a) If both Assertion and Reason are correct and reason is correct explanation for assertion.

(b) If both Assertion and Reasons are correct but reason is not correct explanation for assertion.

(c) If Assertion is correct but Reason is incorrect.

(d) If both Assertion and Reason are incorrect.

1. **Assertion :** Hydrogen combines with other elements by losing, gaining or sharing electrons.

   Reason : Hydrogen forms electrovalent and covalent bonds with other elements.

2. **Assertion :** Nascent hydrogen can discharge the pink colour of $KMnO_4$ solution.

   Reason : Nascent hydrogen is much more reactive than ordinary hydrogen.

3. **Assertion :** H_2O_2 reduces Cl_2 to HCl .

   Reason : H_2O_2 is highly reactive in nature.

4. **Assertion :** Calgon is used for removing Ca^{2+} and Mg^{2+} ions form hard water.

   Reason : Calgon forms precipitate with Ca^{2+} and Mg^{2+} ions.

5. **Assertion :** Temporary hardness can be removed by the addition of lime.

   Reason : $Ca\ (HCO_3)_2$ in hard water is converted to insoluble $CaCO_3$ on moderate heating.

6. **Assertion :** H_2O_2 can be used as antichlor in bleaching.

   Reason : It oxidises HCl to Cl_2.

7. **Assertion :** Decomposition of H_2O_2 is a disproportionation reaction.
Reason : H_2O_2 undergoes simultaneous oxidation and reduction reactions.

8. **Assertion :** Be hydride is of covalent nature
Reason : The electronegativity difference between Be and H is very large.

9. **Assertion :** Permanent hardness in water is removed by treatment with washing soda.
Reason : Washing soda reacts with soluble Mg and Ca sulphate to form insoluble carbonates.

10. **Assertion :** Saline hydrides are non-volatile, non conducting and crystalline solids.
Reason : Saline hydrides are the compounds of hydrogen with most of p-block elements.

Ans: 1. (a) 2. (b) 3. (c) 4. (a) 5. (a) 6. (a) 7. (a) 8. (c) 9. (a) 10. (c)

1-MARK QUESTIONS

1. Name the isotope of hydrogen which is radioactive in nature. [**Ans.** Tritium]
2. H^+ ions does not exist freely and is always associated with other atoms or molecule. Explain.
3. Give the composition of water gas. [**Ans.** CO, H_2]
4. Name the compound whose electrolysis in aqueous state, give high purity (99.95%) dihydrogen. [**Ans.** aq $Ba(OH)_2$ solution]
5. Give the main purpose of water gas shift reaction.
6. Write the chemical reaction occuring during coal gasification.
7. Name the element used in fuel cell for generating electricity. [**Ans.** H_2]
8. Give an example of electron deficient covalent hydride. [**Ans.** B_2H_6]
9. Name the hydrides which have high potential for hydrogen storage. [**Ans.** Metallic hydrides]
10. Name the groups in *d*-block elements which do not form metallic hydrides. [**Ans.** 7, 8, 9]
11. H_2 is relatively inert at room temperature. Explain.
12. Complete the reaction :
$C(s) + H_2O(g) \xrightarrow{1270\ K} (A)\ \_\_\_\ (g) + (B)\ \_\_\_\ (g)$. [**Ans.** CO, H_2]

13. Name the phenomenon as a reason of which water has unusual boiling point. [**Ans.** Extensive hydrogen bonding]

14. Draw structure of water.

15. At atmospheric pressure ices crystallised in the .... form but at very low temperature it condenses to .... form. [**Ans.** Hexagonal, cubic]

16. Mention the temperature at which density of ice is maximum.[**Ans.** 4°C]

17. Density of ice is .... than density of liquid water. [**Ans.** Less]

18. Complete the reaction :

$2H_2O(l) + 2Na(s) \longrightarrow$

19. How many hydrogen-bonded water molecules (*s*) are associted in $CuSO_4.5H_2O$. [**Ans.** One]

20. Name the compound used in Clark's method to remove temporary hardness of water. [**Ans.** Lime]

21. Write the chemical formula of "Calgon". [**Ans.** $Na_4P_6O_{18}$]

22. A 30% solution of H_2O_2 is marketed as .... volume.[**Ans.** 100 volume]

23. Draw gas phase structure of H_2O_2.

24. Name the organic compound whose auto-oxidation is used to produce H_2O_2 commercially or industrially. [**Ans.** 2-Ethylanthraquinol]

25. How is heavy water obtained from ordinary water?

2-MARKS QUESTIONS

1. Complete the following reactions :

(i) $CO(g) + H_2(g) \xrightarrow[\text{Catalyst}]{\Delta}$

(ii) $Zn(s) + NaOH(aq) \xrightarrow{\Delta}$

2. Among NH_3, H_2O and HF which would you except to have highest magnitude of hydrogen bonding and why ?

3. How do you except the metallic hydrides to be useful for hydrogen storage? Explain.

4. How can the production of dihydrogen obtained from "Coal gasification" be increased ?

5. Write the name of isotopes of hydrogen. What is the mas ratio of these isotopes ?

6. Complete the reactions :

(i) $CO(g) + 2H_2(g) \xrightarrow[\text{Catalyst}]{\text{Cobalt}}$

(ii) $CH_4(g) + H_2O(g) \xrightarrow[\text{Ni}]{\text{1270K}}$

7. Comment on the reactions of dihydrogen with :

(i) Chlorine, (ii) Sodium.

8. Arrange the following :

(i) LiH, NaH, CsH (In increasing order of ionic character)

(ii) H—H, D—D, F—F (In decreasing order of bond dissociation enthalpy)

9. List two uses of dihydrogen.

10. Complete the reactions :

(i) $H_2 + CO + RCH = CH_2 \longrightarrow$

(ii) $H_2 + RCH_2CH_2CHO \longrightarrow$

11. Give two reactions to show amphoteric nature of water.

12. Complete the reactions :

(i) $2F_2(g) + 2H_2O(l) \longrightarrow$

(ii) $6CO_2(g) + 12H_2O(l) \longrightarrow$

13. What is the difference between the term hydrolysis and hydration.

14. What do you understand by term 'autoprotolysis' of water ? What is its significance ?

15. What causes the temporary and permanent harness of water ?

16. Is demineralised or distill water useful for drinking purposes ? If not, how can it be made useful ?

17. Explain the terms :

(i) Hydrogen economy.

(ii) Fuel cell.

18. Write chemical reactions to justify that hydrogen peroxide can function as an oxidising as well as reducing agent.

19. Compare the structure of H_2O and H_2O_2.

20. How does H_2O_2 behaves as a bleaching agent ?

21. H_2O_2 acts as an oxidizing as well as reducing agent. Why?

3-MARKS QUESTIONS

1. Complete the chemical reactions :

(i) $8LiH + Al_2Cl_6 \longrightarrow$

(ii) $2LiH + B_2H_6 \longrightarrow$

2. What do you understand by : (i) Electron deficient, (ii) Electron precise, (iii) Electron rich compounds of hydrogen ? Provide justifications with suitable examples.

3. What do you understand by the term "non-stoichiometric hydrides" ? Do you expect this type of the hydrides to be formed by alkali metals. Explain and Justify your answer.

4. Arrange the following :

(i) CaH_2, BeH_2, TiH_2 (in order of increasing electrical conductance)

(ii) NaH, MgH_2, H_2O (in order of increasing bond dissociation enthalpy)

(iii) Li, F, H (in order of increasing ionisation enthalpy)

5. What do you understand by the terms :

(i) Syn gas (ii) Water gas shift reaction (iii) Producer gas.

6. Would gas except the hydrides of N, O and F to have lower boiling point than the hydrides of their subsequent group members ? Give reasons.

7. Can phosphorous with outer electronic configuration $3s^2 3p^3$ form PH_5 ? Explain.

8. Why and how the hydrogen is regarded as a fuel of future ? Explain.

9. Write the reactions when dihydrogen reacts with (i) O_2 (ii) N_2 (iii) Cl_2 under specific conditions.

10. Name the hydrides :

(i) Which is non stoichiometric in nature ?

(ii) Which are stoichiometric compounds ?

(iii) Which has electron rich type hydrides ?

11. Complete the reactions :

(i) $CaO(s) + H_2O(g) \longrightarrow$

(ii) $AlCl_3(g) + H_2O(l) \longrightarrow$

(iii) $Ca_3N_2(s) + H_2O(l) \longrightarrow$

12. Discuss the principle and method of softening of hard water by synthetic exchange of resin method.

13. What is meant by 'demineralised' water and how can it be obtained ?

14. What properties of water make it useful as a solvent ? What types of compound can it (i) dissolved (ii) hydrolyse ?

15. Calculate the strength of 10 volume solution of H_2O_2.

16. Complete the reactions :

(i) $2Fe^{2+}(aq) + 2H^{+}(aq) + H_2O_2(aq) \longrightarrow$

(ii) $HOCl + H_2O_2 \longrightarrow$

(iii) $Mn^{2+} + H_2O_2 \longrightarrow$

17. Give three uses of H_2O_2.

18. Complete the reactions :

(i) $CaC_2 + 2D_2O \longrightarrow$

(ii) $SO_3 + D_2O \longrightarrow$

(iii) $Al_4C_3 + 12D_2O \longrightarrow$

19. Give the limitations of using H_2 as a fuel.

20. H_2O_2 is stored in a wax lined glass or plastic vessels. Explain an equation showing decomposition of H_2O_2 on exposure to light.

5-MARKS QUESTIONS

1. Answer the following :

(a) Name the most abudant form of hydrogen isotope. [**Ans.** ${}_1^1H$]

(b) Name the particles emitted by tritium. [**Ans.** β^-]

(c) Mixture of CO and H_2 is used for preparation .... [**Ans.** Methanol]

(d) Name the catalyst used in Haber's Process for manufacture of $NH_3(g)$. [**Ans.** Fe]

(e) Name two electron rich hydrides. [**Ans.** NH_3, H_2O]

2. Answer the following :

(a) During Clark's method. Name the compound in which Mg is precipitated out. [**Ans.** Magnesium Hydroxide]

(b) Give the formula of Zeolite used in ion exchange method to remove permanent hardness of water. [**Ans.** $NaAlSiO_4$]

(c) Complete the reaction :

$BaO_2.8H_2O(s) + H_2SO_4(aq) \rightarrow$

(d) H_2O_2 is miscible with water. Assign reason.

(e) Name the compound when can be used as a hair beach, mild antiseptic in the form of perhydrol. [**Ans.** H_2O_2]

3. (a) Complete the following chemical equations

(b) ________ + water $\longrightarrow$ $CaCO_3 + NH_3$ (Ammonia)

(c) ________ + Hydrogen peroxide $\xrightarrow{H^+}$ CrO_5 + ________

(d) $Na_2O + H_2O \longrightarrow$ ________

(e) $D_2O + Na_3As \longrightarrow$ ________

4. Describe the usefulness of water in biosphere and biological systems.

HOTS QUESTIONS

1. Calculate the hardness of water sample which contains 0.001 mole of $MgSO_4$ dissolved per litre of water.

Ans. 1 mole $MgSO_4$ = 1 mole $CaCO_3$

10^{-3} Mole $MgSO_4$ = 10^{-3} mol $CaCO_3$

$\therefore$ 0.120g $MgSO_4$ = 0.1g $CaCO_3$ in 1000 mL

$\therefore$ Hardness = =100ppm

2. 2g of Al is treated separately with excess dilute H_2SO_4 and excess NaOH. The ratio of volumes of Hydrogen evolved under similar condition is $\frac{x}{y}$. Find $\frac{x}{y}$

Ans. $2Al + 3H_2SO_4 \longrightarrow Al_2(SO_4)_3 + 3H_2$

$2Al + 2NaOH + 2H_2) 2NaAlO_2 + 3H_2$

$\therefore$ Ratio is 1 : 1

3. What mass of CaO will be required to remove the hardness of 1000 litres of water containing 1.62g of $Ca(HCO_3)_2$ per litre?

Ans. $Ca(HCO_3)_2$ + CaO $\longrightarrow$ $2CaCO_3 + H_2O + CO_2$

162g   56g

$\therefore$ 5.6×10^2g be cause solution has 1620 g $Ca(HCO_3)_2$

4. What is the volume of O_2 liberated at N.T.P. by complete decomposition of 100mL of 2m solution of H_2O_2?

Ans. Volume strength = $11.2 \times M = 22.4$

100mL = 0.1L i.e. $22.4 \times 0.1 = 2.24$L O_2 released

5. Mention an example in which H_2O acts as reducing agent.

Ans. $2F_2 + 2H_2O \longrightarrow O_2 + 4HF$

UNIT TEST-I

Time Allowed: 1 Hr. **Maximum Marks : 20**

General Instructions:

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

---

1. Hydrogen has maximum oxidation state in [1]

   (a) NaH (b) MgH_2 (c) H_2O (d) C & H

2. Which one does not cause hardness of water?

   (a) $MgCl_2$ (b) $CaCl_2$ (c) $MgSO_4$ (d) $AlCl_3$

3. Give one reaction for preparation of hydrogen gas in laboratory. [1]

   In the following questions a statement of Assertion (A) followed by Reason (R) is given use the following key to select correct answer :

(a) Both Assertion and Reason are correct but Reason is the correct explanation of Assertion.

(b) Both Assertion and Reason are correct but Reason is not the correct explanation of Assertion.

(c) Both Assertion and Reason are incorrect.

(d) Assertion is not correct but Reason is correct.

4. **Assertion :** H_2O_2 reduces Cl2 to HCl. [1]

   Reason : H_2O_2 is highly reactive in nature.

5. **Assertion :** Calgon is used for removing Ca^{2+} and Mg^{2+} ions from hard water. [1]

   Reason : H_2O_2 is highly reactive in nature.

6. Complete the reaction with balancing [2]

   (a) $Fe^{2+}(aq.) + H^{+}(aq.) + H_2O_2(aq.) \longrightarrow$

   (b) $HOCl + H_2O_2 \longrightarrow$

7. What is Hydrogen Economy. What are its advantage? [2]

8. Explain the following [3]

   (i) Atomic hydrogen or oxy-hydrogen torch function for cutting and welding purposes. Why?

   (ii) CaH_2, BeH_2 and TiH_2 arrange in order of increasing electrical conductance and give reason.

   (iii) Water shows amphoteric behaviour, support by giving appropriate example.

9. What are different types of hydrides? Give example. [3]

10. Discuss the principle and method of softening of hard water by synthetic ion-exchange resins. [5]

UNIT TEST-II

Time Allowed: 1 Hr. **Maximum Marks : 20**

General Instructions:

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

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1. When MnO_4^- reacts with H_2O_2 in basic medium the following species are involved except? [1]

   (a) MnO_2 (b) O_2 (c) OH^- (d) Mn^{2+}

2. Which one is ionic hydride in nature?

   (a) LiH (b) NH_3 (c) H_2O (d) PH_3

3. What is the chemical name of Calgon's? [1]

   In the following questions a statement of Assertion (A) followed by Reason (R) is given use the following key to select correct answer :

(a) Both Assertion and Reason are correct but Reason is the correct explanation of Assertion.

(b) Both Assertion and Reason are correct but Reason is not the correct explanation of Assertion.

(c) Both Assertion and Reason are incorrect.

(d) Assertion is not correct but Reason is correct.

4. **Assertion :** Decomposition of H_2O_2 is a disproportionation reaction. [1]

   Reason : H_2O_2 undergoes simultaneous oxidation and reduction reactions.

5. **Assertion :** H_2O_2 can be used as an antichlor in bleaching. [1]

   Reason : It oxidises HCl to Cl_2.

6. Complete the following reactions: [2]

   (i) $CO + H_2 \xrightarrow{\text{Catalyst}}$

   (ii) $Zn + NaOH \xrightarrow{\Delta}$

7. What is the difference between the term hydrolysis and hydration? [2]

8. What is meant by demineralised water and how can it be obtained? [3]

9. Give three uses of H_2O_2. [3]

10. Describe the usefulness of water in biosphere and biological systems. [5]

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Chapter - 10

s-Block Elements

FAST TRACK : QUICK REVISION

- s-block elements consists of group-I (Alkali metals) and group-2 (Alkaline earth metals).
- Group 1^{st} elements — Li, Na, K, Rb, Cs, Fr.
- Group 2^{nd} elements — Be, Mg, Ca, Sr, Ba, Ra.
- **Atomic radius :** Atomic radius of alkali metals are greater than alkaline earth metals.
- **Hydration enthalpy :** Decreases with increases in ionic sizes.
- **Ionic mobility :** Smaller the size of ion, more highly it is hydrated and hence lower is its ionic mobility.

  $Li^+ < Na^+ < K^+ < Rb^+ < Cs^+$
- **Ionisation enthalpies :** 1^{st} I.E. of group 1^{st} is smaller than group 2^{nd} elements but 2^{nd} I.E. of group 2^{nd} is smaller than group 1^{st} elements.
- **Flame colouration :** Due to low I.E., *s*-block elements and their salts imparts characteristics colour of oxidising flame (except Be and Mg). Be and Mg do not show flame colouration because they have small size and very high ionisation enthalpy.
- **Reducing character :** Due to large negative electrode potentials alkali metals are stronger reducing agent than alkaline earth metal.
- **Reactivity towards air :**

  $4Li + O_2 \longrightarrow 2Li_2O$ (Lithium oxide)

  $2Na + O_2 \longrightarrow Na_2O_2$ (Sodium peroxide)

  $M + O_2 \longrightarrow MO_2$ (M = K, Rb, Cs metal superoxide)

  Alkaline earth metals being smaller in size do not from superoxides.

- **Reactivity towards H_2O :**

  $\underset{\text{(Alkali metal)}}{2M} + 2H_2O \longrightarrow 2MOH + H_2$

  $\underset{\text{(Alkaline earth metals)}}{M} + 2H_2O \longrightarrow M(OH)_2 + H_2$

- **Reactivity towards hydrogen :**

  $2M + H_2 \longrightarrow 2MH \quad (M = Li, Na, K, Rb, Cs)$

  $M + H_2 \longrightarrow MH_2 \quad (M = Mg, Ca, Sr, Ba)$

  $2BeCl_2 + LiAlH_4 \longrightarrow 2BeH_2 + LiCl + AlCl_3.$

- **Reactivity towards halogens :**

  $2M + X_2 \longrightarrow 2MX$ (M = Li, Na, K, Rb, Cs)

  $M + X_2 \longrightarrow MX_2$ (M = Mg, Ca, Sr, Ba)

  $BeO + C + Cl_2 \xrightleftharpoons{600\text{-}800\ K} BeCl_2 + CO$

- **Solution in liquid ammonia :** The fresh solution of alkali metals and alkaline earth metals (except Be and Mg) is deep blue, paramagnetic and highly reducing due to presence of ammoniated electrons.

- **Solubility of alkaline earth metal carbonate in water :**

  $Li_2CO_3 < Na_2CO_3 < K_2CO_3 < RbCO_3 < Cs_2CO_3$

- **Solubility of alkaline earth metal carbonates in water.**

  $BaCO_3 < SrCO_3 < CaCO_3 < MgCO_3 < BeCO_3$

- **Solubility of alkaline earth metal sulphates in water :**

  $BaSO_4 < SrSO_4 < CaSO_4 < MgSO_4 < BeSO_4$

- **Thermal stability of alkali metal carbonates :**

  $Li_2CO_3 < Na_2CO_3 < K_2CO_3 < Rb_2CO_3 < Cs_2CO_3$

- **Thermal stability of alkaline earth metal carbonates :**

  $BeCO_3 < MgCO_3 < CaCO_3 < SrCO_3 < BaCO_3$

- **Anamolous behaviour of Li and Be :** It is due to very small size, high I.E. and high polarising power (*i.e.*, charge/radius)

- **Diagonal relationship (similarities) between Li and Mg :**

  (i) Both Li and Mg are hard.

(ii) Both react with N_2 to form nitrides.

$$6Li + N_2 \longrightarrow 2Li_3N$$

$$3Mg + N_2 \longrightarrow Mg_3N_2$$

(iii) **Decomposition of carbonates :**

$$Li_2CO_3 \longrightarrow Li_2O + CO_2$$

$$MgCO_3 \xrightarrow{\Delta} MgO + CO_2$$

(iv) Both LiCl and $MgCl_2$ are deliquescent. They form hydrates salts $LiCl.2H_2O$ and $MgCl_2.6H_2O$.

(v) **Decomposition of nitrates :**

$$4LiNO_3 \xrightarrow{\Delta} 2Li_2O + 4NO_2 + O_2$$

$$2Mg(NO_3)_2 \xrightarrow{\Delta} 2MgO + 4NO_2 + O_2$$

- **Diagonal relationship (similarities) between Be and Al :**

(i) Both are passive to acids due to formation of oxide layer.

(ii) Hydroxides of both dissolve in alkali to form $[Be(OH)_4]^{2-}$ and $[Al(OH)_4]^-$.

(iii) Chloride of both has bridged structure.

(iv) Both have tendency to form complexes of BeF_4^{2-}, AlF_6^{3-}.

- **Manufacturing of washing soda ($Na_2CO_3.10H_2O$) :**

Solvay process :

$$NH_3(g) + CO_2(g) + H_2O\ (l) \longrightarrow NH_4HCO_3\ (aq)$$

$$NH_4HCO_3\ (aq) + NaCl\ (aq) \longrightarrow NaHCO_3(s) + NH_4Cl\ (aq)$$

$$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + H_2O(l) + CO_2(g)$$

$$2NH_4Cl\ (aq) + Ca(OH)_2 \rightarrow CaCl_2(s) + 2H_2O(l) + 2NH_3\ (g)$$

- **Manufacturing of caustic soda (NaOH) :** Castner-Kellner cell.

Cathode : $Na^+ + e^- \xrightarrow{Hg} Na\text{-}Hg$

Anode : $Cl^- \longrightarrow \frac{1}{2}Cl_2 + e^-$

$$2Na\text{-}Hg + 2H_2O \longrightarrow 2NaOH + 2Hg + H_2$$

- **Plaster of paris :** ($CaSO_4.½H_2O$)

$$\underset{\text{Gypsum}}{2(CaSO_4.2H_2O)} \xrightarrow[393K]{\Delta} 2(CaSO_4).H_2O + 3H_2O$$

CASE BASE STUDY - QUESTIONS

PASSAGE-I

1. Read the following passage and answer the questions :

In the periodic table Group 1 and Group 2 elements are called s-block elements. Their general electronic configuration is ns^{1to2}. Group 1 are called alkali metals where as group 2 elements are called alkaline earth metals. They resemble with each other in many respects but differ in some of properties due to difference in valence electrons, electronic configuration and atomic size.

(a) Why are group 1 elements softer than group 2 elements?

Ans. It is because group 1 elements are bigger in size and have weak metallic bonds.

(b) Why are group 1 elements more electropositive than group 2?

Ans. It is due to lower ionisation enthalpy due to their bigger atomic size.

(c) Why are K, Rb and Cs used in photoelectric cells?

Ans. It is due to their low ionisation enthalpy.

(d) Why is $BeCl_2$ more covalent than LiCI?

Ans. Be^{2+} is smaller than Li^+ and it is bivalent, therefore, more polarizing power than Li^+.

(e) Which colour is imparted to flame by Ca^{2+} and Ba^{2+}?

Ans. Ca^{2+} imparts brick red, Ba^{2+} imparts apple green colour to the flame.

PASSAGE-II

Elements of Group-I in the periodic table are called Alkali metals. Electronic configuration of these elements is ns1 in valance shell is with +1 oxidation state. They have lowest ionization enthalpies. They are strongly electro positive in nature. They act as strong reducing agents. Alkali metals tarnish in air due to formation of oxide/hydroxides on their surface. Due to high electropositive nature, Alkali metals form salts with Oxo-acids. Lithium shows anomalous behaviour and its compounds are soluble in organic solvents.

(1.-4.) There are assertion and reason which have been put forward. Read the given statement and choose correct alternative from the following :

(**Note** : A-Assertion & R-Reason)

(a) Both A and R true and R is the correct explanation of A.

(b) Both A and R true but R is not the correct explanation of A.

(c) A is true but R is false.

(d) A is false but R is true.

1. **A :** LiCl is predominantly covalent compound.

   R : Electronegativity between Li and Cl is very small.

2. **A :** Alkali metals impart color to the flame.

   R : It is due to their ionization enthalpies which are very low.

3. **A :** Sodium sulphate is soluble while Barium sulphate is insoluble in water.

   R : Lattice energy of barium sulphate exceeds its hydration energy.

4. **A :** Carbonates of Lithium on heating decomposes easily to form Lithium Oxide and carbon dioxide.

   R : Lithium being very small in size has large polarizing power. Large Carbonate ions resulting the formation of more stable Lithium Oxide and Carbon Dioxide.

Or

A : Sodium Chloride is less covalent than Cuprous Chloride.

R : Cu^+ ion is more polarizing than Na^+ ion.

Ans. : 1. (c), 2. (a), 3. (a), 4. (a) or (a)

MULTIPLE CHOICE QUESTIONS (MCQ)

1. The alkali metals are low melting. Which of the following alkali metal is expected to melt if the room temperature rises to 30°C?

   (a) Na (b) K

   (c) Rb (d) Cs

2. Alkali metals react with water vigorously to form hydroxides and dihydrogen. Which of the following alkali metals reacts with water least vigorously?

   (a) Li (b) Na

   (c) K (d) Cs

3. The reducing power of a metal depends on various factors. Suggest the factor which makes Li, the strongest reducing agent in aqueous solution.

   (a) Sublimation enthalpy (b) Ionisation enthalpy

   (c) Hydration enthalpy (d) Electron-gain enthalpy

4. Metal carbonates decompose on heating to give metal oxide and carbon dioxide. Which of the metal carbonates is most stable thermally?

   (a) $MgCO_3$ (b) $CaCO_3$

   (c) $SrCO_3$ (d) $BaCO_3$

5. Which of the carbonates given below is unstable in air and is kept in CO_2 atmosphere to avoid decomposition.

   (a) $BeCO_3$ (b) $MgCO_3$

   (c) $CaCO_3$ (d) $BaCO_3$

6. Metals form basic hydroxides. Which of the following metal hydroxide is the least basic?

   (a) $Mg(OH)_2$ (b) $Ca(OH)_2$

   (c) $Sr(OH)_2$ (d) $Ba(OH)_2$

7. Some of the Group 2 metal halides are cavalent and soluble in organic solvents. Among the following metal halides, the one which is soluble in ethanol is

   (a) $BeCl_2$ (b) $MgCl_2$

   (c) $CaCl_2$ (d) $SrCl_2$

8. The order of decreasing ionisation enthalpy in alkali metals is

(a) Na > Li > K > Rb (b) Rb > Na > K > Li

(c) Li > Na > K > Rb (d) K > Li > Na > Rb

9. The solubility of metal halides depends on their nature, lattice enthalpy and hydration enthalpy of the individual ions. Amongst fluorides of alkali metals, the lowest solubility of LiF in water is due to

(a) Ionic nature of lithium fluoride

(b) High Lattice enthalpy

(c) High hydration enthalpy of lithium atom

(d) Low ionisation enthalpy of lithium atom

10. Amphoteric hydroxides react with both alkalies and acids. Which of the following Group 2 metal hydroxides is soluble in sodium hydroxide?

(a) $Be(OH)_2$ (b) $Mg(OH)_2$

(c) $Ba(OH)_2$ (d) $Ca(OH)_2$

ASSERTION-REASON TYPE QUESTIONS

The question given below contains statement -1 (Assertion) and Statement-2 (Reason) Each question has four choice (a), (b), (c) and (d) out of which only one is correct. Choice the correct option as under.

(a) Statement-1 is true, statement-2 is true.
Statement-2 is a correct explanation for statement-1.

(b) Statement-1 is true, statement-2 is true ;
Statement-2 is not a correct explanation of statement-1.

(c) Statement -1 is true, statement-2 is false.

(d) Statement-1 is false, statement-2 is true.

1. Statement-1 : Sodium metal is softer than potassium metal.

   Statement-2 : Metallic bonding in Potassium is weaker than in Sodium.

2. Statement-1 : $Be(OH)_2$ is soluble in HCl and NaOH.

   Statement-2 : $Be(OH)_2$ is amphoteric in nature.

3. Statement-1 : Metallic character of alkali metals increases on going down a group from top to bottom.

Statement-2 : Ionisation enthalpy of alkali metals increases on going down from top to bottom.

4. Statement-1 : Super oxides of alkali metals are diamagnetic.

Statement-2 : Super oxides contain the ion O_2-which has one unpaired electron.

5. Statement-1 : Alkali metals do not impart colour to the flame.

Statment-2 : Their ionization enthalpies are very low.

6. Statement-1 : Sodium cannot be obtained by chemical reduction of its ore.

Statment-2 : Sodium is one of the strongest reducing agent.

7. Statement-1 : Beryllium hydroxide becomes soluble in excess alkali forming beryllate ion $[Be(OH)_4]^{2-}$.

Statment-2 : Beryllium ion has greater tendency to form complexes.

FILL IN THE BLANKS

1. In the synthesis of sodium carbonate, the recovery of ammonia is done by treating NH_4Cl with $Ca(OH)_2$. The by product obtained in this process is ....

(a) NaCl (b) NaOH

(c) $CaCl_2$ (d) $NaHCO_3$

2. When sodium is dissolved in liquid ammonia, a solution of deep blue colour is obtained. The colour of the solution is due to...............

(a) Sodium ion (b) Ammoniated electron

(c) Sodium amide (d) Ammoniated sodium ion

3. By adding gypsum to cement...............

(a) Setting time of cement becomes less.

(b) Setting time of cement increases

(c) Colour of cement becomes light

(d) Shining surface is obtain.

4. A substance which gives crimson red flame and breaks on heating to give oxygen and a brown gas is

(a) Magnesium nitrate (b) Calcium nitrate

(c) Barium nitrate (d) Strontium nitrate

5. The hydration energy of Mg^{2+} is greater than that of...........

(a) Al^{3+} (b) Be^{2+} (c) Na^{+} (d) Mg^{3+}

6. The active constituent of bleaching power is ....

(a) $Ca(OCl)_2$ (b) $Ca(OCl)Cl$

(c) $Ca(ClO_2)_2$ (d) $Ca(ClO_2)Cl$

7. KO_2 is used in oxygen cylinder is space and submarines because it..........

(a) Absorbs CO_2 and increases O_2 content

(b) Eliminates moisture

(c) Produces ozone (d) None of the above

8. A metal M readily forms water soluble sulphate MSO_4, water insoluble hydrozide and oxide MO which becomes inert on heating. The hydroxide is soluble in NaOH. The metal M oxide M is ....

(a) Be (b) Ca (c) Mg (d) Sr

9. Photo electric effect is maximum in..............

(a) Cs (b) K (c) Na (d) Li

10. Fill in the blanks with proper option given below for the following statement. "All the halides of alkaline earth metals with exception of .... are ionic in nature."

(a) Barium halide (b) Strontium halide

(c) Beryllium halide (d) Calcium halide

11. Flame test is not given by ....

(a) Be (b) Sr (c) K (d) Ca

MATCH THE COLUMNS

In the following questions more than one option of column I and II may be correlated.

1.

	Column-I		Column-II
(i)	Li	(a)	Insoluble sulphate
(ii)	Na	(b)	Strongest monoacidic base
(iii)	Ca	(c)	Most negative E° value among alkali metals.
(iv)	Ba	(d)	Insoluble oxalate
		(e)	$6s^2$ outer electronic configuration

2.

	Column-I		Column-II
(i)	$CaCO_3$	(a)	Dentistry, ornamental work
(ii)	$Ca(OH)_2$	(b)	Manufacture of sodium carbonate from caustic soda
(iii)	CaO	(c)	Manufacture of high quality paper
(iv)	$CaSO_4$	(d)	Used in white washing.

3.

	Column-I		Column-II
(i)	Cs	(a)	Apple green
(ii)	Na	(b)	Violet
(iii)	K	(c)	Brick red
(iv)	Ca	(d)	Yellow
(v)	Sr	(e)	Crimson red
(vi)	Ba	(f)	Blue

4.

	Column-I		Column-II
(a)	NaOH	(a)	Photo electric cells
(b)	Na_2CO_3	(b)	Coolant in nuclear reactors
(c)	Liquid Na	(c)	SO_2 absorber
(d)	Caesium	(d)	Detergent

1-MARK QUESTIONS

1. What is the oxidation state of K in KO_2 ?
2. Why are group I element called alkali metals ?
3. Potassium carbonate cannot be prepared by solvay process. Why ?
4. LiCl is soluble in organic solvent. Why ?
5. Why are group I elements called alkali metals ?
6. Alkali metals are strong reducing agents. Why ?
7. Why do alkali metals give characteristics flame colouration ?
8. Arrange the following in order of increasing covalent character : MCl, MBr, MF, MI (where M = Alkali metal) [**Ans.** MF < MCl < MBr < MI]
9. Alkali metals can not be obtained by chemical reduction method. Explain.
10. Why is sodium metal kept under kerosene oil ?

11. Why Be and Mg do not give characteristics colour to the flame ?

12. Arrange the alkaline earth metal carbonate in the decreasing order of thermal stability.

13. Why do alkaline earth metals not form any superoxide ?

14. Why gypsum is added to cement ?

15. How plaster of paris is obtained from gypsum ?

16. BeO is insoluble in water but $BeSO_4$ is soluble in water ? Why ?

17. Why second I.E. of group II elements is less than group I elements ?

18. What is quick lime ? How is it prepared ?

19. Why does Be show similarities with Al ?

20. Name the alkaline earth metal hydroxide which is amphoteric.

2-MARKS QUESTIONS

1. Why are alkali metals soft and have low melting points ?

2. Write any four similarities between Li and Mg.

3. Why are potassium and caesium rather than Lithium used in photoelectric cells ?

4. Why is Li_2CO_3 decomposed at a lower temperature whereas Na_2CO_3 at higher temperature ?

5. Among the alkali metals which has :

   (i) Highest melting point.

   (ii) Most electropositive character

   (iii) Lowest size of ion.

   (v) Strongest reducing character. [**Ans.** (i) Li (ii) Cs (iii) Li (iv) Li]

6. Why does the solubility of alkali earth metal carbonates and sulphates decrease down the group ?

7. Draw the structure of $BeCl_2$ in (i) Vapour phase (ii) Solid state.

8. When CO_2 gas is passed in lime water it turns milky but in case of excess CO_2 milkiness disappears. Support the statement by giving suitable reaction equations.

9. (i) E^θ for $M^{2+}(aq) + 2e^- \longrightarrow M(s)$ (where M = Ca, Sr, Ba) is nearly constant.

(ii) What is dead burnt plaster ? How is it obtained from gypsum?

10. Write two important uses of (i) Limestone (ii) Quick lime.

3-MARKS QUESTIONS

1. Assign reason for the following :
   (i) Compounds of lithium are generally covalent.
   (ii) Alkali metals are strong reducing agent.
   (iii) LiCl is more covalent than NaCl.
2. Discuss the various reactions that occur in Solvay process.
3. Explain why ?
   (i) Lithium salts are commonly hydrated.
   (ii) Sodium peroxide is widely used as oxidising agent.
   (iii) Sodium wire is used to remove moisture from benzene but can't be used for drying alcohol.
4. Sodium hydroxide is generally prepared by electrolysis of brine solution in the Castner-Kellner cell :
   (i) Write the reactions that occur in the cell.
   (ii) Write any two uses of NaOH.
5. Explain with suitable reasons :
   (a) A solution of Na_2CO_3 is alkaline.
   (b) Alkali metals are prepared by electrolysis of their fused chlorides.
   (c) Sodium is found to be more useful than potassium ?
6. Arrange the following in order of property mentioned against each :
   (i) $BaCl_2$, $MgCl_2$, $BeCl_2$, $CaCl_2$ (Increasing ionic character)
   (ii) $Mg(OH)_2$, $Sr(OH)_2$, $Ba(OH)_2$, $Ca(OH)_2$ (Increasing solubility in water)
   (iii) BeO, MgO, BaO, CaO (Increasing basic strength)
7. What happens when :
   (i) Mg is burnt in air.
   (ii) Quick lime is heated with silica.
   (iii) Chlorine is heated with slaked lime.
8. Write the raw material required for the manufacture of portland cement ? Why gypsum is added into it ?
9. (i) Why alkaline earth metals cannot be obtained by reduction of their oxides ?

(ii) Why the elements of group 2 are known as alkaline earth metals ?

10. (i) Alkaline earth metals forms ionic salt having bivalent cations. Explain. Why ?

(ii) A piece of magnesium ribbon continues to burn in SO_2. Why ?

5-MARKS QUESTIONS

1. Explain the following observation :

(a) LiI is more soluble than KI in ethanol.

(b) Sodium reacts with water less vigorously than potassium.

(c) LiF is insoluble in water.

(d) The mobilities of the alkali metal ions in aqueous solution are $Li^+ < Na^+ < K^+ < Rb^+ < Cs^+$.

(e) Lithium is the only alkali metal to form a nitride directly.

2. Complete the following reaction equations :

(i) $BeCl_2 + LiAlH_4 \longrightarrow$

(ii) $CaO + SiO_2 \longrightarrow$

(iii) $Ca(OH)_2 + Cl_2 \longrightarrow$

(iv) $CaO + P_4O_{10} \longrightarrow$

(v) $Ca(OH)_2 + CO_2 \longrightarrow$

3. Compare the solubility and thermal stability of the following :

Compounds of the alkali metals with those of alkaline earth metals (a) nitrates (b) carbonates (c) sulphates.

4. Explain the significance of Sodium (Na), Potassium (K), Magnesium (Mg) and Calcium(Ca) in biological fluids.

5. Explain the significance of Sodium Potassium, Magnesium and Calcium biological fluids.

6. (i) A solutions of Na_2CO_3 is alkaline why?

(ii) BeO insoluble but $BeSO_4$ in soluble in water. Why?

(iii) Lithium salts are commonly hydrated and those of other alkali metal ions are usually anhydrous give reasons.

(iv) What is the importance of cement?

(v) What happen when quick lime is heated with silica?

UNIT TEST-I

Time Allowed: 1 hr **Maximum Marks : 20**

General Instructions:

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

---

1. Photoelectric effect is maximum in [1]

   (a) Cs (b) K (c) Na (d) Li

2. Flame test is not shown by [1]

   (a) Be (b) Sr (c) K (d) Ca

3. Oxidation state of K in KO_2 is ______________. [1]

4. LiCl is soluble in organic solvent. Why? [1]

5. Why is sodium kept under kerosene? [1]

6. Write only four similarities in properties of Li and Mg. [2]

7. Write two important uses of CaO and $CaCO_3$. [2]

8. Discuss the various reactions that occur in solvay process. [3]

9. What happens when :– [3]

   (a) Mg is burnt in air.

   (b) Quick lime is heated with silica.

   (c) Chlorine is heated with slaked lime.

10. Complete the following chemical reactions : [5]

    (a) $CaO + SiO_2 \longrightarrow$

    (b) $Ca(OH)_2 + CO_2 \longrightarrow$

    (c) $2Mg(NO_3)_2 \longrightarrow$

    (d) $3Mg + N_2 \xrightarrow{\Delta}$

    (e) $NH_4HCO_3 + NaCl \longrightarrow$

UNIT TEST-II
S-BLOCK ELEMENTS

Time Allowed: 1 hr **Maximum Marks : 20**

General Instructions:

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

---

1. Draw the structure of $BeCl_2$ in Vapour phase. [1]

2. What is meant by diagonal Relationship? [1]

3. How do alkali metals react with dihydrogen? [1]

4. Which one of the alkaline earth metal carbonates is thermally the most stable? [1]

   (a) $MgCO_3$ (c) $SrCO_3$

   (c) $CaCO_3$ (d) $BaCO_3$

5. Why is KO_2 paramagnetic? [1]

6. Lithium forms predominantly covalent compounds. Explain. [2]

7. Why can zinc oxide be reduced to the metal by heating with carbon but not chromic oxide? [2]

8. Describe some similarities between beryllium and aluminium? [3]

9. Describe the importance of the following : [3]

   (a) Limestone

   (b) Cement

   (c) Plaster of Paris

10. (I) (i) Why is sodium wire used to remove moisture from C_6H_6 but not for alcohol? [3]

    (ii) Name alkali metal which has most negative E° value?

    (iii) Which raw material is used to manufacture cement?

(II) Last two are Assertion (A) and Reason (R) choose the correct statement : [2]

(a) If both (A) and (R) are correct and (R) is the correct explanation of (A).

(b) If both (A) and (R) are correct and (R) is not the correct explanation of (A).

(c) Assertion is true but Reason is false.

(d) Both (A) and (R) are false.

(i) **Assertion :** Lithium resemble Magnesium.

Reason : Li^+ has same size as Mg^{2+}.

(ii) **Assertion :** NaCl is less Covalent than Cu_2Cl_2.

Reason : Cu^+ has morepolarising power than Na^+.

******

Chapter - 11

p-Block Elements

FAST TRACK : QUICK REVISION

General outer Electronic configuration : ns^2np^{1-6}.

Inert Pair Effect:

- Reluctance of ns^2 electrons of valence shell to participate in bond formation is termed as inert pair effect.
- It arises due to poor or insufficient shielding of ns^2 electrons by intervening d- or f-electrons & hence increases down the group.

Causes of Anomalous Behaviour of First Element in groups of p-Block:

(i) Very small size

(ii) Unavailability of vacant d-orbital

(iii) Tendency to form $p_\pi - p_\pi$ multiple bonds.

Group No-13 Elements: (B, Al, Ga, In, Tl, Nh)

- **General Electronic Configuration: ns^2 np^1**
- **Atomic radius:** $B < Ga < Al < In < TI$

  $r_{Ga} < r_{Al}$ due to ineffective shielding of valence electrons by intervening 3d-electrons in Ga.
- **Ionization Enthalpies:** $B > Tl > Ga > Al > In$
- **Electronegativity:** $B > Tl > In > Ga > Al$
- **Oxidation States:** B (+3), Al (+3), Ga (+3, **+1**), In (+3, **+1**), Tl (+1, **+3**)

  Tl **(+1)** is more stable than Tl **(+3)** due to inert pair effect.
- **Nature of Compounds:** Compounds of group 13 elements are electron deficient i.e. Lewis Acid and hence used as industrial catalyst *e.g.* BF_3, $AlCl_3$.
- **Oxides:**

B_2O_3	Al_2O_3, Ga_2O_3	In_2O_3	Tl_2O
Acidic	Amphoteric	Basic	Strongly Basic

- **Halides:** MX_3 type, Electron deficient (Lewis acid), $AICl_3$ exist as dimer
- **Borax:** $Na_2B_4O_7.10H_2O$. On heating it form transparent glassy bead consisting of $NaBO_2 + B_2O_3$.
- **Boric acid:** H_3BO_3, It acts as a Lewis acid by accepting electron pair from OH^- ions of water.
- **Diborane:** B_2H_6, Colourless & toxic gas, acts as Lewis acid due to having electron deficient 3c-2e⁻ bonds. Obtained by treating BF_3 with $LiAIH_4$ or NaH, Also obtained by treating $NaBH_4$ with l_2.
- **Borazine:** $B_3N_3H_6$, It is isostructural with benzene and hence known as in-organic benzene. Prepared by heating B_2H_6 withNH_3

<u>**Group -14 Elements:**</u> (C, Si, Ge, Sn, Pb,Fl)

- **General** Electronic Configuration: $ns^2\ np^2$
- **Atomic radius:** C < Si < Ge < Sn < Pb
- **lonisation Enthalpy:** LiH_x : C > Si > Ge > Sn < Pb
- **Oxidation States:** C (**+4**), Si (**+4**), Ge (**+4**, +2), Sn (**+4**, +2), Pb (+4, **+2**) Pb (+2) is more stable than Pb (+4) due to inert pair effect.
- **Oxides:** Form di oxides (MO_2) & mono oxides (MO).

  PbO_2 is powerfull oxidizing agent because Pb stabilizes in +2 oxidation state due to inert pair effect. CO_2 is gas while SiO_2 is network solid because C has ability to form $p_\pi — p_\pi$ multiple bonds.
- **Halides:** Form tetra halides (MX_4) & dihalides (MX_2).

  Tetra halides are more covalent due to greater polarizing power of cation.

  CCI_4 is not hydrolysed with water as C has no vacant d-orbital to accept electron pair from water.
- **Catenation:** C >> Si > Ge ≈ Sn >> Pb
- **Allotrops of carbon:** Diamond (sp^3), Graphite (sp^2), Fullerenes (sp^2)
- **Silicones:** Silicones are synthetic organosilicon compounds containing R_2SiO repeating units. Silicones are water repellent, heat resistant, chemically inert, electrical insulators, resistant to oxidation.
- **Silicates:** Silicates are compounds in which anions are derived from Si–o–si– tetrahedral units.
- **Zeolites:** Zeolites are 3D silicates in which some of the Si atoms are replaced by Al^{3+} ions and negative charge is balanced by cations such as Na^+, K^+, Ca^{2+} etc.
- ZSM-5 is used in petrochemical industries to convert methanol into petrol.

CASE BASE STUDY - QUESTIONS

1. Read the following passage and answer the questions :

In the periodic table Group 13 and 14 are p-block elements, consisting of metals, non-metals and metalloids. These Elements exhibit variable oxidation states, lower oxidation states becomes more stable, when we go down the group. The combined effect of size and availability of d-orbitals influence their ability to form π-bonds. Lighter elements form $p\pi$-$p\pi$ bonds whereas heavier elements form $d\pi$ - $p\pi$ or $d\pi$ - $d\pi$ bonds.

Element Boron forms electron deficient compounds. Al exhibits +3 oxidation state. Tl^{+} is more stable than Tl^{3+} due to inert pair effect. Carbon is typical non-metal of group 14, shows property of catenation and forms large number of compounds. It also shows allotropy, diamond, graphite and fullerene are crystalline allotropes of carbon. Group14 elements shows +4 and +2 oxidation state. Pb^{2+} is more stable than Pb^{4+}. CO and CO_2 are oxides of carbon. CO_2 is acidic and CO has lone pair, therefore, forms metal carbonyls. CO is deadly poisonous. CO_2 is greenhouse gas, Silica, silicates and silicones are important classes of compounds of silicon.

(a) Why is Pb^{4+} good oxidizing agent?

Ans. It is due to inert pair effect in Pb^{2+} which is more stable than Pb^{4+}. Pb^{4+} gains 2 electrons to form Pb^{2+}.

(b) Why is CO deadly poisonous?

Ans. It reacts with haemoglobin to form carboxy haemoglobin which does not act as oxygen carrier.

Or

Why are silicones used in implants?

Ans. These are Biocompatible.

(c) What is use of zeolites?

Ans. They act as water softeners.

(d) Why is fullerene purest allotrope of carbons?

Ans. It has soccer ball like structure and does not have edges, therefore, impurities can't enter.

Or

What is structure of SiO_4^{4-}?

Ans. It is tetrahedral, sp^3 hybridised.

(e) Why is NaOH not stored in glass bottles?

Ans. It reacts with SiO_2 present in glass to form sodium silicate.

$2NaOH + SiO_2 \rightarrow Na_2SiO_3H_2O.$

PASSAGE

These elements are characterized by ns^2np^{1to6} valence shell electronic configuration. They belong to Group 13-18 in the periodic table. There are some exceptions in the Atomic Radii and lonization Enthalpies for some elements in the periodic table. Group 13 elements are best reducing agents because of lowest standard reduction potential. They have tendency of ns^2 electrons pair to participate in bond formation that decreases with increase in atomic size.

(1.-4.) There are assertion and reason which have been put forward. Read the given statement and choose correct alternative from the following :

(**Note** : A-Assertion & R-Reason)

(a) Both A and R true and R is the correct explanation of A.

(b) Both A and R true but R is not the correct explanation of A.

(c) A is true but R is false.

(d) A is false but R is true.

1. **A :** Boron has low electrical conductivity.

   R : Boron behaves as a metal at room temperature.

2. **A :** Diamond is not a good conductor of electricity.

   R : Linkage/All C-C bond lengths in diamond are of 154 pm.

3. **A :** TICI is more stable than $TlCl_3$.

   R : Oxidation state (+1) of heaviest element is more stable than (+3).

4. **A :** CO_2 has linear Geometry involving sp hybridized Carbon.

   R : Dry Ice is Solid CO_2.

   Or

   A : Graphite is soft and good lubricating agent.

   R : Successive layers in graphite are held together by weak attractive forces.

Ans. : 1. (c), 2. (b), 3. (a), 4. (b) or (a)

MULTIPLE CHOICE QUESTIONS (MCQ)

1. The element which exists in liquid state for a wide range of temperature and can be used for measuring high temperature is

   (i) B (ii) Al

   (iii) Ca (iv) Ga

2. Which of the following is Lewis acid?

   (i) $AlCl_3$ (ii) $MgCl_2$

   (iii) $CaCl_2$ (iv) $BaCl_2$

3. The geometry of a complex species can be understood from the knowledge of type of hybridisation of orbitals of central atom. The hybridisation of orbitals of central atom in $[Be(OH_4]^-$ and the geometry of the complex are respectively

   (i) sp^3, tetrahedral (ii) sp^3, square planar

   (iii) sp^3d^2, octahedral (iv) dsp^2, square planar

4. Which of the following oxides is acidic in nature?

   (i) B_2O_3 (ii) Al_2O_3

   (iii) Ga_2O_3 (iv) In_2O_3

5. The exhibition of highest co-ordination number depends on the avilability of vacant orbitals in the central atom. Which of the following elements is not likely to act as central atom in MF_6^{3-}?

   (i) B (ii) Al

   (iii) Ga (iv) In

6. Boric acid is an acid because its molecule

   (i) Contains replaceable H^+ ion

   (ii) Gives up a proton

   (iii) Accepts OH^- from water releasing proton

   (iv) Combines with proton from water molecule

7. Catenation i.e., linking of similar atoms depends on size and electronic configuration of atoms. The tendency of catenation in Group 14 elements follows the order:

   (i) C > Si > Ge > Sn (ii) C >> Si > Ge = Sn

   (iii) Si > C > Sn > Ge (iv) Ge > Sn > Si > c

8. Silicon has a strong tendency to form polymers like silicones. The chain length of silicone polymer can be controlled by adding

(i) $MeSiCl_3$ (ii) Me_2SiCl_2

(iii) Me_3SiCl (iv) Me_4Si

9. Ionisation enthalpy (Δ_1H_1 kJ mol^{-1}) for the elements of Group 13 follows the order

(i) B > Al > Ga > In > T1 (ii) B < Al < Ga < In < T1

(iii) B < Al > Ga < T1 (iv) B > Al < Ga > In < T1

10. In the structure of diborane

(i) All hydrogen atoms lie in one plane and boron atoms lie in a plane perpendicular to this plane.

(ii) 2 boron atoms and 4 terminal hydrogen atoms lie in the same plane and 2 bridging hydrogen atoms lie in the perpendicular plane.

(iii) 4 bridging hydrogen atoms and boron atoms lie in one plane and two terminal hydrogen atoms lie in a plane perpendicular to this plane.

(iv) All the atoms are in the same plane.

11. A compound X, of boron reacts with NH_3 on heating to give another compound Y which is called inorganic benzene. The compound X can be prepared by treating BF_3 with Lithium aluminum hydride. The compounds X and Y are represented by the formulas.

(i) B_2H_6, $B_3N_3H_6$ (ii) B_2O_3, $B_3\ N_3\ H_6$

(iii) BF_3, $B_3N_3H_6$ (iv) $B_3N_3H_6$, B_2H_6

12. Quartz is extensively used as a piezoelectric material, it contains ....

(i) Pb (ii) Si

(iii) Ti (iv) Sn

13. The most commonly used reducing agents is

(i) $AlCl_3$ (ii) $PbCl_2$

(iii) $SnCl_4$ (iv) $SnCl_2$

14. Dry ice is

(i) Solid NH_3 (ii) Solid SO_2

(iii) Solid CO_2 (iv) Solid N_2

15. Cement, the important building material is a mixture of oxides of several elements. Besides calcium, iron and sulphur, oxides of elements of which of the group(s) are present in the mixture?

(i) Group 2 (ii) Groups 2, 13 and 14

(iii) Groups 2 and 13 (iv) Groups 2 and 14

MATCH THE COLUMNS

TYPE-I

In the following questions more than one correlation is possible between options of Column I and Column II. Make as many correlation as you can

1.

Column I	Column II
(i) BF_4	(a) Oxidation state of central atom is +4
(ii) $AlCl_3$	(b) Strong oxidishing agent
(iii) SnO	(c) Lewis acid
(iv) PbO_2	(d) Can be further oxidised
	(e) Tetrahedral shape

2.

Column I	Column II
(i) Diborane	(a) Used as a flux for soldering metals
(ii) Galluim	(b) Crystalline form of silica
(iii) Borax	(c) Banana bonds
(iv) Aluminosilicate	(d) Low melting, high boiling, useful for measuring high temperature
(v) Quartz	(e) Used as catalyst in petrochemical industries

3.

Column I	Column II
(i) Boron in $[B(OH)_4]^-$	(a) Sp^2
(ii) Aluminium in $[Al(H_2O)_6]^{3+}$	(b) Sp^3
(iii) Boron in B_2H_6	(c) Sp^3d^2
(iv) Carbon in Buckminsterfullerene	
(v) Silicon in SiO_4^{4-}	
(vi) Germanium in $[GeCl_6]^{2-}$	

TYPE-II

Match the entries of Column-I with appropriate entries of Column-II

1.

	Column I		Column II
(A)	B_2F_6	(a)	Used as a flux for soldering metals
(B)	Galluim	(b)	Crystalline form of silica
(C)	Borax	(c)	3-C-2e-system
(D)	Zeolites	(d)	Low melting, high boiling, useful for measuring high temperatures
(E)	Quartz	(e)	Used as catalyst in petrochemical industries

2.

	Column I		Column II
(A)	Diamond	(a)	Used as antiseptic
(B)	Graphite	(b)	Hardest substance, used as abrasive
(C)	Boric acid	(c)	Used as a lubricant

ASSERTION-REASON TYPE QUESTIONS

In the following questions a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below each question

1. Assertion (A) : If aluminium atoms replace a few silicon atoms in three dimensional network of silicon dioxide, the overall structure acquires a negative charge

   Reason (R) : Aluminium is trivalent while silicon is tetravalent.

   (i) Both A and R are correct and R is the correct explanation of A.

   (ii) Both A and R are correct but R is not the correct explanation of A.

   (iii) Both A and R are not correct

   (iv) A is not correct but R is correct.

2. Assertion (A) : Silicon is water repelling in nature.

   Reason (R) : Silicon is organosilicon polymers, which have ($-R_2SiO-$) as repeating unit

   (i) A and R both are correct and R is the correct explanation of A.

   (ii) Both A and R are correct but R is not the correct explanation of A

   (iii) A and R both are not true.

   (iv) A is not true but R is true.

1-MARK QUESTIONS

1. Mention two important ores of boron.
2. Name the elements of group 13 which forms only covalent compounds.
3. Why the atomic radius of gallium is less than that of Al ?
4. Why does Boron form electron deficient compounds ?
5. Boron does not exist as B^{3+} ion. Why ?
6. Why the trihalide of group 13 elements fume in moist air ?
7. Aluminum form $[AlF_6]^{3-}$ but boron does not form $[BF_6]^{3-}$.
8. Why boric acid is a monobasic acid ?
9. White fumes appear around the bottle of anhydrous $AlCl_3$. Give reason.
10. $AlCl_3$ exist as dimer while BCl_3 exist as monomer, why ?
11. Mention the type of hybridization of Boron in B_2H_6. [**Ans.** sp^3]
12. Write the formula of inorganic benzene.
13. Why aluminum utensils should not be kept in water overnight.
14. Explain what happens when boric acid is heated.
15. BCl_3 exists but BH_3 does not. Explain.
16. Why $SnCl_4$ is more covalent than $SnCl_2$?
17. Why $PbCl_4$ is good oxidising agent ?
18. What are germanes and plumbanes ?
19. Give one example of zeolite.
20. Mention the type of hybridization of carbon in diamond and graphite.
21. Why CCl_4 is insoluble in water but $SiCl_4$ is soluble in water? Explain.
22. Give two uses of silicones.
23. Why graphite is used as lubricant ?
24. Lead (Pb) do not form PbI_4. Why ?
25. CO_2 is gas while SiO_2 is solid at room temperature. Explain why ?
26. Explain why silicon shows a higher covalency than carbon?
27. Out of carbon and silicon which can form multiple bonds and why ?

28. Write the formula of dry ice.

29. Mention the basic building unit of all silicates.

30. Graphite is a good conductor of electricity, but diamond is not. Why ?

2-MARKS QUESTIONS

1. Draw the structure of diborane.

2. What happens when :

   (a) Borax is heated strongly.

   (b) Boric acid is added to water.

3. Write balanced chemical equations for :

   (a) $BF_3 + LiH \longrightarrow$

   (b) $B_2H_6 + NH_3 \longrightarrow$

4. Write chemical reactions to justify amphoteric nature of Al.

5. Suggest reason why the B-F bond length in BF_3 and BF_4^- differ.

6. Give reason for the following :

   (i) BF_3 act as weak Lewis acid.

   (ii) Boron cannot show covalency more than four.

7. How can you explain higher stability of BCl_3 as compared to $TlCl_3$?

8. Give reason for the following :

   (i) Aluminium alloys are used to make aircraft body.

   (ii) Aluminium wire is used to make transmission cables.

9. Describe the shapes of BF_3 and BH_4^-. Assign the hybridization of boron in these species.

10. Explain the chemistry of borax bead test.

11. $[SiF_6]^{2-}$ is known whereas $[SiCl_6]^{2-}$ not. Give reason.

12. Hydrolysis of $SiCl_4$ take place but of CCl_4 does not. Why ?

13. Account for the following :

    (a) CO_2 is gas while SiO_2 is solid at room temperature.

    (b) Solid CO_2 is known as dry ice.

14. Elemental silicon does not form graphite like structure as carbon does. Give reason.

15. Suggest a reason as to why CO is poisonous?

16. How is excessive content of CO_2 responsible for global warming ?

17. What is allotropy ? Name two elements which exhibit allotropy.

18. Write equations for the production of water gas and producer gas from coke.

19. Define zeolite. Name the zeolite which converts alcohols directly into gasoline.

20. Arrange the hybrides of group 14 elements in increasing order of :

    (a) Thermal stability

    (b) Reducing power.

3-MARKS QUESTIONS

1. Give reasons of the following :

   (i) In diborane, two B – H – B bonds are different from common covalent bonds.

   (ii) Aluminium metal shows amphoteric behaviour.

   (iii) Quartz is used to develop extremely accurate clocks.

2. A certain salt X gives the following results :

   (i) Its aqueous solution is alkaline to litmus.

   (ii) It swells up to a glassy material Y on strong heating.

   (iii) When conc. H_2SO_4 is added to a hot solution of X, white crystal of an acid Z separates out. Write equations for all the above reactions and identify X, Y and Z.

3. Write balanced chemical equation for :

   (i) $B_2H_6 + H_2O \longrightarrow$

   (ii) $Al + NaOH \longrightarrow$

   (iii) $NaOH + B_2H_6 \longrightarrow$

4. List two important properties in which boron differs from the rest of the members of group. Mention the main reasons for the difference.

5. What are electron deficient compounds? Are BCl_3 and $SiCl_4$ electron deficient species ? Explain.

6. Select the member(s) of group 14 that :

   (i) Forms the most acidic dioxide.

   (ii) Is commonly found in + 2 oxidation state.

   (iii) Used as semiconductor.

7. What are allotropes ? Sketch the structure of two allotropes of carbon namely diamond and graphite.

8. Give suitable reasons for the following :

   (a) CO_2 turns lime water milky, but if passed for a long time, the solution become transparent again.

   (b) Graphite is a good conductor of electricity but diamond is insulator.

   (c) Lead (IV) chloride is highly unstable towards heat.

9. (i) Write the resonance structure of CO_3^{2-} and HCO_3^{-}.

   (ii) Write the name of thermodynamically most stable form of carbon.

10. (i) Explain why is there a phenomenal decreases in ionisation enthalpy from carbon to silicon ?

    (ii) Write an industrial application of silicones.

5-MARKS QUESTIONS

1. When metal X is treated with NaOH, a white precipitate 'A' is obtained, which is soluble in excess of NaOH to give soluble complex (B). Compound 'A' is soluble in dilute HCl to form compound 'C'. The compound 'A' when heated strongly gives 'D', which is used to extract metal. Identify X, A, B, C and D. Write suitable equations to support their identities.

2. (i) If B-Cl bond has dipole moment explain why BCl_3 molecules has zero dipole moment.

   (ii) A mixture of dil. NaOH and aluminium pieces is used to open drain. Give reason.

(iii) Aluminium wire is used to make transmission cables. Why ?

3. (i) Identify the compounds X and Y in the following reactions :

(a) $Na_2B_4O_7 + 2HCl + 5H_2O \rightarrow 2NaCl + X$

(b) $X \xrightarrow{370\text{ K}} HBO_2 \xrightarrow{>370\text{ K}} Y.$

(ii) Write the name of group 13 element which is used to measure high temperature.

(iii) Why in case of thallium + 1 oxidation state is more stable than + 3?

4. Compare the general trend in the following properties of the elements of group 13 and 14 :

(a) Atomic size, (b) Ionisation enthalpy, (c) Metallic character, (d) Oxidation states, (e) Nature of halides.

5. Name the following :

(a) The crystalline form of silica used in modern radio and T.V. broadcasting and mobile radio communication.

(b) The oxides of carbon which form a complex with haemoglobin 300 times more faster than oxygen.

(c) The allotrope of carbon which has $\Delta_f H^\theta = 0$.

(d) A type of polymer is semiorganic in nature.

(e) Two man made silicates.

6. Explain the formation of (i) water gas (ii) producer gas. Give their uses. What happens when CO_2 is passed through limewater?

(i) for short duration

(ii) for long duration.

UNIT TEST-I

Time Allowed: 1 Hr. **Maximum Marks : 20**

General Instructions:

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

---

1. Which of the following is Lewis acid? [1]

   (a) $AlCl_3$ (b) $MgCl_2$ (c) $CaCl_2$ (d) $BaCl_2$

2. Dry ice is [1]

   (a) Solid CO_2 (b) Solid SO_2 (c) Solid N_2 (d) Solid NH_3

3. Chemical formula of diborane is ___________. [1]

4. Write an example of shape relative catalyst. [1]

5. Allotrope of carbon with sp^3 hybridisation state is _________? [1]

6. Complete the following chemical equations : [2]

   (a) $B_2H_6 + NH_3 \longrightarrow$

   (b) $BF_3 + LiH \longrightarrow$

7. Write the chemical reactions involved in borax bead test. [2]

8. What are allotrope? Sketch the structure of two allotrope of carbon namely diamond and graphite. [3]

9. Compare the properties of the elements of group-13 and 14 [3]

   (a) Atomic size

   (b) Ionisation enthalpy

   (c) Oxidation state

10. (a) Explain the formation of (i) water gas (ii) producer gas [5]

    (b) Identify the compound X and Y in the following reactions

    (i) $Na_2B_4O_7 + 2HCl + 5H_2O \longrightarrow 2NaCl + X$

    (ii) $X \xrightarrow{370\ K} HBO_2 \xrightarrow{>370\ K} Y$

    (c) Write two important applications of silicons.

UNIT TEST-II

Time Allowed: 1 Hr. **(P-Block Elements)** **Maximum Marks : 20**

General Instructions:

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

---

1. Quartz is extensively used as piezoelectric material, it contains_____. [1]
2. Charcoal readily Readily burns in air to form ___________. [1]
3. Mention the state of hybridization of B in BH_4^-. [1]
4. Why $PbCl_4$ is good oxidizing agent? [1]
5. CO combines with haemoglobin irreversibly to form________. [1]
6. $AlCl_3$ exist as a dimer while BCl_3 exist as monomer, Why? [2]
7. BCl_3 exists but BH_3 does not. Explain. [2]
8. Select the members of group 14 that : [3]
   (i) Forms the most acidic dioxide.
   (ii) Is commonly found in +2 oxidation state.
   (iii) Exhibit highest catenation tendency.
9. Give reason for the following statements : [3]
   (i) Boron is unable to form BF_6^{3-}.
   (ii) Stability of +1 oxidation state progressively increases for the heavier elements of Group 13.
   (iii) Graphite is used as a dry lubricant in Machines running at high temperature.
10. (I) Write balanced equation for :
    (i) BF_3 is reacted with ammonia
    (ii) Al is treated with dilute NaOH
    (iii) CO(g) is heated with ZnO

    (II) Last two are Assertion and Reason choose the correct statement.
    (a) Both (A) and (R) are correct and (R) is the correct explanation of (A)

(b) Both (A) and (R) are correct and (R) is not the correct explanation of (A)

(c) Assertion is true but Reason is false.

(d) Both (A) and (R) are false.

(i) **Assertion :** CCl_4 does not hydrolyse unlike $SiCl_4$.

Reason : It is because 'C' does not have d-orbitals.

(ii) **Assertion :** Ga has a lower atomic radius compared to Al.

Reason : Due to poor shielding effect of d-electrons as a result of which effective nuclear charge increases.

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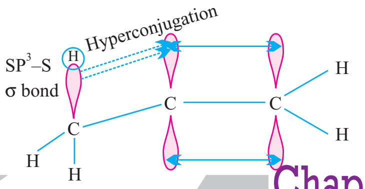


Chapter - 12

Organic Chemistry : Some Basic Principles and Techniques

FAST TRACK : QUICK REVISION

ORGANIC CHEMISTRY

It deals with the study of hydrocarbons (compounds of carbon and hydrogen elements) and their derivatives.

Some organic compounds may also contain nitrogen, oxygen, sulphur, phosphorus, halogens, etc.

Berzelius, proposed that a 'vital force' was responsible for the formation of organic compounds.

This was rejected by F. Wohler who synthesised first organic compound urea from an inorganic compound.

$$\underset{\text{Ammonium cyanate}}{NH_4CNO} \xrightarrow{\Delta} \underset{\text{Urea}}{NH_2CONH_2}$$

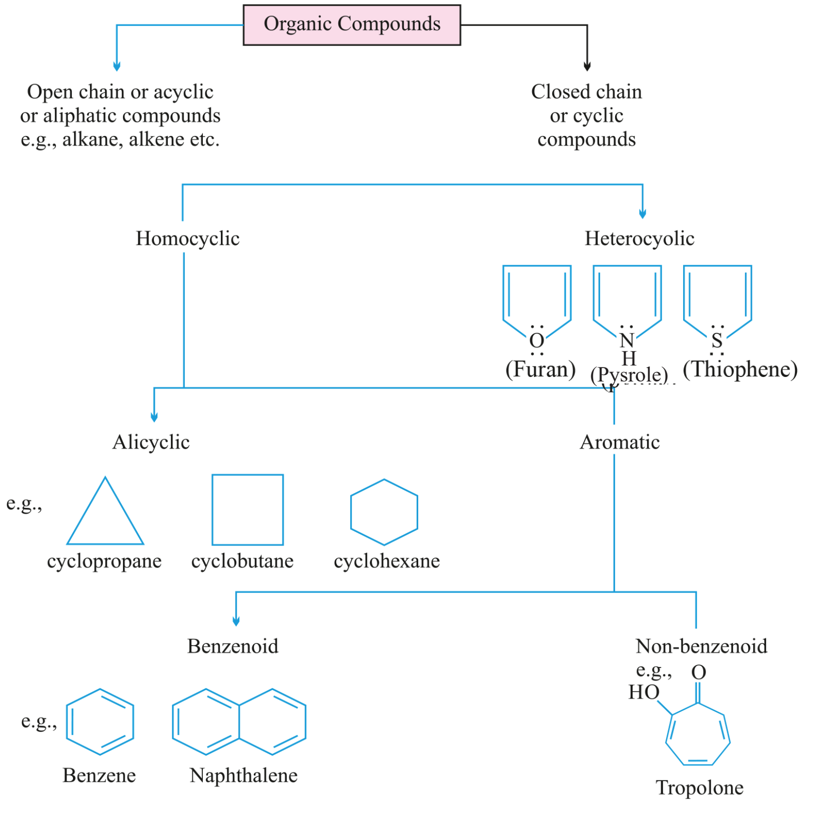
- Acetic acid was synthesised by Kolbe and methane by Berthelot.
- **Types of hybridisation of C-atom :**

Hybridisation	Structure	Bond angle	Examples
sp^3	Tetrahedral	109°28'	Ethane, Methane
sp^2	Trigonal	120°	Ethene, Propene
sp	Linear	180°	Ethyne, Propyne

- **Reasons for existence of large number of organic compounds:**
- **Catenation :** The property of atoms of an element to link with one another forming chains of identical atoms is called *catenation*. Carbon exhibits catenation to the maximum extent.
- **Isomerism :** It is the property by virtue of which two or more compounds have the same molecular formula but different physical or chemical properties.

- **Formation of multiple bonds :** Because of its small size carbon atom is capable of forming multiple bonds with other atoms and this gives a variety of compounds.

- **CLASSIFICATION OF ORGANIC COMPOUNDS**



- **CLASSIFICATION OF CARBON ATOMS**

On the basis of number of C attached

(i) **Primary carbon atom :** when carbon atom is attached with one other carbon atom only, it is called **primary or 1°** carbon atom.

(ii) **Secondary carbon atom :** When carbon atom is attached with two other carbon atoms, it is called **secondary or 2°** carbon atom.

(iii) **Tertiary carbon atom :** When carbon atom is attached with three other carbon atoms, it is called **tertiary or 3°** carbon atom.

(iv) **Quaternary carbon atom :** When carbon atom is attached with four other carbon atoms, it is called **quarterly or 4°** carbon atom.

- **Functional Group :** The atom *e.g.,* –Cl, –Br, etc., or group of atoms *e.g.,* –COOH, –CHO, which is responsible for the chemical properties of the molecule, is called **functional group**.

- **Homologous Series :** The series in which the molecular formula of adjacent members differ by a $-CH_2$ unit, is called homologous series and the individual members are called homologous, *e.g.,* The homologous series of alkene group is

$$\left.\begin{array}{l} C_2H_4 \\ C_3H_6 \\ C_4H_8 \\ C_5H_{10} \end{array}\right\} \text{difference of} -CH_2 \text{ unit or 14 unit mass}$$

The general characteristics of this series are :

1. All the homologues contain same functional group. That's why their chemical properties are almost similar.
2. All the members of a series have same general formula, *e.g.,*

Series	General Formula
Alkanes	C_nH_{2n+2}
Alkenes	C_nH_{2n}
Alkynes	C_nH_{2n-2}
Alcohol and ether	$C_nH_{2n+2}O$
Aldehyde and ketone	$C_nH_{2n}O$
Acid and ester	$C_nH_{2n}O_2$

3. All the members can be prepared by almost similar methods.
4. With increase in the molecular weight of a series, the physical properties vary gradually.

- **Representation of Organic Compounds :**

Organic compounds can be represented by the following ways:

(i) **Complete Structural Formula :** All the bonds present between any two atoms are shown clearly. *e.g.,*

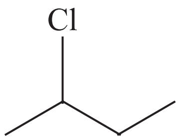
$$\begin{array}{ccccccccc} & & H & & H & & H & & H & & \\ & & | & & | & & | & & | & & \\ H & - & C & - & C & - & C & - & C & - & H \\ & & | & & | & & | & & | & & \\ & & H & & Cl & & H & & H & & \end{array}$$

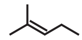
(ii) **Condensed Formula :** All the bonds are not shown clearly. *e.g.*,

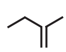
$CH_3CHCH_2CH_3$
$\quad\;\;|$
$\quad\;\;Cl$

$CH_3CH(Cl)CH_2CH_3$

(iii) **Bond Line Formula :** Every fold and free terminal represents a carbon and lines represent the bond. *e.g.*,

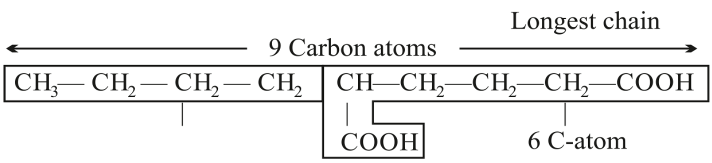


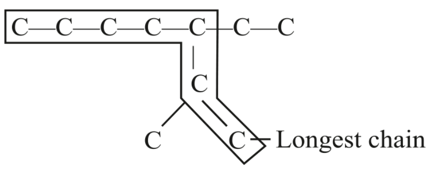
$CH_3-\underset{\underset{CH_3}{|}}{C}=CH-CH_2CH_3 \equiv$ 

$CH_3-CH_2-COOH \equiv$ 

- **IUPAC Nomenclature of Organic Compounds :** Following rules are used to write the IUPAC name of an organic compound.

Rule 1. : Longest chain rule : The chain containing the principal functional group, secondary functional group and multiple bonds as many as possible is the longest possible chain.
In the absence of functional group, secondary group and multiple bonds, the chain containing the maximum number of C-atoms will be the longest possible chain *e.g.*,





Word Root for Carbon Chain

Chain length	Word root	Chain length	Word root
C_1	Meth-	C_7	Hept
C_2	Eth-	C_8	Oct
C_3	Prop-	C_9	Non
C_4	But-	C_{10}	Dec
C_5	Pent-	C_{11}	Undec
C_6	Hex-	C_{12}	Dodec

Rule 2 : Lowest number rule : Numbering is done in such a way so that

(i) branching if present gets the lowest number.

(ii) the sum of numbers of side chain is lowest.

(iii) principal functional group gets the lowest number.

Select the principal functional group from the preference series :

$$—COOH > —SO_3H > \text{acid anhydride} —COOR > —COX > —CONH_2 > —CN > —NC > —CHO > C=O > —OH > —SH > —NH_2 > \text{═} > \equiv > \text{substituents}$$

Functional group other than the principal functional group are called substituents.

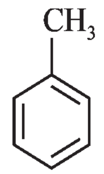
Rule 3: Naming the prefix and suffixes : Prefix represents the substituent and suffix is used for principal functional group.

Primary suffix are **ene, ane** or **yne** used for double, single and triple bonds respectively.

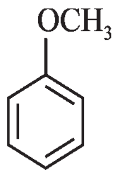
Secondary suffixes are tabulated below :

No.	Class	Formula	Prefix	Suffix
1.	Acid halides	$—\overset{O}{\overset{\parallel}{C}}—X$	halocarbonyl	—oyl halide —carbonyl halide
2.	Alcohols	—OH	hydroxy	—ol
3.	Aldehydes	—CHO	formyl	—al —carbaldehyde
4.	Ketones	$>C=O$	oxo (keto)	—one
5.	Amides	$—CONH_2$	carbamoyl	—amide
6.	Amine	$—NH_2$	amino	—amine
7.	Carboxylic acid	—COOH	carboxy	—carboxylic acid
8.	Ester	—COOR	alkoxy carbonyl	—alkyl alkan**oate**
9.	Nitriles	—CN	cyano	—nitrile
10.	Sulphonic acid	$—SO_2—OH$	sulpho	—sulphonic acid

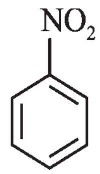
- **Nomenclature of substituted benzene compounds :**



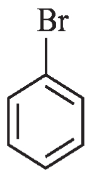
Methylbenzene



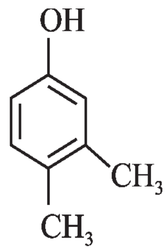
Methoxy benzene



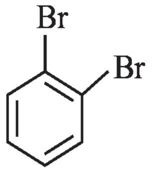
Nitrobenzene



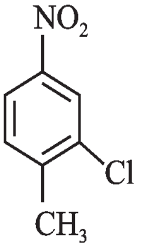
Bremobenzene



3, 4-Dimethyl phenol



1, 2-Dibromo benzene
In Trivial name
1, 2-ortho (o)
1, 3-meta (m)
1, 4-para (p)



2-Chloro-1-methyl
1-4-nitrobenzene

ISOMERISM

Structural isomerism

Same molecular formula but different structures

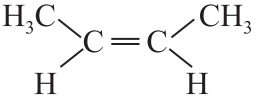
<u>Types</u>

1. **Chain Isomerism**
   e.g., Pentane and
   2-Methylbutane
2. **Position Isomerism**
   e.g., But-1-ene
   But-2-ene
3. **Functional Isomerism**
   e.g., Propanal & Propanone
   Ethanol & Methoxymethane
4. **Metamerism**
   e.g., Pentan-2-one and
   Pentan-3-one

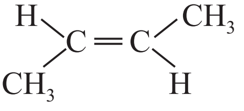
Stereo isomerism

Same molecular and structural formula but different configuration

e.g., Geometrical isomerism (cis-trans isomerism)



Cis.But-2-ene



Trans.But-2-ene

- **Fission of a Covalent Bond :**

(i) **Homolytic Fission :** In this one of the electrons of the shared pair in a covalent bond goes with each of the bonded atoms. The neutral chemical species thus formed, are called free radicals. Generally, homolytic fission takes place in non-polar covalent molecules in the presence of sunlight or high temperature.

$$A - B \xrightarrow{\text{Sunlight}} \underbrace{A^* + B^*}_{\text{free radicals}}$$

$$Cl_2 \xrightarrow{\text{Sunlight}} 2Cl^*$$

Free radicals are highly reactive, neutral and electron deficient species.

(ii) **Heterolytic Fission :** The covalent bond breaks in such a fashion that the shared pair of electrons goes with one of the fragments.

more electronegative

$$A - B \longrightarrow \underset{\text{electrophile}}{A^+} + \underset{\text{nucleophile}}{B^-}$$

less electronegative

$$A - B \longrightarrow \underset{\text{nucleophile}}{A^-} + \underset{\text{electrophile}}{B^+}$$

Heterolytic fission generally takes place in polar covalent molecules but in non-polar molecules, it takes place in the presence of catalyst like $AiCl_3$ (anhy.), $FeCl_3$ (anhy.) etc.

- **Attacking Reagents :**

These are of two types

(i) **Electrophiles or Electrophilic Reagents**

These are electron deficient species, i.e., behave as Lewis acids.

e.g., Cl^+, $\overset{+}{N}O_2$, CH_3CO^+ etc.

BF_3, $ZnCl_2$ (anhydrous), $FeCl_3$ (anhydrous), $AlCl_3$ (anhydrous)

(ii) **Nucleophiles or Nucleophilic Reagents**

These are negatively charged or neutral molecules with unshared electron pair.

e.g., $\bar{O}H$, CN^-, $R\ddot{N}H_2$, $\ddot{N}H_3$

- **Reaction Intermediates :**

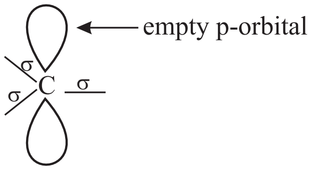
(i) **Free radicals :** These are the product of homolysis and contain an odd electron. These are highly reactive planar species with sp^2 hybridisation.

Their order of stability is

$$(C_6H_5)_3\overset{\circ}{C} > (C_6H_5)_2\overset{\circ}{C}H > C_6H_5\overset{\circ}{C}H_2$$
$$> CH_2=CH-\overset{\circ}{C}H_2 > 3° > 2° > 1° > CH_2=\overset{\circ}{C}H$$

(ii) **Carbocations :** These are the product of heterolysis and contain a carbon bearing positive charge. These are electron deficient species.

These are also polar chemical species i.e., sp^2 hybridised with an empty p-orbital.



Stability order of carbocation is

$$(C_6H_5)_3\overset{+}{C} > (C_6H_5)_2\overset{+}{C}H > C_6H_5\overset{+}{C}H_2$$
$$> CH_2=CH-\overset{+}{C}H_2 > 3° > 2° > 1° > CH_2=\overset{+}{C}H$$

(iii) **Carbanions :** These are the product of heterolysis and contain a carbon bearing negative charge and 8 electrons in its valence shell.

These have pyramidal shape with sp^3 hybridised carbon (having one lone pair) order of stability of carbanions is

$$(C_6H_5)_3\bar{C} > (C_6H_5)_2\bar{C}H > C_6H_5\bar{C}H_2$$
$$> \bar{C}H_3 > 1° > 2° > 3° \text{ carbanions}$$

- **Electron Displacement in Covalent Bond**

1. Inductive Effect : If shared pair is more shifted towards more electronegative atom, the less electronegative atom acquires slight positive charge and more electronegative atom acquires partial negative charge,

e.g., $\overset{+\delta}{C}H_3 \rightarrow\!\!- \overset{-\delta}{Cl}$

Permanent effect and propagates through carbon chain.

Atoms or groups having greater electron affinity than hydrogen are said to have electron attracting or negative inductive effect (–*I*) while that having, smaller electron affinity than hydrogen are said to have electron releasing or positive inductive effect (+*I*).

e.g., $\overset{+\delta\delta}{C}H_3 \rightarrow\!\!- \overset{+\delta}{C}H_2 \rightarrow\!\!- \overset{-\delta}{Cl}$

$\overset{+\delta\delta\delta}{C}H_3 \rightarrow\!\!- \overset{+\delta\delta}{C}H_2 \rightarrow\!\!- \overset{+\delta}{C}H_2 \rightarrow\!\!- \overset{-\delta}{Cl}$

1° alkyl halide

Cl has –I effect and alkyl group has +I effect.

Order of groups producing –I effect is

$R_3N > -NO_2 > -CN > -SO_3H > -CHO > -CO > -COOH > -F$
$> -Cl > -Br > -I > -OH > -OR > -NH_2 > -C_6H_5 > -H$

Order of groups producing +I effect is

3° alkyl group > 2° alkyl group > 1° alkyl group $> -CH_3 > -H$

- **Applications of Inductive Effect**

(i) Presence of groups showing +I effect increases the stability of carbocation while presence of groups showing –I effect decreases their stability.

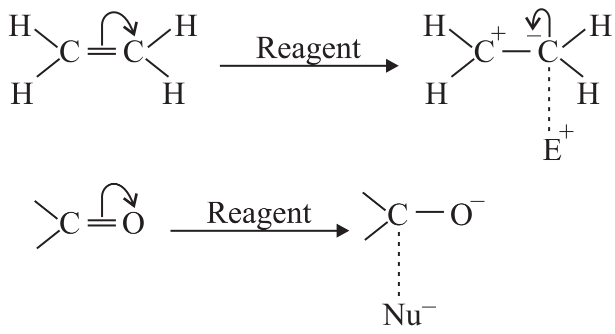
(ii) Strength of acid increases with the attachment of group showing –I effect and decreases with the attachment of group showing +I effect.

(iii) Presence of +I showing groups increases the basic strength of amines.

2. **Electromeric Effect :** Defined as the polarity produced in a multiple bonded compound as a reagent approaches it. In the presence of attacking reagent, the two π electrons are completely transferred to any of the one atom. This effect is temporary.

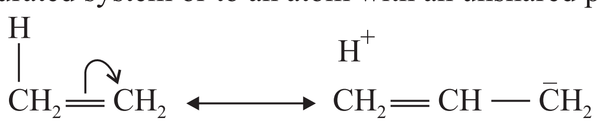
It may be of +E type (when displacement of electron pair is away from the atom of group) or of –E type (when displacement is towards the atom or group).

e.g.,



3. **Hyper-conjugation :** It involves delocalisation of σ electron of a C – H bond of an alkyl group attached directly to an atom of unsaturated system or to an atom with an unshared p-orbital.

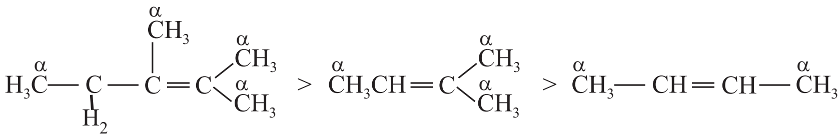
e.g.,



This effect is also called no bond resonance or Baker Nathan effect.

Applications of Hyper-conjugation

Stability of alkenes : More the number of α-hydrogen atoms, more stable is the alkene.



Stability of Carbocation : Greater the number of alkyl groups attached to positively charged carbon atom, the greater is the stability.

e.g., $(CH_3)_2\overset{+}{C}H > CH_3 - \overset{+}{C}H > \overset{+}{C}H_3$

4. Resonance Effect : When the properties of a molecule cannot be shown by a single structure and two or more structures are required to show all the properties of that molecule, then the structures are called resonating structures or canonical forms and the molecule is referred as resonance hybrid. This phenomenon is called resonance.

Conditions for resonance

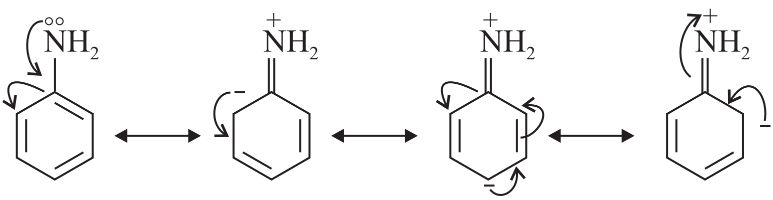
(i) The arrangement of atoms must be identical in all the formula.

(ii) The energy content of all the canonical forms must be nearly same.

(iii) Each canonical of π electrons. This effect may be of +R type or –R type.

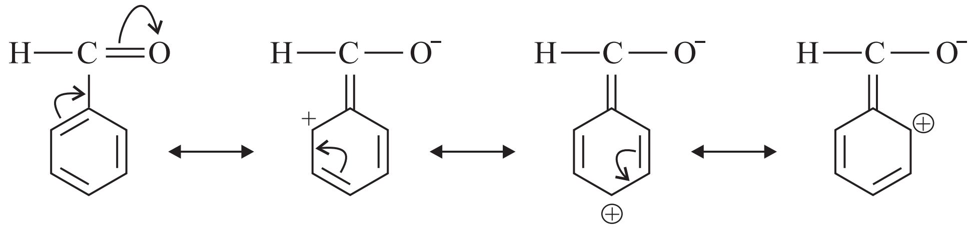
Positive Resonance Effect (+R)

Electron donating groups with respect to conjugated system show +R effect. Central atom of functional groups should be more electronegative than the surrounding atoms or groups to show +R effect. *e.g.*, halogens, –OH, –OR, $-NH_2$, NHCOR, etc.



Negative Resonance Effect (–R)

Electron withdrawing groups with respect to conjugate system show –R effect. Central atom of functional groups should be less electronegative than surrounding atoms or groups to show –R effect. *e.g.*, halogens, –COOH, –COOR, CHO, –CN, $-NO_2$, etc.



• Methods of Purification of Organic Compounds

Method	Principle	Applications
Crystallization	Different solubilities of a given organic compound and its impurities in the same solvent.	• Crystallization of sugar (containing an impurity of common salt) is achieved by shaking the impure solid with hot ethanol at 348K (sugar dissolves whereas common salt remains insoluble).
Sublimation	Some solid substances change from solid to vapour state without passing through liquid state. Sublimable compounds get separated from non-sublimable impurities.	• Iodine from sodium chloride (as iodine sublimes readily leaving behind sodium chloride). • Camphor, naphtalene, anthracence, benzoic Acid, etc. are purified.
Distillation	It is used to separate • Volatile liquids from non-volatile impurities. • Liquids having sufficient difference in their boiling points.	• Hexane (b.p. 342K) and toluene (b.p. 384K) • Chloroform (b.p. 334K) and aniline (b.p. 457K)
– Fractional Distillation	If the difference in boiling points of two liquids is not much, this method is used.	• Crude oil in petroleum industry is separated into various useful fractions such as gasoline, kerosene oil, diesel oil, lubricating oil, etc.
– Steam Distillation	This method is used to separate substances which are (i) steam volatile, (ii) immiscible with water, (iii) posses a vapour pressure of 10-15 mm Hg and (iv) contain non-volatile impurities.	• Aniline is separated from aniline water mixture. • Essential oils, turpentine oil, o-nitrophenol, bromobenzene nitrobenenze, etc. can be purified.
Differential Extraction	By shaking an aqueous solution of an organic compound with an organic solvent in which the organic compound is more soluble than in water. The organic solvent and the aqueous solution should be immiscible with each other so that they can form two distinct layers which can be separated by using separating funnel.	• Benzoic acid can be extracted from its water solution using benzene.

Chromatography	Differential movement of individual components of a mixture through a stationary phase under the influence of a mobile phase.	• Widely used for separation purification, identification and characterization of the components of a mixture, whether coloured or colourless.
– Adsorption Chromatography	Differential adsorption of the various components of a mixture on a suitable adsorbent such as silica get or alumina.	
– Column Chromatography	The mixture is passed through adsorbent packed in glass tube.	• Mixture of naphthalene and benzophenone.
– Thin Layer Chromatography	The mixture is passed over adsorbent on a thin glass plate.	• Amino acids can be detected by spraying the plate with ninhydrin solution.
– Partition Chromatography	Differential partitioning of components of a mixture between stationary and mobile phases.	
– Paper Chromatography	A special quality paper known as chromatography paper is used. It contains water trapped in it, which acts as the stationary phase.	• For separation of sugars and amino acids.

Types of Chromatography	Mobile / Stationary Phase
Column Chromatography	Liquid / Solid
Thin Layer Chromatography	Liquid / Solid
High Performance Liquid Chromatography (HPLC)	Liquid / Solid
Gas Liquid Chromatography (GLC)	Gas / Solid
Partition or Paper Chromatography	Liquid / Solid

Element	Detection	Confirmatory Test	Reactions
Carbon	$2CuO + C \xrightarrow{\Delta} 2Cu + CO_2$	CO_2 gas turns lime water milky.	$\underset{\text{Lime water}}{CO_2 + Ca(OH)_2} \longrightarrow \underset{\text{Milkiness}}{CaCO_3\downarrow} + H_2O$
Hydrogen	$CuO + 2H \xrightarrow{\Delta} Cu + H_2O$	Water droplets appear on the cooler part of the ignition tube and also turns anhydrous $CuSO_4$ blue.	$\underset{\text{White}}{CuSO_4} + 5H_2O \longrightarrow \underset{\text{Blue}}{CuSO_4.5H_2O}$
Nitrogen	Lassaigne's extract (L.E.) $Na + C + N \xrightarrow{\Delta} \underset{\text{(L.E.)}}{NaCN}$	L.E. + $FeSO_4$ + NaOH, boil and cool + $FeCl_3$ + conc. HCl. Gives blue or green colour.	$FeSO_4 + 2NaOH \longrightarrow Fe(OH)_2 + Na_2SO_4$ $Fe(OH)_2 + 6NaCN \longrightarrow Na_4[Fe(CN)_6] + 2NaOH$ $3Na_4[Fe(CN)_6] + 4FeCl_3 \longrightarrow \underset{\text{Prussian blue}}{Fe_4[Fe(CN)_6]_3} + 12NaCl$

Sulphur	$2Na + S \xrightarrow{\Delta} Na_2S$ (L.E.)	– L.E. + sodium nitroprusside A deep violet colour. – L.E. + CH_3COOH + $(CH_3COO)_2Pb$ Gives a black ppt.	$Na_2S + Na_2[Fe(CN)_5NO] \longrightarrow$ (Sodium nitroprusside) $Na_4[Fe(CN)_5NOS]$ (Deep violet) $Na_2S + (CH_3COO)_2Pb \xrightarrow{CH_3COOH}$ $Pbs\downarrow + 2CH_3COONa$ (Black ppt.)
Halogens	$Na + X \xrightarrow{\Delta} NaX$ (L.E.)	L.E. + HNO_3 + $AgNO_3$ – White ppt. soluble in aq. NH_3 (or NH_4OH) confirms Cl. – Yellow ppt. partially soluble in aq. NH_3 (or NH_4OH) confirms Br. – Yellow ppt. insoluble in aq. NH_3 (or NH_4OH) confirms I.	$NaX + AgNO_3 \xrightarrow{HNO_3} AgX\downarrow$ ppt. $AgCl + 2NH_{3(aq.)} \longrightarrow [Ag(NH_3)_2]Cl$ (White ppt.) (Soluble)
Nitrogen and sulphur together	$Na + C + N + S \xrightarrow{\Delta}$ NaSCN Sodium thiocyanate (L.E.)	As in test for nitrogen; instead of green or blue colour, blood red colouration confirms presence of N and S both.	$NaSCN + FeCl_3 \longrightarrow$ $[Fe(SCN)Cl_2 + NaCl$ Blood red colour
Phosphorus	$P \xrightarrow{Na_2O_2,\ boil} Na_3PO_4$	Solution is boiled with nitric acid and then treated with ammonium molybdate $(NH_4)_2MoO_4$. Formation of yellow ppt. indicates presence of phosphate (hence, phosphorus) in organic compound.	$Na_3PO_4 + 3HNO \longrightarrow H_3PO_4 + 3NaNo_3$ $H_3PO_4 + 12(NH_4)_2MoO_4 + 21HNO_3$ $\longrightarrow (NH_4)_3PO_4.12MoO_3$ Ammonium phosphomolybalate (yellow ppt.) $+ 21NH_4NO_3 + 12H_2O$

- **Quantitative analysis of organic compounds :** The percentage composition of elements presence an organic compound is determined by the methods based on the following principles :

Elements	Method
Carbon and Hydrogen	**Liebig's Combustion method :** A known mass of an organic compound is burnt in the presence of excess of O_2 and CuO. $$C_xH_y + \left(x + \frac{y}{4}\right)O_2 \xrightarrow{\Delta} xCO_2 + \frac{y}{2}H_2O$$ CO_2 evolved is absorbed by conc. solution of KOH or ascarite (NaOH + CaO).H_2O produced is absorbed by anhydrous $CaCl_2$ or $Mg(ClO_4)_2$. Increase in masses of these absorbing compounds gives the masses of CO_2 and H_2O produced. $$\% \text{ of C} = \frac{12}{44} \times \frac{\text{mass of } CO_2 \text{ formed}}{\text{mass of compound taken}} 100;$$ $$\% \text{ of H} = \frac{2}{18} \times \frac{\text{mass of } H_2O \text{ formed}}{\text{mass of compound taken}} 100$$
Halogens	**Carius method :** Halogen in organic compound is precipitated as silver halide by boiling with conc. NHO_3 and then adding $AgNO_3$. $$X \xrightarrow[AgNO_3]{HNO_3,\ \Delta} AgX\downarrow$$ $$\% \text{ of X} = \frac{\text{At. mass of X}}{108 + \text{At. mass of X}} \times \frac{\text{mass of AgX formed}}{\text{mass of compound taken}} \times 100$$
Nitrogen	**Dumas method :** Nitrogen containing organic compound is heated with CuO in an atmosphere of CO_2. $$C_xH_yN_z + \left(2x + \frac{y}{2}\right)CO_2 \longrightarrow xCO_2 + \frac{y}{2}H_2O + N_2 + \left(2x + \frac{y}{2}\right)Cu$$ N_2 evolved gets collected over conc. KOH solution which absorbs all other gases. $$\% \text{ of N} = \frac{28}{22400} \times \frac{\text{Vol. of } N_2 \text{ at STP}}{\text{mass of compound taken}} \times 100$$ **Kjeldahl's method :** Organic compound + $H_2SO_{4\,(conc.)} \longrightarrow (NH_4)_2SO_4 \xrightarrow{2NaOH} Na_2SO_4$ + $2NH_3 + 2H_2O + 2NH_3 + H_2SO_4 \longrightarrow (Na_4)_2SO_4$ $$\% \text{ of N} = \frac{1.4 \times \text{molarity of acid} \times \text{vol. of acid used} \times \text{basicity of acid}}{\text{mass of compound taken}}$$

Sulphur	**Carius method :** Sulphur in organic compound is converted into H_2SO_4 by boiling with Na_2O_2 or conc. HNO_3 and is precipitated as $BaSO_4$ by adding excess of $BaCl_2$ solution in water. $S \xrightarrow[\text{(ii) } BaCl_2]{\text{(i) } HNO_3,\ \Delta} \underset{\text{white ppt.}}{BaSO_4\downarrow}$ $\%\ \text{of S} = \frac{32}{233} \times \frac{\text{mass of } BaSO_4 \text{ formed}}{\text{mass of compound taken}} \times 100$
Phosphorus	**Ignition method :** $P \xrightarrow[\text{heat}]{HNO_3} H_3PO_4$ $H_3PO_4 + Mg^{2+} + NH_4CL \xrightarrow{\Delta} \underset{\text{Magnesium ammonium phosphate (white ppt.)}}{MgNH_4PO_4} + HCl$ $2MgNH_4PO_4 \xrightarrow{\Delta} \underset{\text{Magnesium pyrophosphate}}{Mg_2P_2O_7} + 2NH_3 + H_2O$ $\%\ \text{of P} = \frac{62}{222} \times \frac{\text{mass of } Mg\ P_2O_7 \text{ formed}}{\text{mass of compound taken}} \times 100$

MIND MAP : ORGANIC CHEMISTRY

Organic Chemistry Basic Principles and Technology

Types of Covalent Bond Fussion

- Homolytic
  - Gives free radicals
- Heterolytic
  - Gives ions

Types of Attacking Reagents

- Electrophiles e.g., BF_3, No_2^+
- Nucleophiles e.g., H_2O, CN^-

Reaction Intermediates

Carbocations
- Formed by Heterolytic fission
- sp^2C
- Stability 3° > 2° > 1°

Carbanions
- Formed by Heterolytic fission
- sp^3C
- Stability 1° > 2° > 3°

Free radicals
- Formed by Heterolytic fission
- sp^2C
- Stability 1° > 2° > 3°

Types of C

1°, 2°, 3°, 4°

Hybridisation of C

All σ bonds – sp^3

One π bonds – sp^2

Two π bonds – sp

Methods of purification of organic compounds

- Crystallibation
- Sublimation
- Distillation
- Chromatography

Hemologenes Series

Members have same general formula

Two successive members differ by 14u i.e., $-CH_2$ unit

Isomerism

- Structural isomerism
  - Chain isomerism
  - Position isomerism
  - Functional isomerism
  - Metamerism
- Stereo isomerism
  - e.g., Geometrical or Cis-trans isomerism
  - Optical isomerism

IUPAC Name of Organic Compounds

2°prefix + 1°prefix + word root + 1°suffix + 2°suffix

2° prefix — substituents

1° prefix — cyclic or acyclic

word root — No. of C-atoms in principal chain

1° suffix — Saturated or unsaturated

2° suffix — functional group

Quantitative analysis of organic compounds

% C (Leibig methods) $= \frac{12}{44} \times \frac{\text{mass of } CO_2 \text{ formed}}{\text{mass of compounds taken}} \times 100$

% H (Leibig methods) $= \frac{2}{18} \times \frac{\text{mass of } HO_2 \text{ formed}}{\text{mass of compounds taken}} \times 100$

% X (halogen methods) $= \frac{\text{At. mass of X}}{108 + \text{At. mass of X}} \times \frac{\text{mass of AgX}}{\text{mass of compounds taken}} \times 100$

% N (Duma's methods) $= \frac{28}{22400} \times \frac{\text{volume of } N_2 \text{ at NTP}}{\text{mass of compounds taken}} \times 100$

% N (Kiehldahl methods) $= \frac{1.4 \times \text{normality of acid} \times \text{volume of acid}}{\text{mass of compounds taken}} \times 100$

% S (Carius methods) $= \frac{32}{233} \times \frac{\text{mass of } BaSO_4}{\text{mass of compounds taken}} \times 100$

% P (Carius methods) $= \frac{62}{222} \times \frac{\text{mass of } Mg_2P_2O_7}{\text{mass of compounds taken}} \times 100$

CASE BASED STUDY - QUESTIONS

PASSAGE -I

The resonance effect is defined as the polarity produced in the molecule by the interaction of two π bonds as between a π bond and lone pair of electrons present an on adjacent atom. The effect is transmitted through the chain. In positive resonance effect the transfer of electrons is away from on atom or subsitituent group attached to the conjugated system. The electron displacement makes certain positions in the molecule of high electron densities. In negative resonance effect the transfer of electrons is towards the atom or substituent group attached to the conjugated system.

1. Which of the following does not show resonance effect?
   (a) Buta -1, 3-diene (b) Acrylonitrile
   (c) Nitrobenzene (d) Isopropyl isothiocyanate
2. Which of the following shows + M effect
   (a) $-N(CH_3)_2$ (b) $>C=0$
   (c) $-CN$ (d) Both (a) and (c)
3. Which of the following carboxylate ions is the most stable?
   (a) $CH_3-\overset{\overset{O}{\|}}{C}-O^-$ (b) $Cl-CH_2-\overset{\overset{O}{\|}}{C}-O^-$
   (c) $I-CH_2-\overset{\overset{O}{\|}}{C}-O^-$ (d) $\overset{F}{\underset{F}{>}}CH-\overset{\overset{O}{\|}}{C}-O^-$
4. Which of the following resonating structures is not correct for CO_2?
   (a) $:\ddot{O}=C=\ddot{O}:$ (b) $\overset{\ominus}{:}\ddot{\underset{..}{O}}-C\equiv\overset{+}{O}:$
   (c) $\overset{\oplus}{}\ddot{\underset{..}{O}}-C\equiv\ddot{\underset{..}{O}}^{\ominus}$ (d) $:\overset{+}{O}\equiv C-\ddot{\underset{..}{O}}:^{\ominus}$
5. Which of the following pairs constitute resonance structure?
   (a) $H_3C-\overset{+}{N}{\overset{\nearrow O}{\searrow O^-}}$ and $CH_3-O-N=O$ (b) $H_3C-C{\overset{\nearrow O}{\searrow \overset{+}{C}H_2}}$ and $H_3C-C{\overset{\nearrow O^{\ominus}}{\searrow CH_2}}$
   (c) $H_3C-\overset{\overset{O}{\|}}{C}-CH_3$ and $H_3C-\underset{\underset{OH}{|}}{C}=CH_2$
   (d) $H_3C-CH=CH-CH_3$ and $H_3C-CH_2-CH=CH_2$

PASSAGE -II

The Lassaigne's extract is usually alkaline because excess of sodium reacts with water to form sodium hydroxide. If not it may be made alkaline by the addition of a few drops of a dilute solution of sodium hydroxide. To a part of the extract a small amount of a freshly prepared ferrous sulphate solution is added and the content are warmed. A few drops of ferric chloride solution are then added to the contents and the resulting solution is acidified with dilute hydrochloric acid the appearance of a bluish green colour due to the formation of ferric ferrocyanide confirm the presence of nitrogen in the organic compound.

1. In sodium fusion test of organic compounds the nitrogen in an organic compound is converted into :

   (a) Soda lime (b) Sodium cyanide

   (c) Sodium nitrite (d) Sodium nitrate

2. In the Lassaigne's test for the detection of sulphur the purple colour is due to the formation of

   (a) $Na_4 [Fe (CN)_5 NOS]$ (b) $Na_3 [Fe (CN)_5 S]$

   (c) $Na_2 [Fe (CN)_6 NOS]$ (d) $Na_3 [Fe (CN)_6]$

3. For which of the following compounds will Lassaigne's test for nitrogen fail

   (a) $NH_2 CONH_2$ (b) $CH_3 CONH_2$

   (c) $NH_2 NH_2$ (d) $C_6 H_5 NH_2$

4. Lassaigne's extract is boiled with dilute HNO_3 before testing for halogens because :

   (a) Silver halides are soluble in HNO_3

   (b) Na_2S and NaCN are decomposed by HNO_3

   (c) Ag_2S is soluble in HNO_3

   (d) AgCN is soluble in HNO_3

5. In Lassaigne's test the following reagent is used to test the presence of both N and S:

   (a) $AgNO_3$ (b) $FeCl_3$

   (c) Na_2S (d) $(CH_3 COO)_2 Pb$

MULTIPLE CHOICE QUESTIONS (MCQ)

1. Homolytic fission of C-C bond in ethane gives an intermediate in which carbon is:

   a. sp^3 hybridised b. sp^2 hybridised
   c. sp-hybridised d. sp^3d- hybridized

2. The kind of delocalization involving sigma bond in conjugation with pi electrons is called:

   a. Inductive effect b. Hyperconjugation effect
   c. Electromeric effect d. Mesomeric effect

3. Which organic species has only one type of hybridized carbon?

   a. $CH_2{=}C{=}CH_2$ b. $CH_3{-}\overset{\oplus}{C}H{-}CH_3$
   c. $CH_3{-}C{=}CH$ d. $CH_2{=}\overset{\oplus}{C}H{-}CH_2$

4. Which of the following can act as an electrophile?

   a. CN^- b. OH^-
   c. H_2O d. BF_3

5. Which of the following is correct about the species: $(CH_3)_3{-}C^+$

   a. It is planar b. Its C+ is sp^2 hybridised
   c. A nucleophile can attack on its C^+ d. All of these

6. Which of the following has all the effects namely Inductive, Mesomeric and Hyperconjugative ?

   a. CH_3Cl b. $CH_3CH{=}CH_2$
   c. $CH_3CH{=}CHCOCH_2Cl$ d. $CH_2{=}CH{-}CH{=}CH_2$

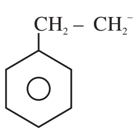
7. The most stable free radical among the following is:

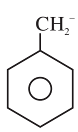
   a. $C_6H_5CH_2\dot{C}H_2$ b. $C_6H_5\dot{C}HCH_3$ c. $CH_3\dot{C}H_2$ d. $CH_3\dot{C}HCH_3$

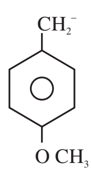
8. Isomers of a compound must have :

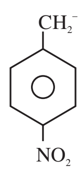
   a. Same physical properties b. Same chemical properties
   c. Same structural properties d. Same molecular weight

9. Most stable carbanion among the following is

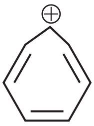
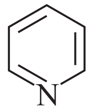
   a. 

   b. 

   c. 

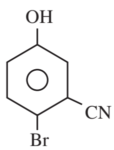
   d. 

10. Which of the following species have six π conjugated electrons?

a.  b. $CH_2=CH-CH=CH-CH_2^-$ c.  d. All of these

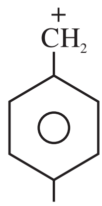
11. The correct decreasing order of priority for the functional groups of organic compounds in the IUPAC system of nomenclature is:
    a. $-COOH$, $-SO_3H$, $-CONH_2$, $-CHO$
    b. $-SO_3H$, $-COOH$, $-CONH_2$, $-CHO$
    c. $-CHO$, $-COOH$, $-SO_3H$, $-CONH_2$
    d. $-CONH_2$, $-CHO$, $-SO_3H$, $-COOH$

12. The IUPAC name of $CH_3-CH=CH-C\equiv CH$ is:
    a. pent-3-en-1-yne
    b. pent-3-en-4-yne
    c. pent-2-en-4-yne
    d. pent-2-en-3-yne

13. The IUPAC name of the following compound is 

    a. 4–Bromo –3– cyanophenol
    b. 2–Bromo–5–hydroxy benzonitrile
    c. 2–cyano–4–hydroxybromo benzene
    d. 6–Bromo–3–hydroxy benzonitrile

14. The order of the stability of the following of carbocations is :

$CH_2=CH-\overset{+}{C}H_2$; $CH_3-CH_2-\overset{+}{C}H_2$; 

I II III

    a. III > I > II
    b. III > II > I
    c. II > III > I
    d. I > II > III

15. Quantitative measurement of nitrogen in an organic compound is done by the method:
    a. Berthelot method
    b. Lassaigne method
    c. Carius method
    d. Kjehldahl method

ANSWERS

1. a 2. b 3. d 4. d 5. d 6. c 7. b 8. d 9. d 10. d
11. a 12. a 13. b 14. a 15. d

FILL IN THE BLANKS

1. The CH_4 molecule has ____________ structure.
2. The property of carbon responsible for the large number of carbon compounds is called ____________.
3. A triple bond between two carbon atoms is composed of one _________ and _________ bonds.
4. An organic compound which decomposes below its boiling point can be purified by ____________.
5. The central atom of $CH_2{=}C{=}CH_2$ is __________ hybridized.
6. There is a difference of _________ mass units between two consecutive members of a homologous series.
7. Geomerical isomerism happens due to _________ around p bond.
8. Electrophiles are the species which attack the regions of ___ electron density.
9. Hyperconjugation effect is also known as ___________ resonance.
10. In Duma's method, the nitrogen present in an organic compound is set free as ____________.

ANSWERS

1. Tetrahedral 2. Catenation 3. σ , two π 4. Vacuum distillation 5. sp
6. 14 7. Restricted rotation 8. high 9. No-bond 10. Nitrogen

TRUE AND FALSE TYPE QUESTIONS

1. In homologous series all the members have the same physical properties.
2. IUPAC name of CH_3CN is Methanenitrile.
3. Cis-trans isomers have different dipole moments.
4. Ethanol and methoxymethane are position isomers.
5. A free radical is a species with an unpaired valence electron.
6. Acetylene is a linear molecule.
7. Resonance brings down the stability of molecule.
8. Inductive effect is observed in π bond in presence of attacking reagent.
9. The percentage of carbon and hydrogen are estimated simultaneously in an organic compound by Liebig method.
10. Chromatography is the method used to separate and purify compounds when present in small amounts.

ANSWERS

1. F 2. F 3. T 4. F 5. T 6. T 7. F 8. F 9. T 10. T

ASSERTION REASON TYPE QUESTIONS

The questions given below are Assertion (A) and Reason (R). Use the following key to select the correct answer.

(a) If both assertion and reason are correct and reason is correct explanation for assertion.

(b) If both assertion and reason are correct but reason is not correct explanation for assertion.

(c) If reason is correct but assertion is incorrect.

(d) If both assertion and reason are incorrect.

1. Assertion: But-1-ene and 2-Methylprop-1-ene are position isomers.
   Reason: Position isomers have same molecular formula but different arrangement of carbon atoms.
2. Assertion: Duma's method is more applicable to nitrogen containing organic compounds than the Kjeldahl's method.
   Reason: Kjeldahl's method does not give satisfactory result in which nitrogen atom is directly attached to oxygen atom.
3. Assertion: Alkanes having more than three carbon atoms exhibit chain isomerism.
   Reason: All carbon atoms in alkanes are sp-hybridised.
4. Assertion: In $CH_2{=}C{=}CH_2$, all the carbon atoms are sp^2 hybridised.
   Reason: All the hydrogen atoms lie in one plane.
5. Assertion: Butane and 2-Methylbutane are homologues.
   Reason: Butane is a straight chain alkane while 2-Methylbutane is branched chain alkane.
6. Assertion: Tertiary carbocations are generally formed more easily than primary carbocations.
   Reason: Hyperconjugation as well as inductive effect due to additional alkyl groups stabilize tertiary carbocations.
7. Assertion: Alkyl carbanions like ammonia have pyramidal shape.
   Reason: The carbon atom carrying negative charge has an octet of electrons
8. Assertion: Carbocations are planar in nature.
   Reason: Carbocations are sp^2 Hybridised.
9. Assertion: IUPAC name of compound $CH_3CH{=}CH{-}CHO$ is But-2-enal.
   Reason: Functional group gets preference over multiple in IUPAC name of a compound.
10. Assertion: Glycerol is purified by distillation under reduce pressure.
    Reason: Organic compounds in liquid state are purified by distillation.

ANSWERS

1. d 2. c 3. c 4. d 5. b 6. a 7 . b 8. a 9. a 10. c

MATCH THE COLUMNS

Match the statements (a,b,c,d) in column I with the statements (I,ii,iii,iv) in column II.

1.

Column I	Column II	Column II
a. Leibig method	i. N_2	e) Aniline
b. Dumas method	ii. AgX	f) Halogens
c. Kjehldahl method	iii. CO_2 and H_2O	g) Schiff's Nitrometer
d. Carius method	iv. NH_3	h) $CaCl_2$ tube

2.

Column I	Column II
a. Nonbenzenoid aromatic compound	i. 50% s character
b. Catenation	ii. Species containing single unpaired nonbonding electrons
c. Free radical	iii. Chain-forming property of an element
d. sp-hybridised carbon atom	iv. Tropolone

ANSWERS

1. a. iiii, h b. i, g c. iv, e d. ii, f
2. a. iv b. iii c. ii d. i

ONE WORD ANSWER TYPE QUESTIONS

1 Write the formula of next higher homologue of C_2H_5OH.

2. Mention the hybridisation of underlined carbon in $CH_3\underline{C}\equiv N$.

3. What type of isomerism is shown by Pentane and 2-Methylbutane?

4. Nucleophiles are Lewis acids or Lewis bases?

5. What type of bond fission results in the formation of free radicals?

6 . What is the number of electrons present in the outermost shell of carbon in the methyl radical?

7. What is the other name for no-bond resonance?

8. What is the name of the Prussian blue coloured compound formed in Lassaigne's test for nitrogen in an organic compound?

9. SO_3 is an electrophile or nucleophile in sulphonation reaction of benzene?

10. Name suitable technique of separation of the components from a mixture of calcium sulphate and camphor.

1-MARK QUESTIONS

1. Which unique property of carbon is responsible for the large number of carbon compounds?
2. How many σ and π bonds are there in propyne?
3. What is the hybridization of carbon in ethyne?
4. Which has the longest C—C bond length among ethane, ethene and ethyne.
5. How many secondary carbon atoms are present in 2-Methylpentane?
6. Draw structure of 3-Isopropyl-2-methylhexane.
7. Draw bond line structure of $CH_3(CH_2)_6CH{=}CH(CH_2)_2{-}COOH$
8. What are the bond angles in sp^3, sp^2 and sp hybrid orbitals?.
9. Write the formulae of first four members of homologous series of alkyne family.
10. Write the correct of priority of the following functional groups:
    $-C{\equiv}N$, $>C{=}O$, $-OH$, $-COOH$, $-CONH_2$
11. Write IUPAC name of :
    (i) $CH_3{-}CH_2{-}CN$
    (ii) $CH_2{=}CHCH_2OH$
    (iii) $CH_3CH_2CH(CH_3){-}CO{-}CH_2CH_3$
    (iv) $CH_3CH_2{-}O{-}CH_2CH(CH_3)CH_3$
    (v) $Cl{-}CH_2{-}C{\equiv}CH$
12. What type of isomerism is exhibited by Propanal and Propanone?
13. What is the essential condition for a compound to exhibit geometrical isomerism?
14. Classify the following into electrophiles and nucleophiles:
    H+, NH_3, $AlCl_3$, NO_2^+, CN^- , H_2O, ROH, RNH_2, Carbocation
15. What type of attacking reagents are produced by heterolytic cleavage of covalent bond?
16. Name each of the following species and indicate which member of each pair is more stable:
    (i) CH_3^+, $CH_3CH_2^+$
    (ii) $C_6H_5\overset{+}{C}HCH_3$, $CH_3\overset{+}{C}HCH_3$
    (iii) $CH_2{=}CH{-}\dot{C}H_2$, $\dot{C}H{=}CH{-}CH_3$
    (iv) $CH_3{-}\overline{C}H_2$, $CH_3{-}\overline{C}H{-}CH_3$

17. Identify electrophilic centre in CH_3CHO.

18. What is state oh hybridization of positively charged carbon atom in carbocation?

19. What is the effect of introducing an alkyl group on the stability of carbocation?

20. Out of Benzyl and ethyl carbocation which is more stable and why?

21. Arrange the following in increasing order of acidic strength:
$ClCH_2COOH$, CH_3CH_2COOH, $ClCH_2CH_2COOH$

22. Name two solvents which are commonly used to dissolve organic solids.

23. Name the technique that can be used for purification of iodine that contains traces of NaCl.

24. A liquid (10 mL) has three components A, B, C. which technique is suitable to sparate A,B, C from such a small amount of mixture?

25. Name one commonly used adsorbent in column chromatography.

26. Under what condition do we use fractional distillation?

27. A liquid compound starts decomposing well before its boiling point under normal pressure. How will you purify it?

28. Which elements are normally not detected in an organic compound?

29. For which type of compounds Kjehldahl's method is not useful?

30. How do you precipitate sulphur in Carius method?

31. Which method is used to estimate carbon and hydrogen?

32. What do we notice in Lassaigne's test if the compound contains both nitrogen and sulphur?

2-MARKS QUESTION

1. How will you account for the presence of large number of organic compounds?

2. Draw the structural formulae of the following compounds:
   (i) Ethoxypropane
   (ii) But-1-en-3-yne
   (iii) 3,4,4,-Trimethylhex-1-yne
   (iv) sec-butyl alcohol
   (v) But-2-enoic acid

3. How is alkyl group represented? Give the structure and the names of the alkyl groups which originate from (i) n-Butane (ii) isobutene

4. Give IUPAC name of the following compounds:
   (i) $C_6H_5\,CH_2\,CH_2OH$
   (ii) $(CH_3)_2\,CH_2\,CH_2\,CHO$
   (iii) $CH_2{=}CH{-}C{\equiv}N$
   (iv) $$\begin{array}{ccccccccc} CH_3 & - & CH & - & C & - & CH & - & CH_3 \\ & & | & & \| & & | & & \\ & & Br & & O & & CH_3 & & \end{array}$$
   (v) $$\begin{array}{ccccccccccc} CH_3 & - & CH & - & CH & = & C & - & CH_2 & - & COOH \\ & & | & & & & | & & & & \\ & & OH & & & & OH_3 & & & & \end{array}$$
5. What is functional isomerism? Give two examples.
6. Distinguish between position isomerism and functional isomerism.
7. What is metamerism? Give example.
8. How are free radicals formed?
9. What is the effect of introducing an alkyl group on the stability of a free radical?
10. Give two examples each of the groups exerting –I and + I effect when attached to a chain of carbon atoms.
11. A tertiary butyl carbocation is is more stable than isobutyl carbocation. Justify.
11. What do you understand by +R and –R effect?
12. Define hyperconjugation.
13. What is the difference between inductive and electromeric effect?
14. All electrophiles are Lewis acids while nucleophile are Lewis bases. Explain.
15. What is the purpose of filtration through hot water funnel?
16. What precautions are necessary while purifying an organic solid with the help of crystallization process?
17. Discuss the principle of steam distillation.
18. Discuss the role of fractionating column in fractional distillation.
19. How will you prepare Lassaigne's extract? Name the elements which can be detected from this extract?
20. Why do we boil Lassaigne's extract with conc. HNO_3 while detecting halogens in an organic compound?

3-MARKS QUESTIONS

1. Discuss the orbital structure of ethene.
2. Define (i) Functional group (ii) Homologous series.
3. What do you understand by 1°, 2°, 3° and 4° carbon? Write one example having atleast one carbon of each type.
4. Why stability of carbocations follows the order: tertiary>secondary>primary?
5. What are the various conditions essential for resonance?
6. Write resonance structures of $CH_2{=}CH{-}CHO$. Indicate relative stability of the contributing structures.
7. Inductive effect is of permanent nature while electromeric effect is only temporary. Explain.
8. What is chromatography? Name different types of chromatographic processes.
9. You are given a mixture of methanol and acetone. Discuss the process which you will employ to separate them.
10. Explain the reason for the fusion of an organic compound with metallic sodium for testing nitrogen, sulphur and halogens.

5-MARK QUESTIONS

1. What are free radicals? Justify the stability of the aliphatic primary, secondary and tertiary free radicals.
2. What is a carbanion? How is it formed? Discuss relative stability of primary, secondary and tertiary carbanion.
3. Arrange the following in the order of property indicated against each set:

   (i) $-C_6H_5$, $-NO_2$, $-COOH$, $-I$, $-F$, $-CH_3$, $-C_2H_5$ (In the increasing order of –I effect)

   (ii) $CH_3CH_2CH_2CH_2^+$, $(CH_3)_3C^+$, $CH_3CH_2CH_2\overset{+}{C}HCH_3$ (In the order of increasing stability)

   (iii) $-Cl$, $-CONH_2$, $-CHO$ (In the increasing priority order if present in same molecule)

4. Draw the resonance strutuctures for the following compounds. Show the electron shift using curved arrow notation.

   (i) $C_6H_5NO_2$

   (ii) $CH_3CH{=}CHCHO$

   (iii) C_6H_5OH

   (iv) $C_6H_5CH_2^+$

   (v) $CH_3CH{=}CHCH_2^+$

5. Suggest a method to separate the constituents from the following mixture:

   (i) Mixture of two miscible liquids

   (ii) A mixture of oil and water

   (iii) A mixture of plant pigments

   (iv) A mixture of solid benzoic acid and sodium chloride

   (v) o-Nitrophenol and p-Nitrophenol present in the mixture.

6. 0.378g of an organic compound containing carbon and hydrogen was subjected to combustion by Leibig's method, the CO_2 and H_2O formed were passed through potash bulbs and anhydrous $CaCl_2$ tube. At the end of the experiment, the increase in the respective weights were 0.264g and 0.162g. Calculate the percentage of carbon and hydrogen.

   (**Ans:** C = 19.05% , H = 4.76%)

UNIT TEST-I

Time Allowed: 1 Hr. **Maximum Marks : 20**

General Instructions:

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

---

1. Write bond line formula for the following compound: [1]

   $HOCH_2CH_2CH_2CH(CH_3)CH(CH_3)COOH$

2. Write IUPAC name of the following compound: [1]

$$\begin{array}{ccccccccc} CH_3 & - & CH & - & C & - & CH & - & CH_3 \\ & & | & & \| & & | & & \\ & & NO_2 & & O & & CH_3 & & \end{array}$$

3. The central atom of compound $CH_2=C=CH_2$ is ______ hybridized. [1]

In the following questions a statement of Assertion (A) followed by Reason (R) is given. Use the following key to select correct answer :

(a) Both Assertion and Reason are correct but Reason is the correct explanation of Assertion.

(b) Both Assertion and Reason are correct but Reason is not the correct explanation of Assertion.

(c) Both Assertion and Reason are incorrect.

(d) Assertion is not correct but Reason is correct.

4. Assertion : Carbocations are planar in nature. [1]

   Reason : Carbocations are sp^2 Hybridized.

5. Assertion : All the carbon atoms of But-2-ene lie in are plane.

   Reason : All the carbon atoms in But-2-ene are sp^2 hybridized.

6. (i) What type of isomerism is exhibited by the following pair of compounds? [1]

$$CH_3CH_2CHO \text{ and } \begin{array}{ccccc} CH_3 & - & C & - & CH_3 \\ & & \| & & \\ & & O & & \end{array}$$

   (ii) Give one example each of nucleophile and electrophile.

7. (i) Arrange the following in increasing order of stability:

$(CH_3)_3C^-$, $CH_3-\overset{-}{C}H-CH_3$, $CH_3CH_2^-$

(ii) Differentiate between inductive and electromeric effect.

8. (i) When do we use hot water funnel for filtration?

(ii) How will you separate a mixture bof two organic compounds which have different solubilities in the same solvent?

(iii) An organic liquid decomposes below its boiling point. How will you purify it?

9. Draw the resonating structures of (a) Phenol (b) Benzaldehyde.

10. Arrange the following in the order of property indicated against each set:

(i) $-C_6H_5$, $-NO_2$, $-COOH$, $-I$, $-F$, $-CH_3$, $-C_2H_5$

(In the increasing order of –I effect)

(ii) $CH_3CH_2CH_2CH_2^+$, $(CH_3)_3C^+$, $CH_3CH_2CH_2\overset{+}{C}HCH_3$

(In the order of increasing stability)

(iii) $-COOH$, $-CONH_2$, $-CHO$

(In the increasing priority order if present in same molecule)

(iv) $HCOOH$, CH_3COOH, $ClCH_2COOH$

(Increasing order of acidic strength)

(v) $O_2NCH_2CH_2O^-$, $CH_3CH_2O^-$

(species having greater stability)

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UNIT TEST-II

Time Allowed: 1 Hr. **Maximum Marks : 20**

General Instructions:

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

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1. Which of the following can act as an electropliile? [1]

   (a) CN^- (b) OH^- (c) H_2O (d) BF_3

2. The most stable free radical among the following is : [1]

   (a) $C_6H_5\ CH_2\ CH_2$ (b) $C_6H_5\ CH\ CH_3$

   (c) $CH_3\ CH_2$ (d) $CH_3\ CH\ CH_3$

3. What is the other name for no band resonance? [1]

   In the following questions a statement of Assertion (A) followed by Reason (R) is given. Use the following key to select correct answer :

(a) Both Assertion and Reason are correct but Reason is the correct explanation of Assertion.

(b) Both Assertion and Reason are correct but Reason is not the correct explanation of Assertion.

(c) Both Assertion and Reason are incorrect.

(d) Assertion is not correct but Reason is correct.

4. Assertion : In $CH_2 = C = CH_2$ all the carbon atoms are sp^2 hybridized. [1]

   Reason : All the hydrogen atoms lie in one plane.

5. Assertion : Glycerol is purified by distillation under reduce pressure.

   Reason : Organic compound in liquid state are purified by distillation.

6. Give IUPAC name of the following compounds : [2]

   (a) $C_6H_5\,CH_2\,CH_2OH$

   (b) $$CH_3 - \underset{\displaystyle Br}{\underset{|}{CH}} - \underset{\displaystyle O}{\underset{||}{C}} - \underset{\displaystyle CH_3}{\underset{|}{CH}} - CH_3$$

7. Discuss the principle of steam distillation. [2]

8. Explain the reason for the fusion of an organic compound with metallic sodium for testing nitrogen sulphur and halogens. [2]

9. What are the various conditions essential for resonance? [3]

10. Suggest a method to separate the constituents from the following mixture : [5]

    (a) Mixture of two miscible liquids.

    (b) A mixture of oil and water.

    (c) A mixture of plant pigments.

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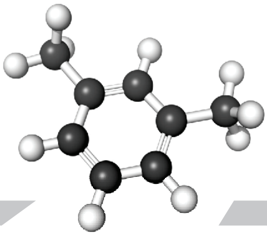


Chapter - 13

Hydrocarbons

FAST TRACK : QUICK REVISION

Hydrocarbons are the organic compounds containing carbon and hydrogen only. Depending upon the types of carbon-carbon bonds present, hydrocarbons can be classified into three categories- (i) Saturated (ii) Unsaturated (iii) Aromatic hydrocarbons.

Saturated hydrocarbons contain carbon-carbon muiltiple bonds–double bonds, triple bonds or both.

ALKANES : Saturated open chain hydrocarbons containing carbon-carbon single bonds. These are inert under normal conditions i.e. do not react with acids, bases and other reagents. Alkanes exhibit Chain isomerism, Position isomerism and conformational isomerism.

General methods of preparation of alkanes :

1. **From Unsaturated hydrocarbons :** By hydrogenation in the presence of platinium, palladium or nickel as catalyst.

   General Chemical Equation :

   $$R-CH=CH_2 + H_2 \xrightarrow[\Delta]{Ni} R-CH_2-CH_3$$

   [Where R is H or Alkyl group]

   e.g. $$\underset{\text{Ethene}}{CH_2=CH_2} + H_2 \xrightarrow[\Delta]{Ni} \underset{\text{Ethane}}{CH_3-CH_3}$$

   $$\underset{\text{Propyne}}{CH_3-C\equiv CH} + H_2 \xrightarrow[\Delta]{Ni} \underset{\text{Propene}}{CH_3-CH=CH_2} + H_2 \xrightarrow[\Delta]{Ni} \underset{\text{Propane}}{CH_3-CH_2-CH_3}$$

2. **From alkyl halides :** on reduction with Zinc and dilute hydrochloric acid

   $$\underset{\text{Chloromethane}}{CH_3-Cl} + H_2 \xrightarrow{Zn,\ H^+} \underset{\text{Methane}}{CH_4} + HCl$$

   $$\underset{\text{Chloroethane}}{C_2H_5-Cl} + H_2 \xrightarrow{Zn,\ H^+} \underset{\text{Ethane}}{C_2H_6} + HCl$$

$$\underset{\text{1-Chloropropane}}{CH_3CH_2CH_2Cl} + H_2 \xrightarrow{Zn,\ H^+} \underset{\text{Propane}}{CH_3CH_2CH_3} + HCl$$

3. **From alkyl halides by Wurtz reaction :** Reaction of alkyl halide with sodium in dry ether, useful only for the preparation of symmetrical alkanes.

$$\underset{\text{Bromoethane}}{CH_3CH_2Br} + 2Na + Br\ CH_2CH_3 \xrightarrow{\text{Dry Ether}} \underset{\text{Butane}}{CH_3CH_2CH_2CH_3}$$

$$\underset{\text{1-Bromopropane}}{CH_3CH_2CH_2Br} + 2Na + BrCH_2CH_2CH_3 \xrightarrow{\text{Dry Ether}} \underset{\text{n–Hexane}}{CH_3CH_2CH_2CH_2CH_2CH_3}$$

$$\underset{\text{1-Bromopropane}}{CH_3CH_2\ Br} + 2Na + \underset{\text{1–Bromoethane}}{Br\ CH_2CH_3} \xrightarrow{\text{Dry Ether}} \underset{\text{n–Pentane (desired)}}{CH_3CH_2CH_2CH_3}$$

4. **From Carboxylic acids :** By decarboxylation with soda lime

$$\underset{\text{Sodium acetate}}{CH_3COONa} + \underset{\text{Sodium Hydroxide}}{NaOH} \xrightarrow[CaO]{\Delta} \underset{\text{Methane}}{CH_4} + \underset{\text{Sodium}}{Na_2CO_3}$$

5. **By Kolbe's electrolytic method :** Electrolysis of an aqueous solution sodium or potassium salt of carboxylic acid. Alkane containing even number of carbon atoms is formed at anode.

$$2CH_3COO\ Na + 2H_2O \xrightarrow{\text{Electrolysis}} CH_3 - CH_3 + 2CO_2 + H_2 + 2NaOH$$

At Anode : (Oxidation)

$$2CH_3 - \overset{\overset{\displaystyle O}{|}}{C} - O^- \xrightarrow{-2e-} 2CH_3 - \overset{\overset{\displaystyle O}{|}}{C} - O^- \longrightarrow 2\dot{C}H_3 + 2CO_2$$

$$2\dot{C}H_3 \longrightarrow CH_3 - CH_3$$

At Cathode : (Reduction)

$$2H_2O \longrightarrow 2OH^- + 2H^+$$

$$2H^+ + 2e^- \longrightarrow H_2$$

Physical Properties of alkanes :

1. Boiling point of alkanes decreases on branching due to decrease in surface ara of molecule with branching which decreases magnitude of van der Waal's forces of attraction.
2. Alkanes being non-polar in nature are soluble in non-polar solvents.

Chemical properties of Alkanes :

- Alkanes undergo substitution reactions.
  e.g., Halogenation, Nitration, Sulphonation.

  Halogenation : For example Chlorination of methane

$$CH_4 + Cl_2 \longrightarrow \underset{\text{Chloromethane}}{CH_3Cl} + HCl$$

$$CH_3Cl + Cl_2 \longrightarrow \underset{\text{Dichloromethane}}{CH_2Cl_2} + HCl$$

$$CH_2Cl_2 + Cl_2 \longrightarrow \underset{\text{Trichloromethane}}{CHCl_3} + HCl$$

$$CHCl_3 + Cl_2 \longrightarrow \underset{\text{Tetrachloromethane}}{CCl_4} + HCl$$

Rate of reaction of alkanes with halogens is $F_2 > Cl_2 > Br_2 > I_2$. Rate of replacement of hydrogen in alkanes is $3° > 2° > 1°$. Fluorination is too violent to be controlled. Iodination is reversible and it is therefore carried out in the presence of oxidising agent like HNO_3.

Mechanism of halogenation : Free radical mechanism

$Cl - Cl \xrightarrow{h\upsilon} Cl\bullet + \bullet Cl$	Initiation
$Cl\bullet + CH_4 \longrightarrow H - Cl + \bullet CH_3$	Propagation
$\bullet CH_3 + Cl - Cl \longrightarrow CH_3\,Cl + \bullet Cl$	Propagation
$Cl\bullet + \bullet CH_3 \longrightarrow CH_3\,Cl$	Termination

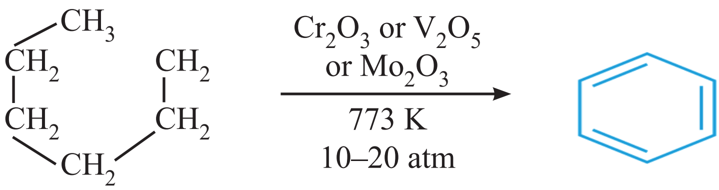
Combustion : Complete combustion gives carbon dioxide and water.

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

Isomerisation :

$$\underset{\text{n-Butane}}{CH_3\,CH_2CH_2CH_3} \xrightarrow[200°\,C,\ 35\ atm]{AlCl_3 + HCl} \underset{\text{Isobutane}}{CH_3\,\overset{\overset{\displaystyle CH_3}{|}}{C}HCH_3}$$

Aromatisation :



(vi) **Reaction with steam**

$$CH_4 + H_2O \xrightarrow[\Delta]{Ni} CO + 3H_2$$

Pyrolysis : Decomposition of higher alkanes to lower alkanes on heating.

$$C_6H_{14} \xrightarrow{773K} \begin{cases} C_6H_{12} + H_2 \\ C_4H_8 + C_2H_6 \\ C_3H_6 + C_2H_4 + CH_4 \end{cases}$$

Conformations :

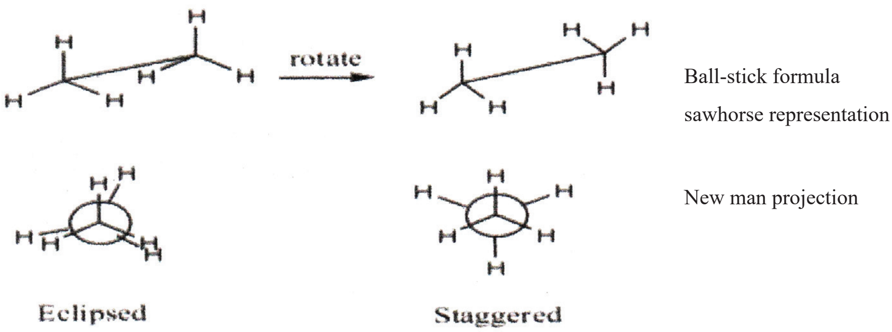
Different spatial arrangement of atoms arising due to rotation around C-C single bond.

Conformation of ethane, CH_3CH_3

Two conformational isomers or conformers.

Eclipsed form = all hydrogen atoms nearest to each other.

Staggered form = all hydrogen atoms are farthest apart.



Stability of eclipsed conformation is least while staggered conformation is most stable. The energy difference between two extreme forms is 12.5kJmol^{-1}. Due to this small energy difference the two forms are easily inter-convertible at ordinary temperature and cannot be separated and isolated.

ALKENES

These are unsaturated non-cyclic hydrocarbons which have.sp^2 -hybridisation with 120° bond angle.

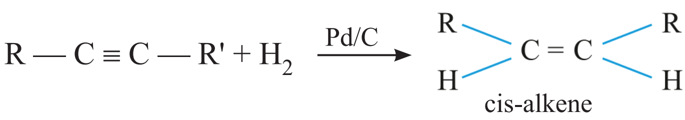
Alkenes are also called olefins [oil.forming] which indicates their high reactive nature.

Alkenes have general formula $C_n H_{2n}$, where n = 2, 3, 4, ...

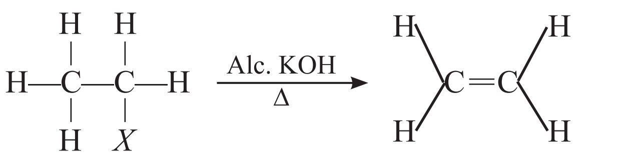
C_2H_4 (ethene), C_3H_6 (propene), etc.

- **Methods of Preparation of Alkenes**

(i) From alkynes



(ii) From alkyl halide [Dehydrohalogenational]



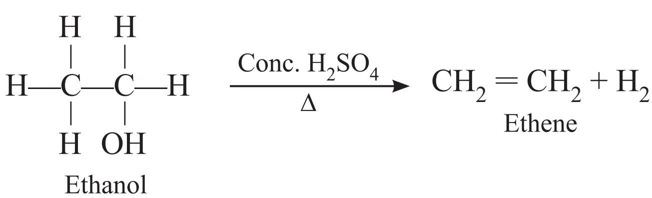
[X = Cl, Br, I] [β-Elimination product]

(iii) From *vicinal* dihalides

$$CH_2Br—CH_2Br + Zn \xrightarrow{\Delta} CH_2 = CH_2 + ZnBr_2$$

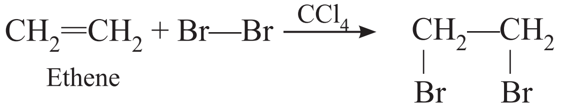
$$CH_3—\underset{Br}{CH}—\underset{Br}{CH_2} + Zn \xrightarrow{\Delta} CH_3—CH = CH_2 + ZnBr_2$$

(iv) From alcohols by acidic dehydrogenation



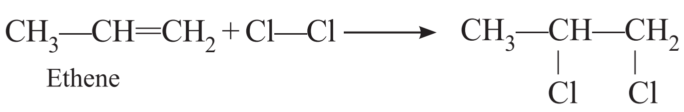
- **Chemical Properties of Alkenes :**

1. Addition of Halogens :



Ethene

1, 2-Dibromoethane

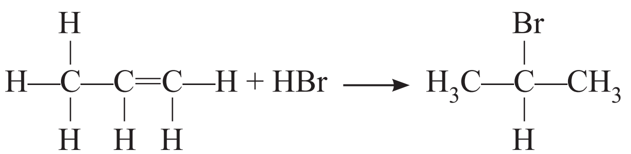


Ethene

1, 2-Dichloropropane

2. Addition of hydrogen halides HCl, HBr, HI : Add up to alkenes to form alkyl halides as per their reactivity order in HI>HBr>HCl.

Addition reaction of HBr to unsymmetrical alkenes (Markownikov's rule) According to Markownikovs' rule, the negative part of the addendum (adding molecule) gets attached to that carbon atom which possesses lesser number of hydrogen atoms.



2-Bromopropane

Anti Markownikov addition or peroxide effect or Kharasch effect in the presence of organic peroxide, addition of only HBr molecule on unsymmetrical alkene takes place contrary to the Markownikov's rule. Peroxide effect is not observed in case of HF, HCl and HI.

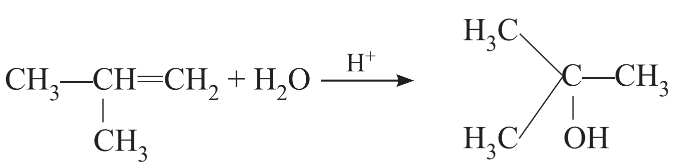
$$CH_3-CH=CH_2 + HBr \xrightarrow[(C_6H_5CO)_2O_2]{} CH_3CH_2CH_2Br$$

1-bromopropane

3. Addition of sulphuric acid

$$CH_3-CH=CH_2 + \underset{\text{[cold and conc.]}}{HOSO_2OH} \rightarrow \underset{\text{propyl hydrogen sulphate}}{CH_3CH(OSO_3H)\ CH_3}$$

4. Addition of water



2-Methylpropene

2-Methylpropan-2-ol

5. **Oxidation :** Alkenes decolourise cold dilute aqueous solution potassium permanganate (Baeyer's reagent). It is used as a test for unsaturation.

$$CH_2{=}CH_2 + H_2O + [O] \xrightarrow[273K]{Dil.KMnO_4} \underset{\displaystyle OH}{\underset{|}{CH_2}}{-}\underset{\displaystyle OH}{\underset{|}{CH_2}}$$

Ethane–1,2-diol
or glycol

Acidic $KMnO_4$ or acidic $K_2Cr_2O_7$ oxidises alkenes to ketones and/or acids depending upon the nature of alkene and the experimental conditions.

$$\underset{\text{2-Methyl propene}}{(CH_3)_2C{=}CH_2} \xrightarrow{KMnO_4/H^+} \underset{\text{Propane-2-one}}{(CH_3)_2CO} + CO_2 + H_2O$$

$$\underset{\text{But-2-ene}}{CH_3{-}CH{=}CH{-}CH_3} \xrightarrow{KMnO_4/H^+} \underset{\text{Ethanoic acid}}{2CH_3COOH}$$

6. **Ozonolysis :** Reaction of ozone with alkene to form ozonide which on subsequent reductive cleavage with zinc dust and water give carbonyl compounds (aldehydes & ketones).

$$(H_3C)_2C{=}CH_2 + O_2 \xrightarrow{Zn/H_2O} (H_3C)_2C{=}O + HCHO + H_2O_2$$

$$Zn + H_2O_2 \longrightarrow ZnO + H_2O$$

7. **Polymerization**

$$n(CH_2{=}CH_2) \xrightarrow[\text{catalyst}]{\text{High temperature/pressure}} \underset{\text{polythene}}{{-}[CH_2{-}CH_2{-}]_n}$$

$$n(CH_3{-}CH{=}CH_2) \xrightarrow[\text{catalyst}]{\text{High temperature/pressure}} \left[{-}\underset{\displaystyle CH_3}{\underset{|}{CH}}{-}CH_2{-}\right]_n$$

ALKYNES

These are unsaturated hydrocarbons with general formula C_nH_{2n-2} e.g., C_2H_2 (ethyne), C_3H_4 (propyne).

Alkynes also exhibit electrophilic addition reaction but less reactive than alkenes because the dissociation of π-electron cloud requires more energy.

H–C≡C–H contins 3σ and 2π -bonds and bond length is 120 pm. In acetylene. H–C–C bond angle is 180°.

- **Methods of Preparation of Alkynes**

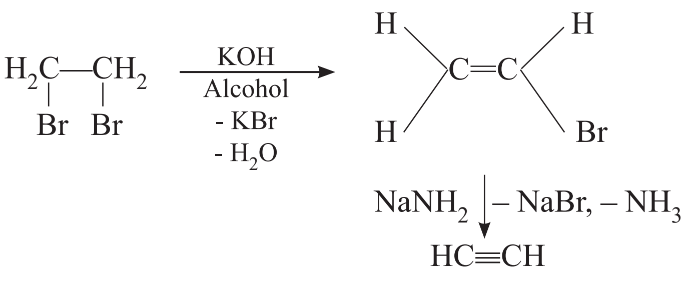
1. From calcium carbide

$$CaCO_3 \longrightarrow CaO + CO_2$$

$$CaO + C \longrightarrow CaC_2 + CO$$

$$CaC_2 + 2H_2O \longrightarrow Ca(OH)_2 + C_2H_2$$

2. From vicinal dihalides



3. From tetrahalides

$$Br_2CH—CHBr_2 + 2Zn \xrightarrow[\Delta]{CH_3OH} H—C\equiv C—H + 2ZnBr_2$$

Physical Properties of Alkynes :

1. The first two members are gases next eight members ($C_5 - C_{12}$) are liquids and higher members are solids.
2. They are all colourless and odourless with the exception of acetylene which has slightly garlic odour due to the presence of PH_3 and H_2S as impurities.
3. Alkynes are insoluble in water but soluble in organic solvents like ethers, carbon tetrachloride and benzene.
4. Melting point, boiling point and density increase with increase in molar mass.

- **Chemical properties of Alkynes**

  Alkynes show electrophilic as well as nucleophilic addition reactions.

(i) Acidic character of alkyne

$$HC \equiv CH + Na \longrightarrow \underset{\text{monosodium acetylides}}{HC \equiv \bar{C}Na} + \frac{1}{2}H_2$$

$$H - C \equiv CNa^+ + Na \longrightarrow \underset{\text{disodium acetylide}}{Na^+ C \equiv \bar{C}Na^+} + \frac{1}{2}H_2$$

$$CH_3 - C \equiv C - H + NaNH_2 \longrightarrow \underset{\text{sodium propynide}}{CH_3 - C \equiv \bar{C}Na^+} + NH_3$$

These reactions are not shown by alkenes, alkanes and non-terminal alkynes, hence used for distinction between alkane, alkene and alkyne.

Acetylenic hydrogens are acidic in nature due to 50% s-character in sp-hybridised orbitals. Acidity of alkynes is lesser than water.

Acidic behaviour order

(i) $\underset{sp}{HC{\equiv}CH} > \underset{sp^2}{CH_2 = CH_2} > \underset{sp^3}{CH_3 - CH_3}$

(ii) $HC{\equiv}CH > CH_3{-}C{\equiv}CH >> CH_3{-}C{\equiv}C{-}CH_3$

(ii) Electrophilic addition reactions

$$-C{\equiv}C- + HZ \xrightarrow{H^+} \underset{\text{vinyl cation}}{\overset{\overset{\large H}{|}\quad +}{-C{=}C-}} + :Z^- \longrightarrow \overset{H\ \ Z}{\underset{}{\overset{|\ \ \ |}{-C{=}C-}}}$$

The addition product formed depends upon the stability of vinylic cation. Addition on unsymmetrical alkynes takes place according to Markovnikov's rule.

$$CH_3{-}C{\equiv}C{-}H + H_2 \xrightarrow{Pt/Pd/Ni} \underset{\text{propene}}{[CH_3{-}CH{=}CH_2]} \xrightarrow{H_2} \underset{\text{propene}}{CH_3CH_2CH_3}$$

Addition of halogens

$$HC{\equiv}CH + Cl{-}Cl \longrightarrow [HCCl{=}CHCl]$$

1, 2-Dichloropropene

$$\Big\downarrow Cl_2$$

$$\begin{array}{cc} Cl & Cl \\ | & | \\ HC & \!\!-\!\!CH \\ | & | \\ Cl & Cl \end{array}$$

1, 1, 2, 2-Tetrachloroethane
or westron

$$\Big\downarrow -HCl$$

$$\begin{array}{l} CH{=}CCl_2 \\ | \\ Cl \end{array}$$

westrosol (1, 1, 2-Trichloroethene)

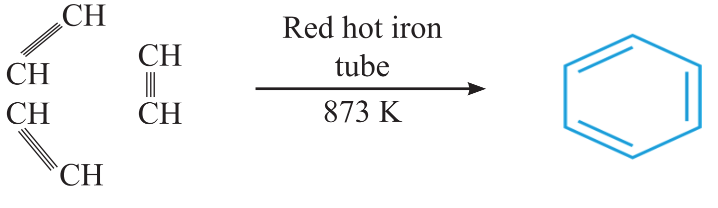
Addition of hydrogen halides

$$CH_3{-}C{\equiv}CH \xrightarrow{HBr} \underset{\text{2-Bromopropene}}{CH_3{-}\underset{\underset{Br}{|}}{C}{=}CH_2} \xrightarrow{HBr} \underset{\text{2, 2-Dibromopropane}}{CH_3{-}\overset{\overset{Br}{|}}{\underset{\underset{Br}{|}}{C}}{-}CH_3}$$

Addition for water

$$\underset{\text{propyne}}{CH_3{-}C{\equiv}CH} + HOH \xrightarrow[333K]{Hg^{2+}/H^+} CH_3{-}\underset{\underset{O-H}{|}}{C}{=}CH_2 \rightleftharpoons CH_3{-}\underset{\underset{O}{\|}}{C}{-}CH_3$$

(iii) Cyclic polymerisation of ethyne

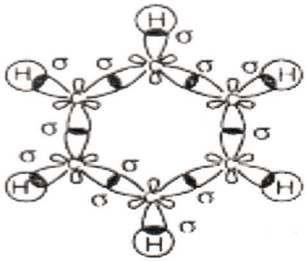


AROMATIC HYDROCARBONS

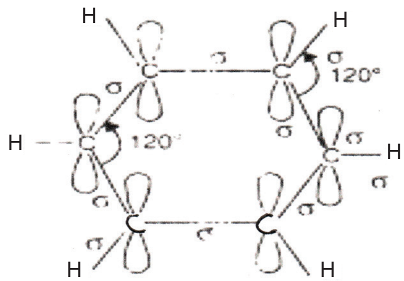
These hydrocarbon are also known as arenes. The parent member of the family aromatic hydrocarbons is benzene.

Aromatic compounds containing benzene ring are known as benzenoids.

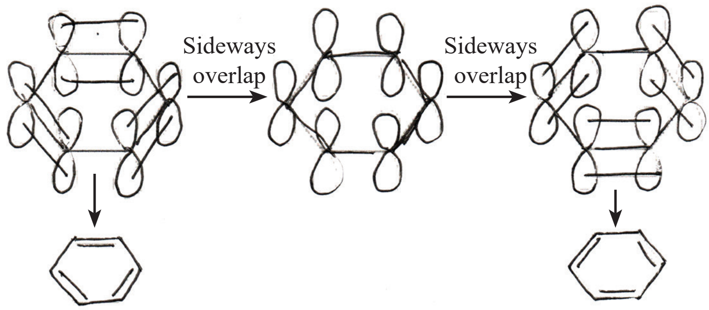
Structure of benzene : Hexagonal ring of carbon atoms with alternate single and double bonds. Each carbon atom is sp^2 hybridised. Planar ring, bond angle 120°. All C-C bond lengths are equal due to complete delocalisation of π electrons.



Formation of C-C and C-H sigma bonds



Sigma skeleton of benzene molecule



HUCKEL'S RULE

- **Huckel's rule, (based on calculations) :** a planar cyclic molecule with alternating double and single bonds has aromatic stability if it has ($4n + 2\pi$) electrons (n is 0, 1, 2, 3, 4)
- For n = 1 : 4n+2 = 6; benzene is stable and electrons are delocalized.

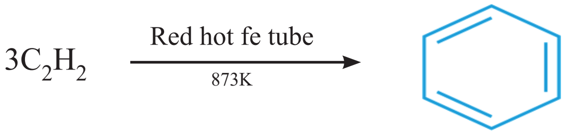
Benzene

Three double bonds;

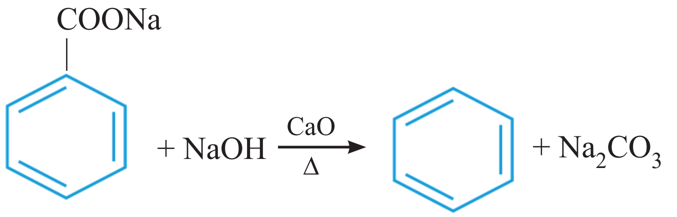
six π electrons

- **METHODS OF PREPARATION**

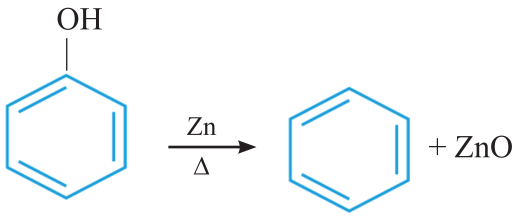
1. Cyclic polymerisation of ethyne



2. Decarboxylation of aromatic acids



3. Reduction of phenol



Physical Properties of Benzene :

(i) Aromatic hydrocarbons are non-polar molecules and are usually colourless liquids or solids with a characteristic aroma.

(ii) Aromatic hydrocarbons are immiscible with water but readily miscible with organic solvents.

(iii) Aromatic compounds burn with sooty flame.

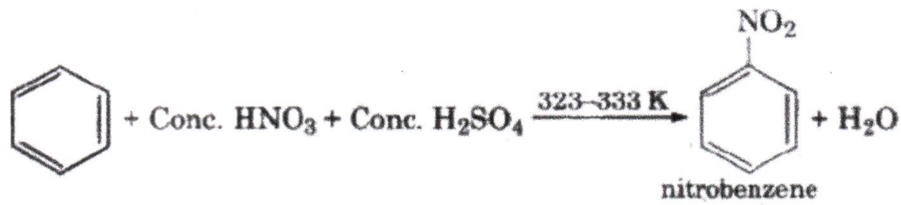
Chemical Reactions of Benzene :

(i) Benzene gives electrophile substitution reactions.

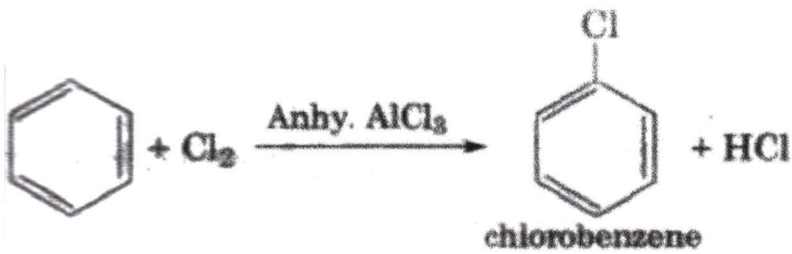
(ii) According to experimental evidences, electrophile substitution reaction involve following three steps :

- Generation of electrophilie
- Formation of carbocation intermediate.
- Removal of proton from the carbocation intermediate.

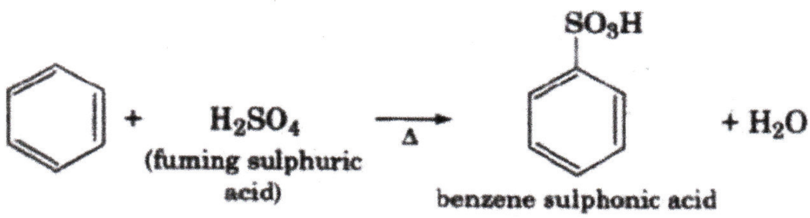
(i) **Nitration**



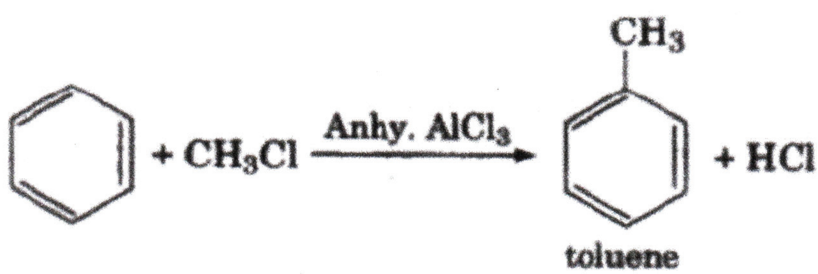
(ii) **Halogenation**



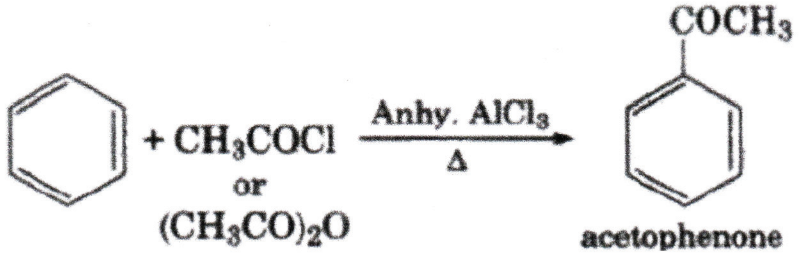
(iii) **Sulphonation**



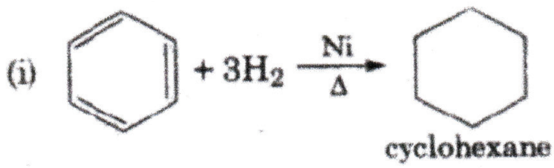
(iv) **Friedel-Craft's alkylation reaction**

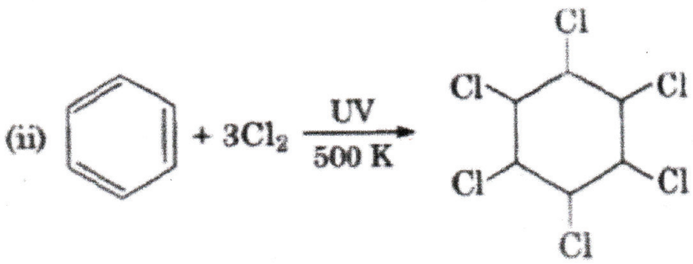


(v) **Friedel-Crafts acylation reaction**



Benzene also undergoes addition reactions e.g.





benzene bexachloride or 666
(BHC or Gammexane or lindane)

- **COMBUSTION**

$$2C_6H_6 + 15O_2 \longrightarrow 12CO_2 + 6H_2O$$

Directing influence of substituents in monosubstituted benzene

(i) **Ortho and para directing groups :** Ring activating groups
e.g., NH_2, $-CH_3$, $-C_2H_5$, $-OCH_3$ etc. (+ R effect)

(ii) **Meta directing groups :** Ring deactivating groups
e.g. - NO_2, $-CN$, $-CHO$, $-COOH$, $-SO_3H$ (– R effect).

CASE BASED STUDY - QUESTIONS

PASSAGE–I

Presence of double bond in an alkene is tested by reacting with either water or with dilute solution of Bayer's regent. The position of double bond is located with the help of ozonalysis. It is done by joining together the product of ozonalysis which are carbonyl compounds at their carbonyl carbon atoms by double bond. One mole of ozone is used in the ozonalysis reaction per mole of double bond in a particular alkene.

1. Which alkene upon ozonalysis will give CH_3CH_2 CHO and CH_3 CO CH_3

   (a.) $CH_3\ CH_2\ CH = C(CH_3)_2$ (b) $CH_3\ CH_2\ CH = CH\ CH_2\ CH_3$

   (c) $CH_3 - \underset{\substack{|\\ CH_3}}{C} = CH\ CH_3$ (d) $CH_3\ CH_2\ CH = CH\ CH_3$

2. The alkene C_6H_{10} producing OHC (CH2)4 CHO an ozonalysis is :

   (a) Hex–1–ene (b) Hex–3–ene

   (c) Cyclohexane (d) 1–methyl cyclohexane

3. On ozonolysis one molecule of a hydrocarbon produces two molecules of ethanal and one molecule of ethanedial. The hydrocarbon could be

   (a) 1, 3 hexadiene (b) 1, 4– cyclohexadiene

   (c) 1, 4 hexadiene (d) 2, 4– hexadiene

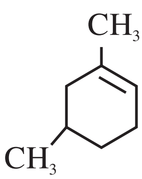
   (e) 1, 3 – cyclohedadiene

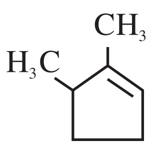
4. $CH_3 - CH = CH - CH_3 + O_3 \xrightarrow[H_2O]{Zn}$ A. A in the following reaction is :

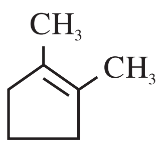
   (a) CH_3 CO CH_3 (b) $CH_3\ CH_2$ CHO

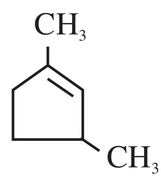
   (c) $CH_3\ CH_2$ CO CH_3 (d) CH_3 CHO

5. Which compound would give 5-keto-2-methyl hexanal upon ozonalysis


(a)


(b)


(c)


(d)

PASSAGE–II

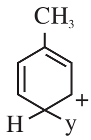
Benzene responds to electrophilic substitution reactions. However some reagents are needed in these reactions in order to generate the attaching electrohiles. The directive influence in disubstitution taking place in the ring depends upon the nature of the group already present. An activating group in creases the electron density at the ortho and para positions. The deactivating group decreases the same at these positions thereby healing the metal position comparatively a point of high electron density.

1. Nitro ($-NO_2$) group in benzene is :

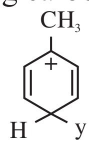
   (a) Activating and O- and p- directing (b) Deactivating and m-directing

   (c) Deactivating and O- and p directing (d) Activating and m- directing

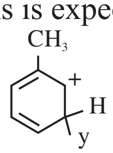
2. Which of the following carbocations is expected to be least stable?



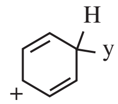
(a)



(b)



(c)



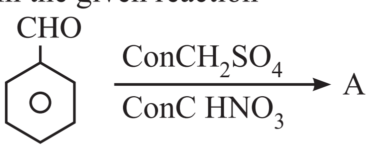
(d)

3. The correct order of decreasing reactivity in electrophilic substitution reactions of the following compounds is :

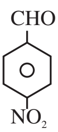

   (a) III > I > II > IV (b) IV > I > II > III

   (c) I > II > III > IV (d) II > I > III > IV

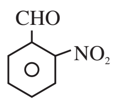
4. In the given reaction



A is



(a)



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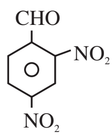
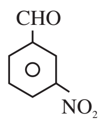
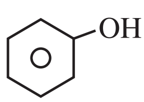


(c)

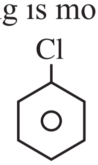


(d)

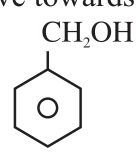
5. Which of the following is most reactive towards electrophilic attack?



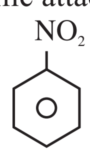
(a)



(b)



(c)



(d)

MULTIPLE CHOICE QUESTIONS (MCQ)

1. Which of the following has zero dipole moment?

   (a.) cis-But-2-ene (b) trans-But-2-ene

   (c) But-1-ene (d) 2-Methylprop-1-ene

2. Bond length of (I) ethane, (II) ethene, (III) Acetylene, (IV) Benzene follows the order:

   (a) I > II > III > IV (b) I > II > IV > III

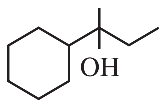
   (c) I > IV > II > III (d) III > IV > II > I

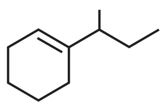
3. The methyl group in benzene ring is:

   (a) Ortho directing (b) Ortho and meta directing

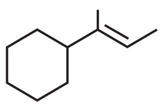
   (c) Para directing (d) Ortho and para directing

4. Which of th following is not the product of dehydration of

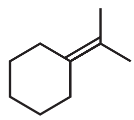




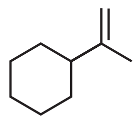
(a)



(b)



(c)



(d)

5. In the hydrocarbon :

   6 5 4 3 2 1

   $H_3C - CH = CH - CH_2 - C \equiv CH$

   The state of hybridization of carbon 1, 3 and 5 are in the order

   (a) sp, sp^2, sp^3 (b) sp^3, sp^2, sp

   (c) sp^2, sp, sp^3 (d) sp, sp^3, sp^2

6. Action of acetylene on dilute H_2SO_4 gives:

   (a) Acetic acid (b) Acetone

   (c) Acetaldehyde (d) Ethyl alcohol

7. Which of the following compounds will exhibit cis-trans (geometrical) isomerism?

   (a) Butanol (b) 2-Butyne

   (c) 2-Butenol (d) 2-Butene

8. Basic strength of :

   $H_3C\,\overset{\ominus}{C}H$, $H_2C = \overset{\ominus}{C}H$ and $HC \equiv \overset{\ominus}{C}$ is in the order of

   (a) I > III > II (b) I > II > III

   (c) II > I > III (d) III > II > I

9. Reaction of hydrogen bromide with propene in the absence of a peroxide is a/an
   (a) free radical reaction (b) nucleophilic substitution
   (c) electrophilic addition (d) nucleophilic substitution

10. Among the following compounds, the one which is most reactive towards electrophilic nitration is:
   (a) Benzoic acid (b) Nitrobenzene
   (c) Toluene (d) Benzene

ANSWERS: 1. b 2. c 3. d 4. a 5. d 6. c 7. d 8. c 9. c 10. c

FILL IN THE BLANKS

1. Alkanes mainly undergo ______________ reaction.
2. Halogenation of alkanes does not occur in _____________.
3. The H – C – H bond angle in ethene is ___________.
4. The addition of HBr to an unsymmetrical alkene takes place in accordance with ____________ rule.
5. Baeyer's reagent is used for testing ____________.
6. Benzene favours ____________ substitution reaction.
7. The Dipole moment of Benzene is ____________.
8. The nitro group in the benzene nucleus is ________ directing. It __________ the reactivity of the benzene ring.
9. Melting point and boiling point increase as the molar masses _______.
10. The reaction of solid calcium carbide with water produces ___________, a flammable gas.

ANSWERS : 1. Substitution 2. Dark 3. 120° 4. Markownikov's 5. Unsaturation 6. electrophilic 7. Zero 8. Meta, decreases 9. Increase 10. Ethyne

TRUE AND FALSE TYPE QUESTIONS

1. Alkanes mainly undergo substitution reactions using the free-radical mechanism.
2. The decreasing order of boiling points among the isomeric pentanes is neo > iso > n.
3. The acidic character of three types of hydrocarbons follows the order alkanes > alkenes > alkynes.
4. The peroxide effect is observed only in addition of HBr, and not with HCl and HI.

5. Wurtz reaction is suitable for the preparation of both symmetrical and unsymmetrical alkanes.
6. For a compound to be aromatic it must have $(4n + 2)\pi$ electrons.
7. Benzene has planar structure.
8. The benzene molecule has two different carbon-carbon bond lengths, corresponding to alternate single and double bonds.
9. In Friedel-Crafts reaction, $AlCl_3$ is an electrophile.
10. An electron-donating substituent in benzene ring gives a meta product.

ANSWERS: 1. T 2. F 3. F 4. T 5. F 6. T 7.T 8. F 9. F 10. F

MATCH THE COLUMNS

Match the statements (a,b,c,d) in column I with the statements (i, ii, iii, iv) in column II.

1.

Column I	Column II	Column III
a. CH_4	i. sp^2	e. Ozonalysis
b. $CH_2 = CH_2$	ii. sp^3	f. Oxidising agent
c. $CH \equiv CH$	iii. sp^3d	g. Saturated nature
d. PCl_5	iv. sp	h. Un Saturated nature

2.

Column I	Column II
a. Alkanes	i. Saturated nature
b. Alkenes	ii. Ozonolysis
c. Alkynes	iii. Geometrical isomerism
d. Arenes	iv. Aromatic character

ANSWERS: 1. a. $\rightarrow$ ii. - g. b. $\rightarrow$ i.-h.-e. c. $\rightarrow$ i.-h.-e. d. $\rightarrow$ iii.-f.
2. a. $\rightarrow$ i. b. $\rightarrow$ ii., iii. c. $\rightarrow$ ii. d. $\rightarrow$ i., iv.

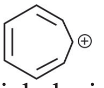
ASSERTION-REASON TYPE QUESTIONS

Type 1. The questions given below consist of Assertion(A) and Reason (R). Use the following key to select correct answer.

(a) If both assertion and reason are correct and reason is correct explanation for assertion.
(b) If both assertion and reason are correct but reason is not correct explanation for assertion.
(c) If assertion is correct but a reason is incorrect.
(d) If assertion and reason both are incorrect.

1. **Assertion:** The IUPAC name of $CH_3CH = CH - C \equiv CH$ is pent-3-en-1-yne and not pent-2-en-4-yne.

   Reason: While deciding the locants of double and triple Bonds, lowest sum rule is always followed.

2. **Assertion:** Tropylium cation  is aromatic in character.

   Reason: The only property which decides the aromatic character is its planar nature.

3. **Assertion:** Friedel-craft reaction between benzene and acetic anhydride in the presence of anhydrous $AlCl_3$ yields acetophenone and not poly-substituted products.

   Reason: Acetophenone formed poisons the catalyst preventing further reaction.

4. **Assertion:** But-1-ene on reacting with HBr in the presence of peroxide, products 1-bromobutane.

   Reason: It involves the formation of a primary free radical.

5. **Assertion:** Cyclopentadienyl anion is aromatic in nature.

   Reason: Cyclopentaclienyl anion has six π-electrons.

6. **Assertion:** Benzene reacts with chlorine in the form of light to form BHC.

   Reason: BHC is also called gammexane or 666.

7. **Assertion:** All the hydrogen atoms in $CH_2 = C = CH_2$ lie in one plane.

   Reason: All the carbon atoms in it are sp^2 hybridised.

8. **Assertion:** Propene reacts with HBr in the presence of benzoyl peroxide to yield 2-bromopropane.

   Reason: In the presence of peroxide, the addition of HBr to propene follows ionic mechanism.

9. **Assertion:** Benzene does not decolourise bromine water.

   Reason: Benzene is stabilised by resonance due to delocalisation of π electrons.

10. **Assertion:** Acidity of C-H bond decreases in the order:

    $HC \equiv CH > H_2C = CH_2 > H_3C - CH_3$

    Reason: Greater the percentage s-character, more is the acidity of C—H bond.

ANSWERS: 1.a 2.c 3.c 4.c 5.a 6.b 7.c 8.d 9.a 10.a

ONE WORD TYPE QUESTIONS

1. What is the state of hybridisation of Carbon atoms in alkanes?
2. What is self linking property of atoms called?
3. What is the general formula of alkenes?
4. What is the other name for Geometrical isomerism?
5. Which out of Ethane, Ethene and Ethyne has longest C-C bond?
6. What is the number of bonds in But-3-en-1-yne?
7. Name the product formed when Propyne is treated with aqueous H_2SO_4 in the presence of dil.$HgSO_4$.
8. What is $C-C-C$ bond angle in benzene?
9. Name the product formed when Benzene reacts with CH_3Cl in the presence of anhydrous aluminium chloride.
10. $-COOH$ is ortho, para directing or Meta directing group?

1-MARK QUESTIONS

1. Name the chain isomer of C_5H_{12} which has tertiary carbon atom.
2. Give the IUPAC name of the lowest molecular weight alkane that contains a quaternary carbon.
3. Write the reaction involved in Kolbe's electrolytic method to prepare ethane.
4. Define term decarboxylation.
5. Why dry ether and not water is used as a solvent in the preparation of alkane by Wurtz reaction?
6. Sodium salt of which carboxylic acid will be needed for the preparation of propane by decarboxylation method?
7. Complete the following reaction:

   $CH_3Cl + Na \xrightarrow{\text{dry ether}}$
8. Amongst the following which one has the maximum boiling point?

   n-Pentane, iso-pentane, neo-pentane.
9. Define the term conformation.
10. Write IUPAC name of $CH_3CH=CHCH_2CH=\underset{\underset{CH_2CH_3}{|}}{C}CH_2CH=CH_2$

11. Draw the cis and trans isomers of $CHCl{=}CHCl$.

12. What happens when 2-Bromobutane is being treated with alc. KOH?

13. Name the reagents used to carry out the following conversions:

$CH_3{-}CH{=}CH_2 \rightarrow CH_3CH(OH)CH_2OH$

14. Complete the following reaction :

$CH_3{-}CH{=}CH_2 + HBr \xrightarrow{\text{Organic peroxide}}$

15. An alkene A on ozonolysis gives a mixture of ethanol and pentan-3-one. Write IUPAC name of element.

16. When alkyne is treated with bromine water then what will be the colour of the product?

17. Why alkynes do not exhibit geometrical isomerism?

18. Complete the following reaction:

(i) $CH_3C \equiv CH \xrightarrow{H_2O,\ Hg^{2+}/H^+}$?

(ii) $CaC_2 + 2H_2O \longrightarrow$ __________ + __________

19. How will you convert ethyne to benzene?

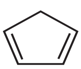
20. Write chemical equation for combustion reaction of Hexyne.

21. Write IUPAC name of $C_6H_5{-}CH_2{-}CH_2{-}CH{=}CH_2$.

22. Why is benzene extraordinarily stable although it contains three double bonds?

23. Write chemical reaction to exemplify Friedel-Crafts alkylation of benzene.

24. What is the nature of substitution in benzene?

25. Why  is not aromatic?

26. C-C bond length in benzene is intermediate between C$-$C and C$=$C. Why?

27. Starting from benzene,how would you synthesize m- Bromonitrobenzene.

28. Give one example each of o, p-directing group and m-directing group.

29. Complete the reaction:

$C_6H_6 + CH_3COCl \xrightarrow{\text{Anhy. } AlCl_3}$

30. Write the electrophile which is involved in the nitration of benzene.

2-MARKS QUESTIONS

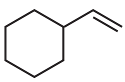
1. What effect does branching have on the boiling point of an alkane and why?
2. What is the difference between isomers and conformers?
3. Is it possible to isolate pure staggered ethane or pure eclipsed ethane at room temperature? Give reason.
4. Draw Newman projection formula for conformations of ethane.
5. How will you convert methyl bromide to ethane?
6. Wurtz reaction cannot be used for the preparation of unsymmetrical alkanes? Give reason.
7. How can ethene be prepared from (i) Ethanol (ii) Ethyl bromide?
8. Melting point of cis-But-2-ene is lower than that of trans-But-2-ene. Give reason.
9. Draw the structures of cis and trans Hex-2-ene.
10. Explain with the help of equation : Ozonolysis of propene.
11. Give a chemical test to distinguish between ethene and ethane.
12. What do you understand by peroxide effect (Kharasch effect)?

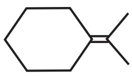
11. What factor determines the stability of alkene?

14. Arrange the following alkenes in decreasing order of stability :

    $CH_3-CH=CH-CH_3$, $CH_2=CH_2$, $CH_3-CH=CH_2$

15. Complete the reaction:

    (i)  $+ HBr \rightarrow ?$

    (ii)  $+ O_3 \xrightarrow[CH_3COOH]{Zn} ? + ?$

16. An alkene on treatment with HBr in presence of peroxide can generate two types of free radicals $CH_3-\underset{\underset{CH_3}{|}}{C}\bullet-CH_2\text{-}Br$ and $CH_3-\underset{\underset{Br}{|}}{C}(CH_3)-CH_2\bullet$

    Predict the final product of the reaction and give reason.

    (Hint: Stability of free radicals)

17. What happens when But-2-ene reacts with acidified potassium permanganate solution?

18. You are provided with But-2-yne, how will you convert it into:
    (i) cis-But-2-ene
    (ii) trans-But-2-ene
19. An alkene C_4H_8 reacts with HBr both in the presence and absence of peroxide to give the same product. Identify the alkene.
20. Arrange ethane, ethene and ethyne in the order of increasing acidity.
21. Identify A and B in the following reaction:

$$A \xrightarrow{Na} CH\equiv CH \xrightarrow[873K]{\text{Red hot iron tube}} B$$

22. Write the structures of the products A and B of the following reactions:
    (i) $HC\equiv CH \xrightarrow{Na} A \xrightarrow{CH_3Br} B$
    (ii) $BrH_2C-CH_2Br \xrightarrow{\text{Alc.KOH}} A \xrightarrow{NaNH_2} B$
23. Give a chemical test to distinguish between ethyne and ethene.
24. Out of benzene and toluene ,which will undergo nitration easily and why?
25. Why does presence of a nitro group make the benzene ring less reactive in comparison to the unsubstituted benzene ring? Explain.
26. What happens when Chlorine is passed through benzene in the presence of sunlight and absence of halogen carrier?

3-MARKS QUESTIONS

1. Write the structures and name of products obtained in the reaction of sodium with a mixture of 1-Iodo-2-methylpropane and 2-Iodopropane.
2. State Markownikov's rule. Using this rule, write the reaction of propene with (i) HCl & (ii) H_2O.
3. Complete the following reactions:
    (i) $CH_3CH_2Br \xrightarrow{\text{Alc.KOH}}$
    (ii) $CH_3CH=CH_2 + O_3 \xrightarrow{Zn/H_2O}$
    (iii) $CH_2=CH_2 + H_2O + [O] \xrightarrow{\text{Dil.}KMnO_4}$
4. (i) Write the structure of 3, 4-Dimethylhept-3-ene.
    (ii) Name the compounds obtained by ozonolysis of 3-Methylpent-2-ene.

5. Complete the following reactions:

(i) $CH \equiv CH \xrightarrow{NaNH_2, CH_3Br}$?

(ii) $CH \equiv CH \xrightarrow{H_2O, HgSO_4/H_2SO_4}$?

(iii) $CH_3C \equiv CH + H_2 \xrightarrow{Pt}$? $\xrightarrow{H_2}$?

6. Write the mechanism of nitration of benzene.

7. Arrange in the order of decreasing relative reactivity with an electrophile and explain:
Toluene, p-Nitrotoluene, 1, 4-Dinitrobenzene

8. What is meant by delocalization of π electrons? How does it affect stability of benzene?

9. What are the conditions for a compound/species to be aromatic according to Huckel's rule?

10. How will you convert benzene into
(i) Acetophenone
(ii) m- Chloronitrobenzene?

5-MARKS QUESTIONS

1. Define isomerism. Write all the structural isomers of hexane(C_6H_{14}) and arrange them in increasing order of boiling points.

2. Write short note on (i) Wurtz reaction (ii) Kolbe's electrolysis (iii) Ozonolysis

3. Alkenes show geometrical isomerism while alkanes do not. Give a suitable explanation.

4. An alkene 'A' of molecular mass '28u' on treatment with bromine gives a product 'B'. The Compound 'B' on further dehalogenation with zinc gives back 'A'. Give the structures of 'A' and 'B' and also the sequence of reactions.

5. An organic compound 'A' with formula C_4H_9Br on treatment with KOH(alc.) gave two isomeric compounds 'B' and 'C' with formula C_4H_8. Ozonolysis of 'B' gave only one product CH3CHO while 'C' gave two different products. Identify A, B and C.

6. How will you convert Ethyne into (i) 1, 1, 2, 2-Tetrachloroethane (ii) Ethene (iii) Ethanal (iv) Benzene (v) Sodium ethynide

7. Discuss the structure of benzene with an emphasis on resonance and orbital pictures.

UNIT TEST-I

Time Allowed: 1 Hr. **Maximum Marks : 20**

General Instructions:

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

1. Amongst the following which one has the maximum boiling point and why? n-Pentane , iso-pentane, neo-pentane [1]

2. What is the number of σ and π bonds in But-3-en-1-yne? [1]

3. Action of acetylene on dilute H_2SO_4/dil.$HgSO_4$ gives: [1]

   (a) Acetic acid (b) Acetone (c) Acetaldehyde (d) Ethyl alcohol

In the following questions a statement of Assertion (A) followed by Reason (R) is given. Use the following key to select correct answer :

(a) Both Assertion and Reason are correct but Reason is the correct explanation of Assertion.

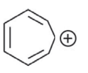
(b) Both Assertion and Reason are correct but Reason is not the correct explanation of Assertion.

(c) Both Assertion and Reason are incorrect.

(d) Assertion is not correct but Reason is correct.

4. **Assertion :** Benzone reacts with chlorine in the form of light to from BHC.

   Reason : BHC is also called gammexane or 666. [1]

5. **Assertion:** Tropylium cation  is aromatic in character.

   Reason: The only property which decides the aromatic character is its planar nature. [1]

6. Arrange the following alkenes in decreasing order of stability and give reason. [1]

   $CH_3-CH=CH-CH_3$, $CH_2=CH_2$, $CH_3-CH=CH_2$

7. (i) Give a chemical test to distinguish between ethyne and ethene. [2]

(ii) Melting point of cis-But-2-ene is lower than that of trans-But-2-ene. Give reason.

8. Complete the following reactions: [3]

(i) $CH_3CH_2Br \xrightarrow{\text{Alc.KOH}}$

(ii) $CH_3CH{=}CH_2 + O_3 \xrightarrow{Zn/H_2O}$

(iii) $CH_2{=}CH_2 + H_2O + [O] \xrightarrow{\text{Dil.}KMnO_4}$

9. (i) What are the conditions for a compound/species to be aromatic according to Huckel's rule? [3]

(ii) How will you convert Benzene to acetophenone?

10. (i) An alkene 'A' of molecular mass '28u' on treatment with bromine gives a product 'B'. The Compound 'B' on further dehalogenation with zinc gives back 'A'. Give the structures of 'A' and 'B' and also the sequence of reactions. [5]

(ii) Why is benzene extraordinarily stable although it contains three double bonds?

(iii) How can we convert ethyne into benzene?

UNIT TEST-II

Time Allowed: 1 Hr. **Maximum Marks : 20**

General Instructions:

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

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1. The methyl group in Benzene ling is [1]
   (a) Ortho directing (b) Ortho and meta directing
   (c) Para directing (d) Ortho and para directing
2. Action of acetylene on dilute H_2SO_4 gives : [1]
   (a) Acetic acid (b) Acetone
   (c) Acetaldehyde (d) Ethyl alcohol
3. What is the other name for Geometrical isomerism? [1]

In the following questions a statement of Assertion (A) followed by Reason (R) is given. Use the following key to select correct answer :

(a) Both Assertion and Reason are correct but Reason is the correct explanation of Assertion.

(b) Both Assertion and Reason are correct but Reason is not the correct explanation of Assertion.

(c) Both Assertion and Reason are incorrect.

(d) Assertion is not correct but Reason is correct.

4. **Assertion:** Benzene does not decolourise bromine water.
   Reason: Benzene is stabilised by resonance due to delocalisation of π electrons.
5. **Assertion:** Acidity of C-H bond decreases in the order:
   $HC \equiv CH > H_2C = CH_2 > H_3C - CH_3$
   Reason: Greater the percentage s-character, more is the acidity of C—H bond.
6. How will you convert methyl bromide to ethane? [2]
7. Explain with the help of equation ozonolysis of propene. [2]
8. Write the mechanism of nitration of benzene. [3]
9. How will you convert benzene into [3]
   (i) Acetophenone
   (ii) Toluene
10. Write short note on the following : [5]
   (i) Wurtz reaction.
   (ii) Kolbe's electrolysis
   (iii) Ozonolysis

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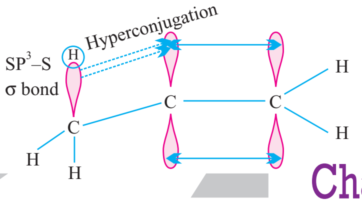


Chapter - 14 Environmental Chemistry

FAST TRACK : QUICK REVISION

► **Environmental pollution:** Environmental pollution is the effect of undesirable changes in our surroundings that have harmful effects on plants, animals and human beings. A substance which causes pollution is known as pollutant. Pollutants can be degradable and non-degradable.

► **Atmospheric pollution:** Any undesirable changes in their atmosphere which adversely effect living beings is called air pollution. Air pollution is generally limited to troposphere and stratosphere.

Ozone is present in stratosphere and prevents UV radiations of sun from reaching the earth's surface.

► **Tropospheric pollution:** It is due to gaseous and particulate pollutants.

1. Gaseous air pollutants:

Oxides of sulphur: Major sources of oxides of sulphur (mainly SO_2) are burning of fossil fuels containing sulphur. Sulphur dioxide is converted to sulphur trioxide in presence of particulat matter.

$$2SO_2 + O_2 \longrightarrow 2SO_3$$

Sulphur dioxide is a corrosive gas which produces acid rain that causes damage and destruction of vegetation and degradation of soils, building materials and watercourses. SO_2 in ambient air is also associated with asthma and chronic bronchitis. It also causes irritation to eyes.

- **Oxides of nitrogen:** Major sources of nitrogen oxides are high temperature combustion processes, oxidation of nitrogen in the air and fuel respectively, denitrifying bacteria, etc.

$$N_2 + O_2 \longrightarrow 2NO$$
$$2NO + O_2 \longrightarrow 2NO_2$$
$$NO + O_3 \longrightarrow NO_2 + O_2$$

Finally, these gases are converted into nitric acid (HNO_3) which comes down to the surface of the earth in the form of acid rain.

— NO_2 is a respiratory irritant,

— The oxides produce eye irritation, injury to liver and kidneys.

- **Hydrocarbons:** They are majorly produced naturally (e.g. marsh gas) as well as due to incomplete combustion of automobile fuel.

  — Hydrocarbons are carcinogenic, these harm plants.

- **Oxides of carbon:** two major pollutants are oxides of carbon i.e., carbon monoxide and carbon dioxide.

- **Carbon monoxide:** Carbon monoxide (CO) is a toxic gas which is emitted into atmosphere by incomplete combustion of coal and firewood and by oxidation of hydrocarbons and other organic compounds.

  CO may reduce the oxygen carrying capacity of the blood by combining with haemoglobin to produce carboxyhaemoglobin, This oxygen deficiency results in headache weak eyesight, choking and cardiovascular disorders.

- **Carbon dioxide:** CO_2 is released into atmosphere by respiration burning of fossil fuels, forest fire decomposition of limestone in cement industry, etc.

  — It is a greenhouse gas, the concentration of which is constantly raising.

  — In excess it causes headache and nausea.

► **Greenhouse effect and global warming:** The greenhouse effect is the process in which the emission of infrared radiation by the atmosphere warms the Earth surface.

- Greenhouse gases include carbon dioxide, methane, ozone chlorofluorocarbons (CFCs) and water vapour.
- Earth absorbs energy from sunlight entering the atmosphere and emit energy out to space in form of infrared rays. The outgoing radiation emitted by the surface is in the absorption range of many atmospheric gases, including carbon dioxide, methane, and water vapour. These radiations are thus locked in the earth's atmosphere. This results in the steady increase in the temperature of the earth resulting in global warming.

► **Acid rain:** Rainwater normally has a pH of 5.6 due to dissolution of CO_2 present in the atmosphere.

$$CO_2 + H_2O = H_2CO_3 = H^+ + HCO^-_3$$

- When the pH Falls below 5.6, the rain water becomes acidic, It is caused due to presence of acidic gases into the atmosphere the common ones are sulphur dioxide and nitrogen oxides which are changed into sulphuric acid and nitric acid by combining with oxygen and water.

$$2SO_2 + O_2 + 2H_2O \longrightarrow 2H_2SO_4$$
$$4NO_2 + O_2 + 2H_2O \longrightarrow 4HNO_3$$

- Harmful effects of acid rain: It is causes extensive damage to buildings and statues made by marble, limestone due to the reaction,

$$CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + CO_2 + H_2O$$

— It is toxic to vegetation and aquatic life.

— It corrodes water pipes resulting in the leaching of the heavy metals such as Fe, Pb, and Cu into the drinking water which have toxic effects.

2. **Particulate pollutants:** Particulate pollutants are small solid particles and liquid droplets suspended in air.

Smoke: it consists of solid or mixture of solid and liquid particles formed by combustion of organic matter. e.g., cigarette smoke, oil smoke, smoke from fossil fuel etc.

Dust: It consists of fine particles produced during crushing and grinding of solid materials. Common dust particulate emission include cement, fly ash, silica dust, from Industries, dust storm, ground limestone, etc.

Mist: These are formed by particles of spray liquids and condensation of sepals in air. For example, sulphuric acid, mist herbicide or insecticide that Miss their targets and travel through air from mist.

Fumes: These are produced by condensation of vapours. For example, metal fumes, metallurgical fumes and alkali fumes.

Smog: The word smog has its origin from smoke and fog. It is a major air pollutant.

Classical smog	**Photochemical smog**
Also called as London smog.	Also called as Los Angeles smog.
Form due to oxides of sulphur.	Formed due to oxides of Nitrogen.
Contains primary pollutants.	Content secondary pollutants.
Causes bronchitis and problem in lungs.	Causes irritation in Eyes.
It is reducing in nature.	It is oxidising in nature.

Formation of photochemical smog: It is formed through sequence of following reactions:

$$\underset{\text{(in gasoline)}}{N_2 + O_2} \longrightarrow 2NO$$

$$2NO + O_2 \longrightarrow 2NO_2$$

$$NO_2 \longrightarrow NO + O$$

$$O + O_2 \longrightarrow O_3$$

$$O_3 + NO \longrightarrow NO_2 + O_2$$

Ozone reacts with hydrocarbons to form Peroxyacetyl nitrate (PAN), formaldehyde, acrolein etc. Effects of photochemical smog:

Ozone and PAN are eye irritants. Photochemical smog also corrodes metals stones buildings materials rubber and painted surfaces.

Measures to control photochemical smog:

Catalytic converters are used in automobiles, which prevent the release of Nitrogen oxide and hydrocarbon to the atmosphere. Certain plants e.g. Pinus, Juniparus, Quercus, Pyrus and Vitis can metabolize nitrogen oxide and therefore their plantation could help in this matter.

- **Stratospheric pollution:** The upper stratosphere consists of considerable amount of ozone (O_3) which protects us from the harmful ultraviolet (UV) radiations coming from the sun. These radiations causes skin cancer in humans.

Depletion of Ozone layer : Nitric Oxide and chlorofluorocarbons are found to be most responsible for depletion of Ozone layer.

$$NO + O_3 \longrightarrow NO_2 + O_2$$

$$O_2 \longrightarrow O + O$$

$$NO_2 + O \longrightarrow NO + O_2$$

$$CF_2Cl_2 \xrightarrow{hv} {}^{\bullet}CF_2Cl + Cl^{\bullet}$$

(free radical)

$$CFCl_3 \xrightarrow{hv} CFCl_2 + Cl^{\bullet}$$

$$Cl^{\bullet} + O_3 \longrightarrow ClO^{\bullet} + O_2$$

$$ClO^{\bullet} + O \longrightarrow Cl + O_2$$

- **Ozone depletion by oxides of Nitrogen:**

  Nitrous oxide is quite inert, in the stratosphere it is photochemically converted into more reactive nitric oxide.

  $NO + O_3 \longrightarrow NO_2 + O_2$

  $O_2 \xrightarrow{hv} O + O$

  $NO_2 + O \longrightarrow NO + O_2$

  Thus NO is regenerated in chain reaction.

- **Effects of ozone depletion:**

  With the depletion of Ozone layer, more UV radiation filters into troposphere.

  — UV radiations leads to ageing of skin, cataract, Sunburn, skin cancer, killing of many phyotplanktons, damage to fish productivity, etc.

Water pollution: Water pollution may be defined as any change in its physical, chemical, biological properties or contamination with foreign materials that can adversely affect human beings or reduce its utility for the intended use.

Major water pollutants and their sources:

Pollutants	Major sources
natural waste	Leaching of minerals slits from soil erosion falling of organic matter from bank,etc.
organic Chemicals	Pesticides, surfactants, detergents, Industrial waste
metals	Nuclear power plants, mining, metal plating industries.
man-made wastes	Sewage domestic waste, soaps and detergents, waste from animal sheds and slaughter houses, run off from agricultural fields, industrial wastes, oil pollution.

- **Eutrophication:** The process in which nutrient enriched water bodies support a dense plant population, which kills animal life by depriving it of Oxygen and results in subsequent loss of biodiversity is known as eutrophication.

- **BOD:** The amount of oxygen required by bacteria to break down the organic matter present in a certain volume of a sample of water, is called Biochemical Oxygen Demand (BOD)

International standards for drinking water:

Element	Permissible limit	Effect of excess amount
Fluoride	1 ppm or 1mg dm^{-3}	Over 10 ppm causes harmful effect to bones and teeth.
Lead	50ppb	Excess amount can damage kidney, liver reproductive system, etc.
Nitrate	50ppm	Excess amount can cause blue baby syndrome.
Sulphate	500ppm	Excess can cause laxative effects.

► **Soil pollution:** Soil pollution is the addition of such chemical substances (in an indefinite proportion) which deteriorates the quality, texture and mineral content of the soil and disturbs the biological balance of the organisms in it and has little effect on the plant growth.

Some major soil pollutants and their sources:

Pollutants	Major sources
Industrial wastes	Waste products from paper, sugar, chemical Industries dumped into the soil.
Agricultural wastes	Chemical such as fertilizers pesticides extra used for killing insects fungi and weeds.
Soil conditioners	Used to protect soil fertility but contains several toxic metals like Pb, As, Hg, Cd, etc
Farm wastes	Wet slurry, faecal wastes are seeped into the soil.
Radioactive pollutants	Dumping of nuclear waste into the soil.

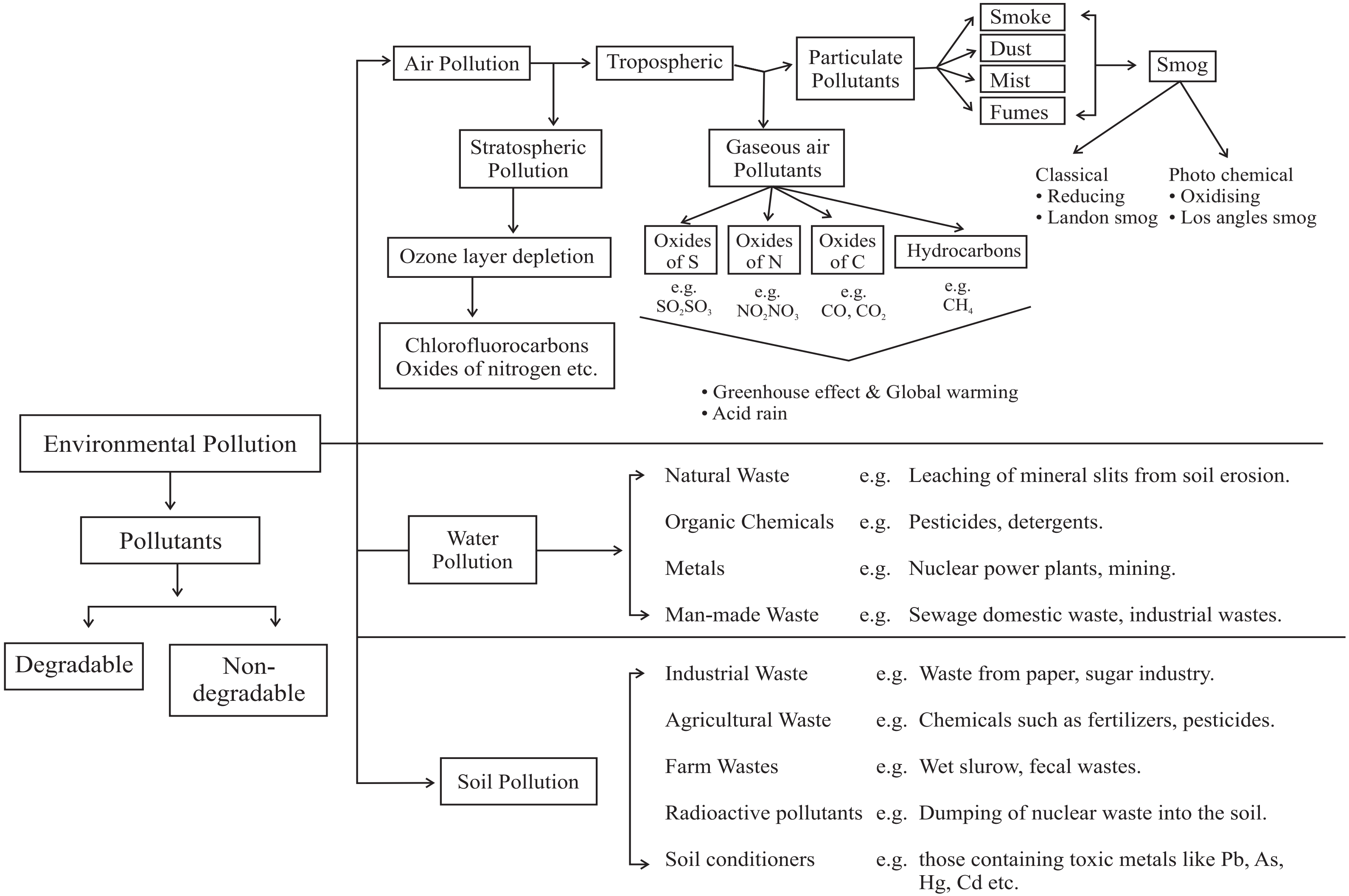
► **Remedial measures:**

- Forestation should be done to check the spread of desert.
  - — Use of chemical fertilizers should be minimised.
  - — Recycling, digestion and incineration of urban waste and organic waste should be done.
  - — The industrial effluents should not be allowed to discharge into fields.
  - — The fertility of the soil can be improved by soil rotation and mixed farming.

- **Control of environmental pollution:**
  - **Waste management:** Environmental pollution can be controlled to a certain extent by managing the waste disposal in a proper way.
  - **Recycling:** A large amount of disposed waste materials can be reduced by recycling the waste.
    Thus, it reduces the landfill and converts waste into usable products.

- **Green chemistry:** Green Chemistry may be defined as a strategy to design chemical process and products that reduces or eliminate the use and generation of hazardous substances.
  - It is an alternative tool for reducing pollution. Green Chemistry includes concepts such as waste minimization, solvent selection, atom utilisation, intensive processing and alternative synthetic routes from sustainable resources.
  - **Green chemistry in day-to-day life:**
    - Dry cleaning of clothes: Tetra chloroethene ($Cl_2C = CCl_2$) was earlier used as solvent for dry cleaning. The compound contaminates the ground water and is also a suspected carcinogen.
      The process using this compound is now being replaced by a process, where liquefied carbon dioxide, with suitable present is used.
    - Bleaching of paper: Chlorine gas was used earlier for bleaching paper. These days, hydrogen peroxide (H_2O_2) with suitable catalyst, which promotes the bleaching action of hydrogen peroxide, is used.

MIND MAP : ENVIRONMENTAL CHEMISTRY



CASE BASED STUDY QUESTIONS

PASSAGE-I

75% of the solar energy reaching earth is absorbed by earth's surface which increases its temperature. The rest of the heat radiates back to the atmosphere. They add to the heating of atmosphere which causes 'Global warming' (heat trapped by gases such as CO_2, CH_4, O_3 CFCs present in atmosphere).

Answer the following questions on the basis of above paragraph :

1. What is Green house effect?
2. What can we do to reduce the rate of Global warming?
3. Give one consequence of Green house effect.
4. Give full form of CFC.
5. Give names of some green house gases.

PASSAGE-II

The major cause of environmental pollution is rapid industrialisation particularly. The developments of those industries which either produce or use toxic chemicals one way to protect our environment from chemical effluents and waste is to use Green chemistry.

Answer the following questions on the basis of above paragraph :

1. What do you mean by Green chemistry?
2. Give the basic aims of Green chemistry.
3. What measures are taken to reduce the pollution?
4. What is photo chemistry?
5. Which gas is replaced as blowing agent in the manufacture of polystyrene foam sheets.

MULTIPLE CHOICE QUESTIONS (MCQ)

1. Which of the following is not the consequence of global warming?
   (a) Increase in average temperature of Earth.
   (b) Melting of Himalayan glaciers
   (c) Rise in sea level
   (d) Eutrophication
2. Which of the following statement is incorrect?
   (a) Oxidize of Nitrogen in atmosphere can cause depletion of Ozone layer
   (b) Ozone absorbs infrared rays
   (c) Depletion of O_2 is due to its chemical reaction with halo alkanes
   (d) None of these
3. Which of the following are the hazardous pollutants present in automobile exhaust gases?
   (i) N_2 (ii) CO (iii) CH_4 (iv) Oxides of nitrogen
   (a) ii and iii (b) i and ii
   (c) ii and iv (d) i and iii
4. Which of the following gas causes green house effect to maximum extent?
   (a) CH_4 (b) Water vapour
   (c) N_2O (d) CO_2
5. Which of the following is a sink for CO ?
   (a) Haemoglobin (b) Micro-organisms
   (c) Oceans (d) Plants
6. Classical smog occurs in place of
   (a) Excess of NO_2 (b) Warm dry climate
   (c) Cool humid climate (d) All of these
7. When huge amount of sewage is dumped in a river, the BOD
   (a) Will increase (b) Will remain unchanged
   (c) Will in decrease (d) May increase or decrease
8. Which of the following practices will not come under Green chemistry?
   (a) Use of CO_2 as solvent instead of Cl_2
   (b) Use of H_2O_2 instead of Cl_2 for bleaching
   (c) Synthesis of ethanal from ethane in one step
   (d) Use of tetrachloroethene as a solvent for dry cleaning

9. Eutrophication causes reduction in
   (a) Dissolved salts (b) Dissolved oxygen
   (c) Nutrients (d) All of these
10. SO_2 and NO_2 cause pollution by increasing
   (a) Acidity (b) Alkalinity
   (c) Buffer action (d) Both (a) and (c)

ANSWERS: 1.d 2.b 3.c 4.d 5.a 6.c 7.a 8.d 9.d 10. a.

FILL IN THE BLANKS

1. Three substances normally considered as primary pollutant are ____, ____, and _____.
2. Sulphur dioxide is mainly produced by the burning of ________.
3. BOD stands for ___________.
4. The single plant nutrient mainly responsible for eutrophication is ______.
5. The lowest layer of atmosphere is the_______.
6. A crucially important species formed by oxygen in stratosphere is _____.
7. _______ is a greenhouse gas.
8. A major class of organic halides that are thought to pose a threat to stratospheric ozone are _______.
9. The component that distinguishes classical smog from photochemical smog is _____.
10. Carbon dioxide traps heat in the atmosphere. This is called the ______.

   Answers : 1. CO, NO_2, SO_2 2. Coal 3. Biochemical oxygen demand 4. Phosphate 5. Troposphere 6. Ozone 7. Carbon dioxide 8. Chlorofluorocarbons 9. Sulphur dioxide 10. Greenhouse effect

TRUE AND FALSE TYPE QUESTIONS

1. The troposphere is the region above the stratosphere.
2. Dust, mist, fumes, smoke and smog are particulate pollutants.
3. Carboxyhaemoglobin is less stable than oxyhaemoglobin.
4. Ozone occurs naturally in the troposphere.
5. Plants such as Pinus, Juniparus, Pyrus and Vitis metabolize nitrogen oxides.
6. Clean water should have BOD of 17 ppm or more.

7. Photochemical smog is a mixture of oxidising pollutants.
8. The exhaust from jet aeroplanes contains nitric oxide, which can destroy the ozone layer.
9. PAN is one of the constituents of photochemical smog.
10. DDT is non-biodegradable and persistent.

Answers : 1. F 2. T 3. F 4. F 5. T 6. F 7. T 8. T 9. T 10. T

MATCH THE COLUMNS

Match the column:

1.

Column I	**Column II**
a. CO_2	i. a gas produced by the partial combustion of many fuels
b. CO	ii. a gas that occurs naturally in the atmosphere and which is needed for photosynthesis
c. O_3	iii. a dangerous gaseous pollutant with corrosive properties formed by combustion of fossil fuels.
d. SO_2	iv. an allotrope of oxygen found in the upper atmosphere

Column III

e. forms stable complex with Fe
f. Act as reducting agent
g. Act as oxidising agent
h. A green house gas

2. Match the pollutants (a, b, c, d) in column I with the effects (i, ii, iii, iv) in column II.

Column I	**Column II**
a. Phosphate fertilisers in water	i. BOD level of water increases
b. Methane in air	ii. Acid rain
c. PAN	iii. Global warming
d. Nitrogen oxides in air	iv. Photochemical oxidant

ANSWERS: 1. a. ii, h b. i, e c. iv, g d. iii, f
2. a. i b. iii c. iv d. ii

ASSERTION-REASON TYPE QUESTIONS

In the following questions a statement of Assertion (A) followed by reason(R) is given. Use the following key to select correct answer.

(a) Both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

(b) Both Assertion and Reason are correct but Reason is not the correct explanation of Assertion.

(c) Both Assertion and Reason are incorrect.

(d) Assertion is not correct but Reason is correct.

1. **Assertion:** The pH of acid rain is less than 5.6.

   Reason: Carbon dioxide present in the atmosphere dissolves in rain water and forms carbonic acid.

2. **Assertion:** Photochemical smog is oxidizing in nature.

   Reason : Photochemical smog contains NO_2 and O_3, which are formed during the sequence of reactions.

3. **Assertion:** If BOD level of water in a reservoir is less than 5ppm, it is highly polluted.

   Reason: High biological oxygen demand means low activity of bacteria in water.

4. **Assertion:** Ozone is destroyed by solar radiation in upper atmosphere.

   Reason: Thinning of the ozone layer allows excessive UV radiations to reach the surface of earth.

5. **Assertion:** Carbondioxide is an important greenhouse gas.

   Reason: It is largely produced by respiratory function of animals and plants.

ANSWERS : 1. b   2. a   3. c   4. d   5. b

ONE WORD TYPE QUESTIONS

1. Name the gas which reacts with haemoglobin in blood.
2. In which part of atmosphere is ozone layer present?
3. Besides CO_2 name one other green house gas.
4. Which acid is most abundant in acid rain?
5. Name the gas whose release was responsible for Bhopal gas tragedy.

6. What is the nature of photochemical smog?
7. Write full form of BOD.
8. What is the lowest region of the atmosphere which extends upto a height of 10 km from sea level?
9. Name the gas which is produced by the incomplete combustion of gasoline.
10. What does CFC stand for?

1-MARK QUESTIONS

1. Name two gaseous pollutants.
2. What is the size range of particulates?
3. What are primary pollutants?
4. Name two greenhouse gases.
5. What is the composition of photochemical smog?
6. What is the composition of classical smog?
7. Which are the compounds responsible for ozone layerdepletion?
8. Name the pollutants which has affected Taj Mahal.
9. Name two strong acids present in acid rain.
10. What is PAN?
11. Name two sources of phosphate pollution.
12. When a huge amount of sewage is dumped into a river, what will be the effect on BOD?
13. How is NO formed in atmosphere?
14. In which season the depletion of ozone on Antarctica takes place and when is it replenished?
15. Define acid rain.

2-MARKS QUESTIONS

1. Explain giving reason: The presence of CO reduces the amount of haemoglobin available in the blood for carrying oxygen to body cells.
2. Oxygen plays a key role in the troposphere while ozone in stratosphere. Explain.

3. What is meant by Eutrophication?
4. Define BOD.
5. What is the importance of measuring BOD of a water body?
6. Why does water with excessive algae growth become polluted?
7. A person was using water supplied by municipality. Due to shortage of water, he started using underground water, he felt laxative effect. What could be the cause?
8. What do you understand by the term Green chemistry?
9. Give two examples each of biodegradable and non-biodegradable waste.
10. List few ways to control photochemical smog.

3-MARKS QUESTIONS

1. Give three harmful effects of oxides of sulphur.
2. What is Global warming? What is its cause?
3. What is photochemical smog and what are its harmful effects?
4. How is classical smog different from photochemical smog?
5. State briefly the reactions causing ozone layer depletion in the stratosphere.
6. How does rain water get contaminated with acidic impurities?
7. Discuss the harmful effects of acid rain.
8. Suggest any four methods for waste management.

5-MARKS QUESTIONS

1. What is Green house effect? How is it responsible for global warming?
2. How can you apply green chemistry in for the following?
   (i) To control photochemical smog
   (ii) To avoid use of halogenated solvents in dry cleaning
   (iii) To reduce the use of detergents
   (iv) To reduce the consumption of petrol and diesel.

UNIT TEST-I

Time Allowed: 1 Hr. **Maximum Marks : 20**

General Instructions:

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

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1. The lowest region of atmosphere is [1]
   (a) Stratosphere (b) Troposphere
   (c) Mesosphere (d) Hydrosphere
2. Classical smog occurs in place of [1]
   (a) Excess of NO_2 (b) Warm dry climate
   (c) Cool humid climate (d) All of these
3. Name two Greenhouse gases. [1]

In the following questions a statement of Assertion (A) followed by Reason (R) is given. Use the following key to select correct answer :

(a) Both Assertion and Reason are correct but Reason is the correct explanation of Assertion.

(b) Both Assertion and Reason are correct but Reason is not the correct explanation of Assertion.

(c) Both Assertion and Reason are incorrect.

(d) Assertion is not correct but Reason is correct.

4. Assertion: Ozone is destroyed by solar radiation in upper atmosphere. [1]
   Reason: Thinning of the ozone layers allows excessive UV radiations to reach the surface of earth.
5. Assertion: Carbon dioxide is an important Green house gas. [1]
   Reason: It is largely produced by Respiratory function of animals and plants.
6. Explain giving reason: The presence of CO reduces the amount of haemoglobin available in the blood for carrying oxygen to body cells. [2]
7. How is classical smog different from photochemical smog? [2]
8. Define BOD. What is the importance of measuring BOD of a water body? [3]
9. How does rain water get contaminated with acidic impurities? Write one harmful effect of acid rain. [3]
10. How can you apply green chemistry for the following? [5]
    (i) To control photochemical smog
    (ii) To avoid use of halogenated solvents in dry cleaning
    (iii) To reduce the use of detergents
    (iv) To reduce the consumption of petrol and diesel.

UNIT TEST-II

Time Allowed: 1 Hr. **Maximum Marks : 20**

General Instructions:

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

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1. Which of the following gas causes green house effect to maximum extent? [1]

   (a) CH_4 (b) Water vapour

   (c) N_2O (d) CO_2

5. Which of the following is a sink for CO ? [1]

   (a) Haemoglobin (b) Micro-organisms

   (c) Oceans (d) Plants

3. Write full form of BOD. [1]

In the following questions a statement of Assertion (A) followed by Reason (R) is given. Use the following key to select correct answer :

(a) Both Assertion and Reason are correct but Reason is the correct explanation of Assertion.

(b) Both Assertion and Reason are correct but Reason is not the correct explanation of Assertion.

(c) Both Assertion and Reason are incorrect.

(d) Assertion is not correct but Reason is correct.

4. **Assertion:** The pH of acid rain is less than 5.6. [1]

   Reason: Carbon dioxide present in the atmosphere dissolves in rain water and forms carbonic acid.

5. **Assertion:** Photochemical smog is oxidizing in nature. [1]

   Reason : Photochemical smog contains NO_2 and O_3, which are formed during the sequence of reactions.

6. What is meant by Eutrophication? [2]

7. List few ways to control photochemical smog. [2]

8. What is Global warming? What is its cause? [3]

9. Suggest any four methods for waste management. [3]

10. Explain how green house effect causes global warming. [5]

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QUESTION FOR PRACTICES-I

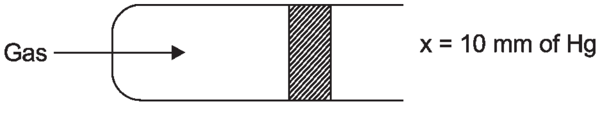
1. What are the oxygen moles in 0.5 mol of $CaCO_3$?
   (a) 1 mol (b) 0.2 mol
   (c) 1.5 mol (d) 3.0 mol

2. What is the unit of wave number (ν) ?

3. The general configuration of 'f' block is
   (a) $(n-1)\ f^{1-14}\ nd^{0-1}\ ns2$ (b) $(n-1)f^{0-1}\ nd^2\ ns^2$
   (c) $(n-2)\ f^{1-14}\ (n-1)\ d^{0-1}\ ns^2$ (d) $(n-2)\ f^{1-14}\ (n-1)d^{0-2}\ ns^{0-1}$

4. The shape of IBr^-_2 is
   (a) Tetrahedral (b) Planar
   (c) Linear (d) V-shape

5. What is the pressure of the gas in tube



6. Arrange the following in order of decreasing boiling point : Be, Mg, Ca, Sr

7. $\Delta_f H^0$ for Graphite is ____________ .

8. Nature of NaH is ____________ .

Q.9 - Q.10 Assertion-Reason Type Questions

Each question contains statements-1 (Assertion) and Statement-2 (Reason) Examine the statements carefully and mark the correct answer according to the instruction given below:

A. If both the statements are true and statement-2 is the correct explaination of statement-1.
B. If both the statements are true but statement-2 is not the correct explanation of statement-1.
C. If statement-1 is true and statement-2 is false.
D. If statement-1 is false and statement-2 is true.

9. Statement-1 For reaction $A + B \rightleftharpoons C$, $K = 4$ on addition of catalyst K becomes more than 4.
   Statement-2 Catalyst only helps to attain the equilibrium faster from either end of reaction.

10. Statement-1 $Cl_2 + 2OH^- \longrightarrow ClO^- + Cl^-$ is a disproportion reaction.
Statement-2 In disproportionation, the same element get oxidised as well as reduce.

11. Complete the reaction

$H_2(g) + Pd^{2+}(aq.) \longrightarrow$

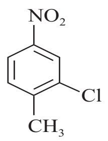
OR

$CO(g) + H_2O(g) \xrightarrow[\text{Catalyst}]{673K}$

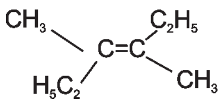
12. Why ammoniacal solution of alkali metal is blue in colour?

13. What is a producer gas?

14. Write the IUPAC name of following



OR



15. What does B.O.D. stands for?

16. Calculate number of atoms in 52u of He.

17. Which series of lines of the hydrogen spectrum lie in the visible region?

18. Write the name of element with highest electron gain enthalpy.

19. Draw the shape of ClF_3.
OR, Draw the shape of SF_6.

20. What is the unit of ‘a’ in van der Waal's equation?

21. (i) What are the number of waves made by a Bohr electron in an orbit of maximum magnetic quantum number 3?
(ii) If kinetic energy of a particle is doubled. What will happen to de Broglie wavelength as compared to previous de Broglie wavelength.

22. (i) Why $PbCl_2$ is more stable than $PbCl_4$?
(ii) Why Electron gain enthalpy of Mg is positive?

23. (i) Second I.E. (Ionisation Enthalpy) is always more than first Ionisation energy.
(ii) Why first electron gain enthalpy of sulphur is more negative than oxygen.

24. Balance the following reaction by (ion-electron or oxidation number method)

$Cl_2O_7(g) + H_2O_2\ (aq.) \longrightarrow ClO_2^-(aq.) + O_2\ (g) + H^+$ (Acidic medium)

25. (i) What is the difference between hydrolysis and hydration?

(ii) Arrange the following in order of increasing electrical conductance CaH_2, BeH_2 and TeH_2.

26. A sample of 0.5g of an organic compound was treated according to Kjeldahl's method. The ammonia evolved was absorbed in 50 ml of 0.5 M H_2SO_4. The residual acid requirede 60 mL of 0.5 solution of NaOH for neutralisation. Find the percentage composition of nitrogen in the compound.

27. (i) Out of benzene, m-dinitrobenzene and toluene, which will undergo nitration most easily and why?

(ii) What effect does branching of an alkane chain has on its boiling point?

28. (i) What is Eutrophication?

(ii) What is the action of F^- on enamel present on the surface of teeth?

29. (i) What is the upper limit concentration of lead in drinking water?

(ii) What is smog? Classify them as reducing smog or oxidising smog.

30. A crystalline salt on being rendered anhydrous loses 45.6% of its weight. The percentage composition of the anhydrous salt is

Al = 10.50%, K= 15.1%, S= 24.96%, O=49.92%

Find the simplest formula of the anhydrous and crystalline salt.

(Atomic Mass : K= 39, Al = 27, S = 32, O = 16).

31. Explain following with example :

(i) Aufbau's Rule (ii) Hund's Rule (iii) Pauli's Exclusion Principle

32. An ion with mass number 81 contains 31.7% more neutrons as compared to protons. Assign the atomic symbol.

33. Explain the bonding in SF_6 using hybridisation concept and define what is hybridisation.

34. On the basis of molecular orbital theory find the bond order, molecular orbital configuration and magnetic nature of O_2^+.

35. Derive van der Waal's equation :

$$\left(P + \frac{an^2}{v^2}\right)(v - nb) = nRT$$

36. Explain Born Haber cycle with by considering example of formation of $MgCl_2$ as given in the chemical reaction

$$Mg(s) + Cl_2(g) \longrightarrow MgCl_2(s)$$

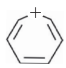
37. Give suitable reasons :

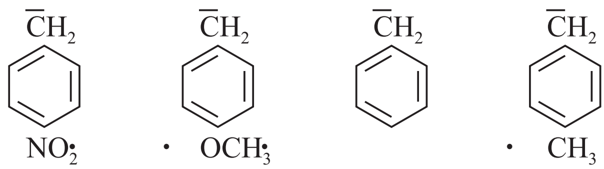
(i) A solution of Na_2CO_3 is alkaline why?

(ii) Beo insoluble but $BeSO_4$ soluble in water why?

(iii) Lithium salts are commonly hydrated as compare to other alkali metal ions. Why?

38. Arrange following in order of increasing stability

(a) $\overset{+}{C}H_3$ $\quad CH_3\overset{+}{C}H_2 \quad (CH_3)_3C^+$ 

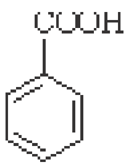
(b) 

(c) CH_3CH_2, CH_3, $CH_2–CH= CH_2$, $CH = CH_2$

39. (i) What is ambident nucleophile? Mention one example.

(ii) Distinguish between homolytic and hetrolytic bond cleavage.

(iii) Which one is stronger acid and why

H—COOH, 

40. (a) What is a buffer solution? Give example.

(b) What is common ion effect?

(c) Define Le-Chatlier principle and explain effect of following :

(i) Change of concentration (ii) Change of pressure

41. (a) Find out K_c for following reaction

$$2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)\ ;\ K_p = 1.8\times10^{-4} \text{ at } 500K$$

(b) $K_p = 0.04$ atm at 899K. What is the equilibrium concentration of C_2H_6 where it is placed in a flask at 4.0 atm pressure and allow to come to equilibrium

$$C_2H_6 \rightleftharpoons C_2H_4(g) + H_2(g)$$

(c) What is the unit of K_p for the following chemical reaction?

$2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)$

42. (i) Show with the help of chemical reaction that Al shows amphoteric behaviour.

(ii) Draw the structure of (a) B_2H_6 (b) Boric acid.

(iii) Write the formula of Borax.

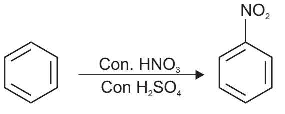
43 (i) Explain Lewis acid strength

$BF_3 < BCl_3 < BBr_3 < BI_3$

(ii) What are silicones? Give reaction for formation of chain silicones.

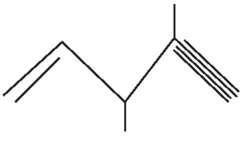
(iii) Why CO is poisionous in nature?

44. (i) Explain with the help of mechanism



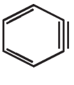
(ii) Draw the Newman structure of (a) 2-Methyl butane
(b) 1-Methyl prop-1-ene

(iii) Calculate total number of σ and π bond(s) in

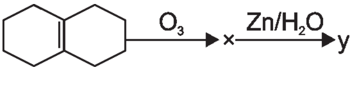


45. (i) Explain Kolbe's electrolysis with mechanism.

(ii) State Huckel Rule's.

Check whether  is an aromatic or non aromatic, anti-aromatic.

(iii) Write the product



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QUESTION FOR PRACTICES-II

1. The number of nodal planes in p_x orbitals is

   (a) 1 (b) 2 (c) 3 (d) 0

2. Which of the following has smallest bond angle?

   (a) H_2O (b) H_2S (c) NH_3 (d) SO_2

3. For a reaction to be spontaneous at all the temperature:

   (a) ΔG –ve, ΔH +ve, ΔS +ve

   (b) ΔG +ve, ΔH -ve, ΔS +ve

   (c) ΔG –ve, ΔH -ve, ΔS - ve

   (d) ΔG –ve, ΔH -ve, ΔS +ve

4. Which is is most strongly hydrated?

   (a) Li^+ (b) Na^+ (c) K^+ (d) Rb^+

5. Which of the following has largest ionic radii?

   (a) Na^+ (b) Mg^{2+} (c) F^- (d) O^{2-}

6. When carbon is bonded to four other atoms or groups it uses ________ hybrid orbitals.

7. Surface tension ____________ with increase in temperature.

8. The second electron gain enthalpy is ________.

   Directions for Question No. 9 and 10 : A statement of assertion (A) followed by a statement of reason (R) is given. Choose the correct option out of the choices given below for each question:

   (a) A and R both are correct and R is the correct explanation of A.

   (b) A and R both are correct but R is not the correct explanation of A.

   (c) A is true but R is false.

   (d) A and R both are false.

9. **Assertion:** The entropy of ice is less than that of water.

   Reason: Ice has a cage like structure.

10 **Assertion:** London forces are much more stronger between Xenon atoms than between Helium atoms.

Reason: Xenon atom is bigger than Helium atom.

11. Write empirical formula of CH_3COOH and K_2CO_3
12. Define mole fraction.
13. Mention the quantum number which determines the energy of electron in the H-atom.
14. How many unpaired electrons are there in Ni^{2+} ion? (Given : Z =28)
15. State the condition for the formation of precipitate.
16. Write the conjugate acid and conjugate base of HSO_4^-.
17. Using VSEPR theory draw the shape of XeF_4 molecule.
18. Write IUPAC name of $CH_2 = CH - CH(OH)C \equiv CH$.
19. In a reaction between an oxidant and a reductant which will give up electrons and which will accept electrons?
20. Calculate oxidation number of Cr in $K_2Cr_2O_7$ and Mn in $KMnO_4$.
21. Elements of which group form electron precise hydrides?
22. Which part of periodic table is known as hydride gap?
23. State the reason of using certain alkali metals in photoelectric cells.
24. Name those alkaline earth metals which do not impart colour to the flame.
25. Mention the compounds which are responsible for ozone layer depletion.
26. Cis But-2-ene has lower melting point that trans But-2-ene. Give reason.
27. Balance the following redox reaction in acidic medium by ion electron method.

    $$Zn(aq.) + NO_3^-(aq.) \longrightarrow Zn^{2+}(aq.) + N_2O(g) + H_2O$$

28. (i) Mg^{2+} ion is smaller than O2-ion, although both are isoelectronic. Give reason.

    (ii) Write IUPAC name and symbol for the element with atomic no. 120.

29. (i) Mention the number of radial nodes in 6s orbitals.

    (ii) Write electronic configuration of Fe^{2+} ion. (Given, Z = 26)

30. Calculate the wavelength of a ball of mass 0.1kg moving with a velocity of $10 ms^{-1}$. (Given, $h = 6.626 \times 10^{-34}$ Js)

31. Describe on one method to remove permanent hardness of water.

32. Give one chemical reaction each to show that hydrogen peroxide can act as oxidising as well as reducing agent.

33. Write a short note on Greenhouse effect and global warming.

34. State the point of differences between Classical and photochemical smog.

35. (i) Stability of carbocations follows the order $3° > 2° > °1$. Explain this order of stability of carbocations.

    (ii) In what manner is Electromeric effect different from Inductive effect?

36. (i) Mention the reason of not using Wurtz reaction for the preparation of unsymmetrical alkanes from alkyl halides.

    (ii) How will you convert Benzene to p-Nitrobromobenzene?

37. The density of 3M solution of NaCl is 1.25g/mL. Calculate the molality of the solution. (Given: Atomic masses: Na=23u , Cl=35.5u)

38. Calculate the molarity of nitric acid (HNO_3) in a sample having a density 1.41g/mL and mass percent of nitric acid in it being 69%. (Atomic mass: N=14u, H=1u, O=16u)

39. (i) The ball hit with a hockey by a player does not form a wave. State reason.

    (ii) Write the possible values of 'm' for an electron with l=2.

    (iii) Chromium has configuration $3d^5 4s^1$ and not $3d^4 4s^2$.Explain.

40. (i) Explain non linear shape H_2S and non-planar shape of PCl_3 using VSEPR theory.

    (ii) Can we have a diatomic molecule with its ground state molecular orbitals full with electrons. Give reason for your answer.

41. Calculate enthalpy change for the reaction:

    $$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(l)$$

    The enthalpy of formation of $CH_4(g)$,$CO_2(g)$ and $H_2O(l)$ are $-74.8 kJmol^{-1}$, $-393.5 kJmol^{-1}$ and $285.8 kJmol^{-1}$ respectively.

42. Calculate the bond enthalpy of Cl-Cl bond from the following data:

$CH_4(g) + Cl_2(g) \rightarrow CH_3Cl\ (l) + HCl \quad \Delta H = -100.3 kJmol^{-1}$

Given: bond enthalpies of C — H, C — Cl and H — Cl bonds are 413, 326 and 431 $kJmol^{-1}$ respectively.

43. A neon-dioxygen mixture contains 70.6 g dioxygen and 167.5 g neon. If pressure of the mixture of gases in the cylinder is 25 bar, what is the partial pressure of dioxygen and neon in the mixture? (Atomic mass: O = 16u, Ne = 20u)

44. (i) Compounds of beryllium are much more covalent than other group 2 elements. Give reason.

(ii) Why does the solubility of alkaline earth metal carbonates and sulphates in water decrease down the group?

(iii) When a metal of group 1 is dissolved in liquid ammonia a blue solution is obtained initially. How do you account for the blue colour of the solution?

45. (i) State the necessary compound to be aromatic according to Huckel's rule.

(iii) Explain why alkyl groups act as electron donors when attached to a π system.

46. (i) Draw the resonance structures of Phenol.

(ii) Suggest a method used to purify the liquids which have high boiling points and decompose below their boiling points.

47. (i) Boron trihalides(BX_3) act as Lewis acids. Why?

(ii) Conc. HNO_3 can be transported in aluminium containers. Give reason.

(iii) Pb(IV) is less stable tha Pb(II). Give reason.

(iv) Gallium has higher ionisation enthalpy than aluminium. Why?

(v) What do you understand by diagonal relationship?

48. (i) Why CCl_4 is resistant to hydrolysis but $SiCl_4$ is readily hydrolysed?

(ii) Explain why there is a decrease in ionisation enthalpy from carbon to silicon?

(iii) Boron does not form B^{3+} ion. Give reason.

(iv) How can you explain greater stability of BCl_3 as compared to $TlCl_3$?

(v) Define diagonal relationship between elements in modern period table.

49. (i) Explain common ion effect with example.

(ii) The concentration of hydrogen ion in a sample of soft drink is 4 x 10-3 M. Calculate its pH.

(iii) What is the effect of removal of CH_3OH on the equilibrium of the reaction, $2H_2(g) + CO(g) \rightleftharpoons CH_3OH(g)$.

50. (i) Calculate H_3O^+ ion concentration of a water sample having pH = 6.78.

(ii) Define buffer solutions.

(iii) State Lewis definition of acids and bases. Give one example of each.

51. (i) An alkene A on ozonolysis gives a mixture of propanal and pentan-3-one. Write the structural formula of A.

(ii) Complete the following reactions:

(a) $CH_3CH{=}CH_2 + HBr \xrightarrow{\text{organic peroxide}}$

(b) $CH_3CH_2Br + Na \xrightarrow{\text{Dry Ether}}$

(iii) Write a short note on Friedel Crafts alkylation.

52. (i) Why eclipsed form and staggered form of ethane cannot be isolated at room temperature?

(ii) State Markovnikov's rule.

(iii) Which out of Ethene or Ethyne is more acidic and why?

(iv) What happens with 2-Bromobutane is being treated with KOH (alcoholic)?

****

QUESTION FOR PRACTICES-III

1. Which of the following d-orbital has double disc (body shooter shape)

   (a) d_{xy} (b) d_{z^2} (c) $d_{x^2-y^2}$ (d) d_{yz}

2. Among the following, the compound that contains, ionic, covalent and Co-ordinate linkage is

   (a) NH_4Cl (b) NH_3 (c) NaCl (d) CO_2

3. Which of the following is a state function

   (a) q (b) w (c) q + w (d) None of these

4. Which of the following alkali metal ion has highest ionic mobility

   (a) Li^+ (b) Na^+ (c) k^+ (d) Cs^+

5. The correct order of electron gain enthalpy with negative sign of F, Cl, Br and I having atomic number 9, 17, 35 and 53 respectively is

   (a) I > Br > Ci > F (b) F > Cl > Br > I

   (c) Cl > F > Br > I (d) Br > I > Cl > F

6. Arrange the following carbonations in order of their increasing stability

   $(CH_3)_3C^+$, $CH_3CH_2^+$, $(CH_3)_2CH^+$, CH_3^+

7. The IUPAC name and symbol of element with Z = 120 is __________.

8. Direction for Question No. 9 to 10 : A statement of assertion (A) followed by a statement of Reason (R) is given.

   (i) A and R both are correct, and R is correct explanation of A.

   (ii) A and R both are correct, but R is not correct explanation of A.

   (iii) A is true but R is false.

   (iv) A and R both are false.

9. Assertion (A) : Enthalpy of graphite is lower than that of diamond.

   Reason (R) : Enthalpy of graphite is greater than that of diamond.

10. Assertion (A) : Lower the critical temperature of the gas; more easily can it be liqufied.

    Reason (R) : Critical temperature is the temperature above which a gas cannot be liquefied depending upon the pressure.

11. If ten volumes of dihydrogen gas react with five volumes of dioxygen gas, how much volume of water vapour would be produced?

12. Calculate the number of atoms in 32.0 u of He.

13. Why are alkali metals used in photoelectric cells?

14. Write electronic configuration of Cr^{3+} ion. (Atomic No. of Cr = 24)

15. Draw the shape of ClF_3 molecule according to VSEPR theory?

16. Write the conjugate acid and conjugate base of H_2O.

17. Write the relation between solubility and solubility product of $Cr_2(SO_4)_3$.

18. Consider the given standard reduction potentials of following elements A, B, C & D and arrange them in order of their increasing reducing power.

    A = –3.71V, B = –0.76V, C = +0.34 V, D = +0.80 V

19. Write the cause of temporary and permanent hardness of water.

20. Why do magnesium and beryllium not import colour to the flame in the flame test?

21. Write IUPAC name of $CH_3 — CO — CH_2 — CHO$.

22. Out of Cis-But-2-ene and Trans-but-2-ene which has greater boiling point and why?

23. Define Biochemical oxygen demand.

24. (i) What is the lowest value of n that allows 'g' orbitals to exist?

    (ii) Why 4s orbital is filled before 3d?

25. Calculate wave number for the longest wavelength transition in the Balmer Series of hydrogen atom.

26. Explain why?

    (i) $\Delta_i H_1$ of 'N' is more than that of 'O'.

    (ii) A cation is smaller than parent atom.

27. Balance the following redox reaction in acidic medium by ion electron method.

    $Cr_2O_7^{2-}(aq.) + SO_2(g) \longrightarrow Cr^{3+}(aq.) + SO_4^{2-}(aq.)$

28. Write chemical reactions to justify that H_2O_2 can act as an oxidising as well as reducing agent.

29. (i) What is water gast shift reaction?

    (ii) What do you mean by 20 vol. H_2O_2?

30. In sulphur estimate, 0.157 g of an organic cmpound gave 0.4813 g of barium sulphate. What is the percentage of sulphur in the compound?

31. Write chemical equations to covert:

    (i) Ethyne to Ethanal

    (ii) Benzene to m-Nitrotoluene

32. Define smog. How is classical smog different from photochemical smog?

33. Explain the following terms:

    (a) Green house effect

    (b) Green chemistry

34. Calcium carbonate reacts with aqueous HCl according to the reaction:

    $CaCO_3(s) + 2HCl(aq.) \longrightarrow CaCl_2(aq.) + CO_2(g) + H_2O(l)$

    What mass of CaCO3 is required to react completely with 25 mL of 0.75 M HCl?

35. (i) State Hund's rule of maximum multiplicity of electrons.

    (ii) The mass of an electron is 9.1×10^{-31} kg. If its K.E. 3.0×10^{-25} J, calculate its wavelength.

36. N_2 is diamagnetic while O_2 is paramagnetic. Explain on the basis of molecular orbital theory.

37. Explain the structure of PCl_5 according to hybridization. Why all P — Cl bonds.

38. What will be the pressure exerted by a mixture of 3.2 g of methane and 4.4 g of carbon dioxide contained in 9 dm^2 flask at 27°C.

39. Calculate the compressibility factor for CO_2, if one mole of it occupies 0.4 litre at 300K and 40 atm. Comment on the result.

40. The combustion of 1 mol of benzene takes place at 298K. After combustion CO_2 and H_2O are formed and 3267 kJ mol^{-1}, $\Delta_f H^\ominus(H_2O) = -393$ kJ mol^{-1}.

41. For the reaction : $2A(g) + B(g) \longrightarrow 2D(g)$, $\Delta U^\ominus = -10.5$ kJ and $\Delta S^\circ = -44.1$ J K^{-1}. Calculate ΔG° for the reaction, and predict whether the reaction will occur spontaneously.

42. Complete the following reaction equations:

(i) $Li(NO_3)_2 \xrightarrow{\Delta}$

(ii) $BeCl_2 + LiAlH_4 \xrightarrow{\Delta}$

(iii) $Ca(OH)_2 + Cl_2 \xrightarrow{\Delta}$

43. (i) Out of $NO_2 — CH_2 — O$ and $CH_3 — CH_2 — O^-$ which is more stable and why?

(ii) Why is it necessary to prepare Lassaigne extract for detection of N, S and halogens?

(iii) Define the term hyperconjugation.

44. (i) State Le Chatelier's principle.

(ii) Calculate the pH of 10^{-8} M HCl.

(iii) A sample of HI (g) is placed in flask at a pressure of 0.2 atm. At equalibrium the partial pressure of HI (g) is 0.04 atm. What is the Kp for given equilibrium?

$$2HI\,(g) \rightleftharpoons H_2(g) + I_2(g)$$

45. (i) Define common ion effect.

(ii) Write the relationship between K_p and K_c for the reaction:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(iii) Equal volume of 0.002 M solutions of sodium iodate and cupric chlorate are mixed together. Will it lead to precipitation of copper iodate? (For cupric iodate $K_{sp} = 7.4 \times 10^{-8}$)

46. (i) Draw the structure of Diborane indicating electron precise and electron deficient bonds.

(ii) Give reason for the following :

(a) $PbCl_4$ is powerful oxidising agent.

(b) Fullerenes are the purest allotropes of carbon.

(c) N — N bond dissociation enthalpy is less than P — P bond dissociation enthalpy.

47. (i) What happens when (give chemical equation) :

(a) Borax is heated strongly.

(b) BF_3 is treated with LiH.

(ii) Give reason for the following :

(a) $NaBiO_3$ is good oxidising agent.

(b) Graphite acts as a good lubricant.

(c) Boric and acid is a weak acid.

48. (i) Propanal and pentan-3-one are the ozonolysis product of an alkene. What is the structural formula and IUPAC name of alkene?

(ii) Give the main products of the reactions:

(a) $C_6H_6 + CH_3Cl \xrightarrow{\text{Anhydrous } AlCl_3}$

(b) $CH_3Cl + Na \xrightarrow{\text{Dry ether}}$

(c) $CH_3 - CHCl - CH_2 - CH_3 + KOH(alc.) \longrightarrow$

49. (i) Give chemical euqation for each of the following :

(a) Decarboxylation

(b) Friedel Craft acetylation

(ii) Addition of HBr to propene yields 2-Bromopropane, while in the presence of benzoyl peroxide, the same reaction yields 1-Bromopropane. Explain and give mechanism.

****

QUESTION FOR PRACTICES-IV

1. Number of matamers possible for molecular formula C_4H_{10} are ________.

2. Among the following, the least thermally stable is ?

   (a) K_2CO_3 (b) Li_2CO_3

   (c) Na_2CO_3 (d) Rb_2CO_3

3. Van der waals constant is a maximum for

   (a) He (b) Ne

   (c) Ar (d) Kr

4. Orbital which is not possible

   (a) 2p (b) 3d

   (c) 3s (d) 3f

5. Which of the following is paramagnetic

   (a) CO (b) O^-_2

   (c) N_2 (d) NO^+

6. Which of the following is not correct?

   (a) ΔG is zero for a reversible reaction.

   (b) ΔG is positive for a spontaneous reaction.

   (c) ΔG is negative for a spontaneous reaction.

   (d) ΔG is positive for a non-spontaneous reaction.

   Direction for Question No. 7 and 8 :

   (i) If both assertion & reason are true and the reason is the correct explanation of the assertion.

   (ii) If both assertion & reason are true but the reason is the correct explanation of the assertion.

   (iii) If assertion is true statement but reason is false.

   (iv) If both assertion and reason are false statements.

7. Assertion : Number of orbitals in 3rd shell is 9.

   Reason : Number of orbitals for a particular value of $n = n^2$.

8. Assertion : Ionic radius of Na^+ is smaller than Na.

   Reason : Effective nuclear charge of Na^+ is higher than Na.

9. What is the IUPAC name of picric acid.

10. Why noble gases have positive electron gain enthalpy?

11. How many molecules of SO_2 are present in 11.2 L at STP?

12. Calculate the number of atoms in 35 g of Li (Atomic mass of Li = 7 u).

13. For an isolated system, $\Delta U = 0$, what will be ΔS ?

14. Write the statement of third law of thermodynamics.

15. Calculate the number of sigma and pie bonds in C_2H_2?

16. Give the relation between K_a and K_b.

17. Write the conjugate base of H_2CO_3.

18. Write the oxidation number of Cr in $K_2Cr_2O_7$.

19. Write the stock notation MnO_2.

20. Give an example of electron deficient covalent hydride.

21. Name the isotope of hydrogen which is radioactive in nature.

22. Potassium carbonate cannot be prepared by solvay process. Why?

23. Define the Boyle temperature or Boyle point.

24. Out of staggered and eclipsed form which is more stable and why?

25. What is the meaning of the term eutrophication with regards to water pollution.

26. Explain why :
    (a) The three electron present in 2p subshell of nitrogen remain upaired.
    (b) Cr has configuration $3d^5\,4s^1$ and not $3d^4\,4s^2$.

27. Calculate the radius of Bohr's fifth orbit for hydrogen atom.

28. (a) Show by a chemical reaction with water that Na_2O is a basic oxide and Cl_2O_7 is an acidic oxide.
    (b) Name a species that will be isoelectronic with each of the following atoms or ions, (i) F^- (ii) Ca^{2+}

29. Balance the following redox reaction in acidic medium

$$MnO_4^- + H^+ + Fe^{2+} \longrightarrow Mn^{2+} + H_2O + Fe^{3+}.$$

30. What do you understand by the terms :

(i) Syn gas

(ii) Hydrogen economy

31. What causes the temporary and permanent harness of water?

32. 0.40 g of an organic compound gave 0.3 g of silver bromide of Carius method. Find the percentage of bromine in the compound. [Atomic mass of Ag & Br are 105 and 80 u]

33. Propanal and pentan-3-one ate the ozonolysis product of an alkene. What is the structural formula of alkene?

34. Convert the following :

(a) 1-Bromopropane to 2-Bromopropane

(b) Ethanol to Glycol

35. Explain the following terms :

(a) Acid Rain (b) Global warming

36. What are the reactions involved for ozone layer depletion in the stratosphere?

(a) Green house effect (b) Green chemistry

37. In a compound $C_xH_yO_z$, the mass % of C and H is 6 : 1 and the amount of oxygen present is equal to the half of the oxygen required to react completely C_xH_y. Find the empirical formula of the compound.

38. When light with a wavelength of 400 nm falls on the surface of sodium, electrons with a kinetic energy of 1.05×10^5 J mol^{-1} are emitted.

(a) What is the minimum energy needed to remove on electron from sodium?

(b) What is the maximum wavelength of light that will cause a photoelectrons to be emitted?

39. (a) Describe the hybridisation in case of C_2H_2.

(b) Which out of NH_3 and NF_3 has higher dipole moment and why?

40. (a) Use molecular orbital theory to predict why the He_2 molecule does not exist?

(b) Compare the stability of O_2 and O_2^+ on the basis of molecular theory.

41. Pressure of one gram of an ideal gas A at 27°C is found to be 2 bar. When 2g of another gas (ideal) B is introduced in the same flask at the same temperature the pressure become 3 bar. Find a relationship between their molecular masses.

42. Explain the following terms :

(a) Dalton's law of partial pressure

(b) Surface tension

(c) Coefficient of viscosity

43. The standard enthalpy of combustion of Surcose ($C_{12}H_{32}O_{11}$) at 298 K producing $CO_2(g)$ and $H_2O(l)$ is –5200.7 kJ mol^{-1}. If $\Delta_fH°$ of $CO_2(g)$ and $H_2O(l)$ are –393.0 kJ mol^{-1} and –286 kJ mol^{-1}.

44. Explain the First law of thermodynamics and how can you prove the following relation :

$\Delta H = \Delta U + P\,\Delta V$ from the first law of the thermodynamics ($\Delta U = q + w$)?

45. Assign reason for the following :

(a) Potassium carbonate cannot be prepared by solvay process.

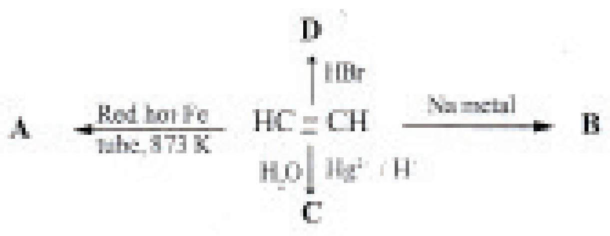
(b) Be and Mg do not give characteristics colour to the flame.

(c) Alkali metals are strong reducing agent.

46. Explain the resonance effect and draw the resonance structures of $CH_2 = CH — CHO$. Indicate the relative stability of the contributing structures.

47. (a) Addition of HBr to propene yields-2-bromopropane, while in the presence of benzoylperoxide, the same reaction yields 1-bromopropane. Explain and give tis mechanism.

(b) Identify A, B, C & D



(c) Give a chemical test between ethen and ethane.

48. (a) Out of benzene and toluene, which will undergo nitration more easily and why?

(b) Explain the following :

(i) Friedal - Craft reaction

(ii) Wurtz reaction

49. (a) What is solubility product? How is it different from ionic product?

(b) Equal volume of 0.02 M solutions of sodium iodate and cupric chlorate are mixed together. Will it lead to precipitation of copper iodate? (For cupric iodate Ksp = 7.4×10^{-8}).

50. (a) Define Le-Chatelier principle.

(b) Explain ionic product of water. What is the effect of temperature on ionic product of water?

(c) Calculate the pH of 10^{-10} M NaOH solution.

51. (a) Draw the structure of diborane.

(b) Explain the following reactions :

(i) Silicon is heated with methyl chloride at high temperature in the presence of Cu.

(ii) Hydrate alumina is treated with aqueous NaOH solution.

52. (a) What are silicons. If the starting material for the manufacture of silicons is $RSiCl_3$, write the structure of the product formed.

(b) Complete the following reactions :

(i) $B_2H_6 + NH_3 \longrightarrow$ (ii) $H_3BO_3 + H_2O \longrightarrow$

(c) Explain Inert pair effect.

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SAMPLE PAPER– I
CLASS - XI
CHEMISTRY THEORY (043)

Time: 3 Hours — Max. Marks : 70

General Instructions:

Read the following instructions carefully.

a) There are 33 questions in this question paper. All questions are compulsory.

b) Section A: Q. No. 1 to 16 are objective type questions. Q. No. 1 and 2 are passage based questions carrying 4 marks each while Q. No. 3 to 16 carry 1 mark each.

c) Section B: Q. No. 17 to 25 are short answer questions and carry 2 marks each.

d) Section C: Q. No. 26 to 30 are short answer questions and carry 3 marks each.

e) Section D: Q. No. 31 to 33 are long answer questions carrying 5 marks each.

f) There is no overall choice. However, internal choices have been provided.

g) Use of calculators and log tables is not permitted.

SECTION A (OBJECTIVE TYPE)

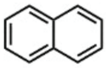
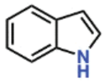
1. Read the passage given below and answer the following questions: [1×4 = 4)]

A research group from Japan has made a <u>substituted naphthalene that contains the most twisted benzene rings ever synthesised.</u> According to Erich Hückel's 1931 rule, a molecule can only be aromatic if it has a certain number of p electrons that are delocalised around a planar ring. However, researchers have been pushing this rule to the limit by synthesising sterically hindered systems that twist aromatic rings out of planarity. Having previously discovered how to easily synthesise non-planar aromatics, Kenichiro Itami and his Nagoya University team were exploring helical molecules by fusing various aromatic rings to a central naphthalene core. When one of their reactions didn't go as planned, they found that they had made a new propeller-shaped molecule that inter converted into a twisted saddle-shaped stereoisomer when heated. With an almost 36° twist angle, this isomer's central benzene rings have a 6° higher twist angle than the previous record holder .By studying distorted aromatic systems the team hopes to ultimately develop new functional materials.

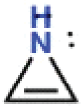
References :T Fujikawa, Y Segawa and K Itami, J. Am. Chem. Soc., 2016, 138, 3587 (DOI: 10.1021/jacs.6b01303)

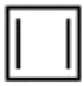
The following questions are multiple choice questions. Choose the most appropriate answer:

(I) Among the following molecule the one which is not aromatic is

A)  B)  C)  D) 

(II) Which of the following molecule is Non-Aromatic

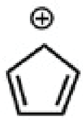
A) 

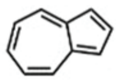
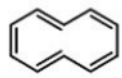
B)  C) 

D) 

OR

Which of the following molecule is Aromatic in nature

A)  B) 

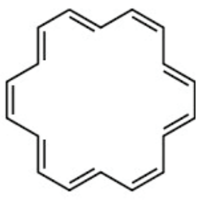
C)  D) 

(III) Condition not required for the molecule to be aromatic is

A) $4n+2$ π electrons B) Cyclic

C) Conjugated system D) Planar

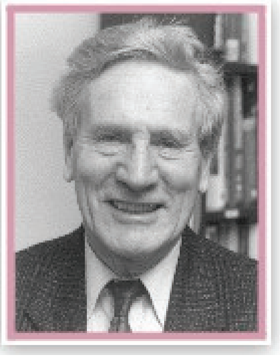
(IV) The compound Cyclooctadecanonaene nature is



A) Aromatic B) Anitaromatic

C) Non-Aromatic D) Cannot be predicted

2. **Read the passage given below and answer the following questions: (1x4=4)**



Ronald J. Gillespie **Sir Ronald Sydney Nyholm.**

The Valence Shell Electron Pair Repulsion Theory :Sidgwick and Powell in 1940, proposed a simple theory based on the repulsive interactions of the electron pairs in the valence shell of the atoms. It was further developed and redefined by Nyholm and Gillespie(1957) and they put forward the concept of important difference of lone pair and the bonding pairs of electrons. While the lone pairs are localized on the central atom, each bonded pair is shared between two atoms. In the molecule the bond pair, lone pairs (if any)will occupy such position around the central atom to obtained a minimum repulsion energy states. These repulsions effects result in deviation from idealized shapes and alteration in bond angles in molecules

In these questions (Q. No V-VIII , a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement.

(V) Assertion : The shape of NH_3 is pyramidal

Reason : NH_3 contain one lone pair and three bond pair.

(VI) Assertion :The XeF_4 molecule is tetrahedral in nature

Reason :The XeF_4 molecule has F-Xe-F bond angle as 90^0

(VII) Assertion : The central bond angle in Water is less than that of Methane.

Reason : Water molecule contain Hydrogen bonding but Methane do not.

(VIII) Assertion : The shape of XeF_6 is distorted octahedral

Reason : The XeF_6 molecule has zero lone pair and 6 bond pair.

OR

Assertion : The shape of I_3^- is linear

Reason : The lone pairs occupy the equatorial position in I_3^-.

Following questions (No. 3 -11) are multiple choice questions carrying 1 mark each

3. Which of the following option has incorrect UNIT

S.No	PARAMETER	UNIT
1	Frequency	Hz
2	Wavelength	cm^{-1}
3	Energy	eV
4	Wave number	cm^{-1}

A) Frequency B) Wavelength

C) Energy D) Wave number

4. Which of the following group has +R effect and –I effect

A) $-CH_3$ B) –H

C) $-NH_3^+$ D) –F

OR

Among the following group, the group having highest priority in IUPAC nomenclature scheme is :

A) –F B) $-OCH_3$

C) $-CH_3$ D) –COOH

5. The correction factor ‘a’ in Vander Waal equation stands for

A) Volume B) Pressure

C) Temperature D) Moles

6. Which of the following molecule has coordinate bond

A) CH_4. B) H_2O

C) CO_2 D) NH_4^+

OR

Which molecule has zero dipole moment?

A) AMMONIA (NH_3) B) WATER

C) CO_2 D) $CHCl_3$

7. Which of the following form is most stable for Butane

A) Fully Staggered B) Staggered

C) Eclipsed D) Fully Eclipsed

OR

IUPAC name of product formed by oxidation using heated alkaline $KMnO_4$ followed by acidification of 1,2 Dimethylbenzene is

A) 1,2 DihydroxyBenzene B) 1,2 Diethylbezene

C) Benzene 1,2 Dicarboxylic Acid D) 2-MethylBenzoic Acid

8. Which of the following element has highest electronegativity

A) I B) Br

C) Cl D) F

OR

Which block element forms the Ionic bond type compounds mainly

A) 's' B) 'p'

C) 'd' D) 'f'

9. Which of the compound is not used to remove permanent hardness

A) Lime B) Na_2CO_3

C) CALGON D) ZEOLITE

10. Select the incorrect statement for the Benzene structure

A) C-C bond length is 139 pm

B) π electron is delocalized above and below the benzene ring

C) All the carbon atom are 'sp' hybridised

D) All C-H bond are in the same plane.

11. Which of the following is heavier in weight

A) 2g He B) 22.4 L at STP- He

C) 20 moles H_2 D) 10 Moles N_2

In the following questions (Q. No. 12 - 16) a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement.

12. Assertion : Benzene is Non-Aromatic compound

Reason : Compound which follows Huckel's rule are Aromatic in nature

13. Assertion : Boric acid is a weak acid

Reason : It releases its H^+ with difficulty.

14. Assertion : NH_3 is a Lewis Base

Reason : NH_3 molecule is pyramidal in shape.

OR

Assertion: CO molecule can act as poisonous gas

Reason : CO molecule can bind with metal

15. Assertion: Cis-But-2-ene is more polar than Trans-But-2-ene.

Reason :Trans-But-2-ene has higher melting point than Cis-2-But-2-ene.

16. Assertion : CH_4 can be prepared by Kolbe's electrolytic process

Reason : Even number alkane can be prepared in Kolbe's Electrolytic process generally.

SECTION-B

The following questions, Q.No. 17 – 25 are short answer type and carry 2 marks each.

17. Answer the following :

a) Draw the Newman and Sawhorse structure of Butan-2-ol

b) Illustrate with the help of one chemical test how you will distinguish between ethene and ethane

OR

Explain the following :

(i) Kolbe's Electrolysis

(ii) Wurtz Reaction

18. (i) Arrange the following type of radiations in increasing order of frequency

Radiation from microwave oven, Amber light from traffic signal, Cosmic rays from outer space, X- Ray, Radiation from FM radio

(ii) How many electrons in an atom of Na (Z=11) have $n=2, l=1, m_l=0, m_s=+1/2$

19. Answer the following :

(i) Draw the shape of (a) ClF_3 (b) XeF_4

(ii) Why He_2 does not exist, give reason based on Molecular Orbital Theory

OR

(i)Explain why O_2 is paramagnetic on the basis of Molecular Orbital Theory. (ii)Why H_2O is liquid but H_2S is gas.

20. The uncertainity in the momentum of a particle is 2.5×10^{-14} $gcms^{-1}$, with what accuracy can its position be determined ? ($h=6.25 \times 10^{-27}$ gcm^2s^{-1})

OR

What will be the wavelength of the emitted radiations when an electron jumps from a third orbit to a first orbit in a hydrogen atom ? Rydberg constant,R=109677 cm^{-1}.

21. The molar heats of combustions of $C_2H_2(g)$, C(Graphite) and $H_2(g)$ are 310.62kcal, 94.05 kcal and 68.32 kcal respectively. Calculate the standard heat of formation of $C_2H_2(g)$.

22. Explain with the help of reactions how the presence of 'N' can be detected by 'Lassaigne's Test'

23. Balance the following redox reaction by ion-electron or oxidation number method.

$MnO_4^-(aq.) + I^-(aq.) \rightarrow MnO_2(s) + I_2(s)$ (Basic medium)

24. Explain the following reaction with the help of suitable example

A) Hydrogenation of Alkene

B) Dehalogenation Reaction

25. Explain the effect of following on the reaction $N_2(gas) + 3H_2(gas) \rightleftharpoons 2NH_3(gas)$

(a) Addition of HCl(gas)

(b) Addition of NH_3 gas

SECTION-C

Q.No. 26-30 are Short Answer Type II carrying 3 mark each.

26. Arrange the following :

(a) CaH_2,BeH_2 and TiH_2 in order of increasing electrical conductance

(b) LiH, NaH and CsH in order of increasing ionic character

(c) H-H,D-D and F-F in order of increasing bond dissociation enthalpy.

OR

Arrange the following :

(a) F, Cl, Br, I in order of increasing electronegativity

(b) Al^{3+}, Mg^{2+}, Na^{+}, F^{-} in order of increasing ionic size.

(c) Be, B, C, N , O in order of increasing ionization potential.

27. Arrange the following in increasing order of property specified:

(a) CH_2=CH_2, CH_3CH=CH_2, CH_3CH=$CHCH_3$ in order of increasing rate of reaction with HBr.

(b) Cl_3CCOOH,$Cl_2CHCOOH$,$ClCH_2COOH$ in increasing order of acidic strength.

(c) 1-MethylBenzene, Anisole, Acetophenone increasing rate of Electrophilic Aromatic chlorination subsitition reaction.

OR

A hydrocarbon 'A', adds one mole of hydrogen in presence of Platinum catalyst to form n-Hexane. When 'A' is oxidized vigorously with $KMnO_4$, a single carboxylic acid containing three carbon atoms is isolated. Give the structure of A and write the reaction involved.

28. At a certain temperature the equilibrium constant (K) is 16 for the reaction

$$SO_2(g) + NO_2(g). \rightleftharpoons SO_3(g) + NO(g)$$

If the container contain 1M concentration of each component initially, then what is the concentration of SO_2 at the equilibrium.

29. Which of the following compound will shows geometrical isomerism. Write the 'cis' and 'trans' form (if exist) for the compound.

a) Propene b) But-2-ene c) 1, 2 Dichloroethene

30. What happens when

(a) Magnesium is burnt in air

(b) Quick lime is heated with silica

(c) Calcium Nitrate is heated

SECTION-D

Q.No. 31 to 33 are long answer type carrying 5 marks each.

31. (a) Explain the hybridization in PCl_5. Why PCl_5 has two types of bond length. **(2+3)**

(b) Calcium burns in nitrogen to produce a white powder which dissolves in sufficient water to produce a gas (A) and an alkaline solution. The solution on exposure to air produces a thin solid layer of (B) on the surface. Identify the compound 'A' and 'B'

OR

(i) Answer the following questions: **(2+3)**

(a) Which one BCl_3 or $TlCl_3$ is more stable and why ?

(b) Why Zn, Cd & Hg are not referred as transition elements ?

(ii) When a metal 'X' is treated with sodium hydroxide, a white precipitate [A] is obtained, which is soluble in excess of NaOH to give soluble complex [B].Compound [A] is soluble in dilute HCl to form compound [C]. The compound [A] when heated strongly gives [D], which is used to extract metal. Identify [X], [A],[B],[C] and [D]. Write suitable equations to support their identities.

32. One mole of a hydrocarbon [A] reacts with 1 mole of bromine giving a dibromo compound[B], $C_5H_{10}Br_2$. Compound [A] on treatment with cold dilute alkaline $KMnO_4$ solution forms a compound,[C] $C_5H_{12}O_2$. On Ozonolysis, [A] gives equimolar quantities of CH_3COCH_3- propanone and ethanal –CH_3CHO.Deduce the structure of [A] and write the corresponding reactions. **(5)**

OR

Give answer of following :

(i) (a) Give the stability order of the following carbocation :

$(CH_3)_3C^+$, $(CH_3)_2HC^+$, $(CH_3)\ H_2C^+$, CH_3^+

(b) Out of Benzene, m- Dinitrobenzene ,toluene which will undergoes nitration most easily and why ? (ii) Explain the Markovnikov Rule with the help of one example and relevant mechanism.

33. (a) What is an empirical formula?

(b)A compound containing sodium ,sulphur,hydrogen and oxygen gave the following results on analysis : Na= 14.28%, S=9.92 %, H=6.20%. Calculate the molecular formula of the anhydrous compound. If Hydrogen and Oxygen are present in the form of water of crystallization only, what is the structure of the crystalline salt ?(Molecular Weight of Crystalline Salt =322) **(1+4)**

OR

(a) Define Enthalpy of formation with one example.

(b) Calculate the C-C bond energy from the following data :

2C(Graphite) + $3H_2(g) \rightarrow C_2H_6(g)$, ΔH= -84.67kJ ------equation-1

C(Graphite)$\rightarrow$C(gas), ΔH=716.7 kJ -------equation-2

H_2(gas)$\rightarrow$2H(gas), ΔH= 435.9 kJ ---------equation-3

Assume C-H bond energy is 416 kJ **(1+4)**

ANSWER

1. I-D,II-C Or C III-D IV-A

2. V-A,VI-D, VII-B,VIII-C Or A

3. B

4. D or D

5. B

6. D or C

7. A or C

8. D or A

9. A

10. C

11. D

12. D

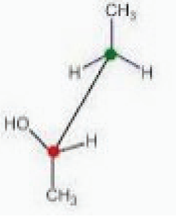
13.C

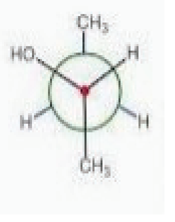
14.B or A

15.B

16.D

17.

a- Sawhorse: 

Newman : 

b- Ethene decolourise the red liquid Br_2 due to double bond and Ethane does not decolorize Br_2

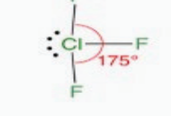
OR

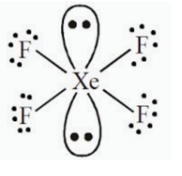
(a) Kolbe's Electrolytic Process: Sodium salt of carboxylic acid is electrolysed to form hydrocarbon containing even number of carbon atom. Hydrogen gas is released at cathode.

(b) Wurtz Reaction: Alkyl halid on reaction with Na in presence of Dry ether produce hydrocarbon containing double number of carbon atom as are present in parent alkyl halide.

18.(i)Cosmic rays<X-Rays<Amber colour<microwaves<radiation from FM radio.(ii)1

19.(i)

(a) ClF_3 

(b) XeF_4 

(ii) Due to zero bond order

Or

(i) O_2 is paramagnetic as it contains unpaired electron in pie antibonding molecular orbital.

(ii) Due to hydrogen bonding in H_2O which results large association of water molecules together but in H_2S there is no hydrogen bonding.

20. $\Delta x=[h/(4x3.14)]/\Delta v=2.11x10^{-14}cm$ Or $[1/\lambda]= 109737\ [1/n_1^2 - 1/n_2^2]$ $n_1=1$, $n_2=3$, $\lambda=1.025x10^{-5}cm$.

21. $\Delta H=2x(-94.05)+ (-68.32)-(-310.62)=54.20kcal$

22. $Na + C+N + Heat \rightarrow NaCN$

$6CN^- + Fe^{2+} \rightarrow [Fe(CN)_6]^{4-}$

$3[Fe(CN)_6]^{4-} + 4Fe^{3+} \rightarrow Fe_4[Fe(CN)_6]_3.x\ H_2O$(Prussian Blue)

23. $2MnO_4^-(aq.) +6\ I^-(aq.)+ 4H_2O \rightarrow 2MnO_2(s) + 3I_2(s) +8OH^-$ (Basic medium).

24. (A)Hydrogenation of Alkene: When alkene are subjected to react with hydrogen gas in the presence of the catalyst such Ni, then alkane are produced.

$CH_2=CH_2 + H_2 + CATALYST \rightarrow C_2H_6$

B) Dehalogenation Reaction: When vicinal dihalides are treated with zinc metal, lose a molecule of ZnX_2 to form alkene e.g $CH_2Br\text{-}CH_2Br + Zn \rightarrow CH_2=CH_2 + ZnBr_2$

25. (A) Addition of HCl gas ,cause forward reaction as HCl will react with NH_3 to form white fumes of NH_4Cl and hence according to Le Chatelier principle reactions will move in forward direction.

(B) Addition of NH_3 will result backward direction for the equilibrium reaction as it will result more consumption of the Ammonia gas added at equilibrium.

26. (a) $CaH_2 < BeH_2 < TiH_2$ order of increasing electrical conductance

(b)LiH < NaH < CsH order of increasing ionic character

(c) H-H < D-D < F-F order of increasing bond dissociation enthalpy.

OR

(a)I < Br < Cl < F order of increasing electronegativity (b)$Al^{3+} < Mg^{2+} < Na^+ < F^-$ order of increasing ionic size. (c)B < Be < C < O < N order of increasing ionization potential.

27. (a) $CH_2=CH_2$,$CH_3CH=CH_2$,$CH_3CH=CHCH_3$ order of increasing rate of reaction with HBr. (b)$ClCH_2COOH < Cl_2CHCOOH < Cl_3CCOOH$ increasing order of acidic strength

(c) Acetophenone < 1-MethylBenzene < Anisole, increasing rate of Electrophilic Aromatic chlorination substitution reaction.

OR

'A' is Hex-3-ene and

'A'+ $H_2 \rightarrow$ Propane

'A'+ $KMnO_4$+ Heat $\rightarrow$ Propanoic Acid

28. $SO_2(g) + NO_2(g) \rightleftharpoons SO_3(g) + NO(g)$

t=0	1	1	1	1
$t=t_{eq}$	1-x	1-x	1+x	1+x

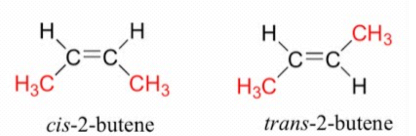
Therefore $K=16=[1+x]^2/[1-x]^2$

Or $4=[1+x]/[1-x]$ Therefore $x=0.6$ Hence $[SO_2]=1-0.6=0.4$ moles/Litre

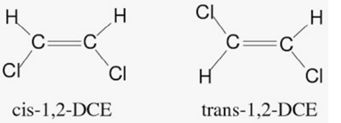
29. $CH_3CH=CH_2$, Propene will not shows geometrical isomerism

$CH_3CH=CHCH_3$, But-2-ene will shows geometrical isomerism

$CHCl=CHCl$, 1,2 Dicholoroethene will shows geometrical isomerism.



cis-2-butene *trans*-2-butene



cis-1,2-DCE trans-1,2-DCE

30. (a) $2Mg + O_2 \rightarrow 2MgO$

(b) $CaO + SiO_2 \rightarrow CaSiO_3$

(c) $2Ca(NO_3)_2 \rightarrow 2CaO + 4NO_2 + O_2$

31. (a) PCl_5 has sp^3d hybridization. As the axial bond pairs suffer more repulsive interaction from the equatorial bond pairs, therefore axial bonds have been found to be slightly longer and hence slightly weaker than the equatorial bonds, which makes PCl_5 more reactive

(b) $2Ca + O_2 + Heat \rightarrow 2CaO$, $3Ca + N_2 + Heat \rightarrow Ca_3N_2$

$Ca_3N_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2NH_3(A)$

$Ca(OH)_2 + CO_2 \rightarrow CaCO_3[B\text{-White}] + H_2O$

OR

(i)-(a) BCl_3, due to inert pair effect.

(b) As Zn,Cd and Hg do not have partially filled 'd' orbital in their ground state as well as in common oxidation states.

(ii) X-Al, A- $Al(OH)_3$, B-$Na[Al(OH)_4]$, C-$AlCl_3$, D-Al_2O_3

32. [A] = $CH_3CH{=}C(CH_3)_2$ [B] = $CH_3CHBr{-}CBr(CH_3)_2$ [C] = $CH_3CH(OH){-}C(OH)(CH_3)_2$

OR

(i) (a) $(CH_3)_3C^+ > (CH_3)_2HC^+ > (CH_3)H_2C^+ > CH_3^+$

(b) Toluene > Benzene > m-Dinitrobenzene

(ii) $CH_3CH{=}CH_2 + HBr \rightarrow CH_3CH(Br){-}CH_3$ (Major)+ $CH_3CH_2{-}CH_2Br$(Minor)

33. (a) Empirical formula is the shortest formula of the compound without considering its bonding aspect. It may or may not be same as Molecular formula of a substance.

(b) Empirical formula : $Na_2SH_{20}O_{14}$, Molecular Formula : $Na_2SO_4.10H_2O$

OR

(a) The standard enthalpy change for the formation of one mole of a compound from its element in their most stable states of aggregation.

(b) 2Xequ (ii) + 3Xequ (iii)- equ (i) give ΔH=2825.77 kJ for the reaction $C_2H_6(g) \rightarrow 2C(g) + 6H(g)$

Let 'x' is the C-C bond energy then 'x' + 6 BE(C-H)=2825.77 and hence BE (C-C)=329.77 kJ

SAMPLE PAPER– II
CLASS - XI
Sub. : CHEMISTRY

Time: 3 Hours | Max. Marks : 70

General Instructions:

i) There are 33 questions in this question paper. All questions are compulsory.

ii) Section A : Q. No. 1-2 are case-based questions having four MCQs or Assertion-Reason type based on given passage each carrying 1 mark and Questions 3 to 16 are MCQs and Assertion-Reason type questions carrying 1 mark each.

iii) Section B: Q. No. 17 to 25 are short answer type I questions and carry 2 marks each.

iv) Section C: Q. No. 26 to 30 are short answer type II questions and carry 3 marks each.

v) Section D: Q. No. 31 to 33 are long answer questions carrying 5 marks each.

vi) There is no overall choice. However, internal choices have been provided.

vii) Use of calculators and log tables is not permitted.

SECTION-A
(OBJECTIVE QUESTIONS)

Passage Based Questions : (1x4=4)

1. Read the passage given below and answer the following questions :

Gases are complicated. They are full of billions and billions of energetic gas molecules that can collide and possibly interact with each other. Since, it's hard to exactly describe a real gas, people created the concept of an ideal gas as an approximation that helps us model and predict the behaviour of real gases. The term ideal gas refers to a hypothetical gas composed of molecules. Ideal gas molecules do not attract or repel each other. The only interaction between ideal gas molecules would be an elastic collision upon impact with each other or an elastic collision with the walls of the container.

Ideal gas molecules themselves take up no volume. The gas takes up volume since the molecules expand into a large region of space, but the ideal gas molecules are approximated as point particles that have no volume in and of themselves. If this sounds too ideal to be true, you're right. There are no gases that are exactly ideal, but there are plenty of gases that are close enough that the concept of an ideal gas is an extremely useful approximation for many situations. Infect, for temperatures near room temperature and pressures near atmospheric pressure, many of the gases we care about are very nearly ideal. If the pressure of the gas is too large (e.g. hundreds of times larger than atmospheric pressure), or the temperature is too low. There can be significant deviations from the ideal gas law :

An ideal gas is defined as one in which all collisions between atoms or molecules are perfectly elastic and in which there are no intermolecular attractive forces. An ideal gas can be characterized by three state variables: absolute pressure (p), volume (V) and absolute temperature (T).

The relationship between them may be deduced from kinetic theory and is called the Ideal gas law : $pV = nRT = NkT$

- n = number of moles
- R = universal gas constant = 8.3145 J/mol K
- N = number of molecules
- k = Boltzmann constant = 1.38066×10^{-23} J/K = 8.617385×10^{-5} eV/K
- $k = R / N_A$
- N_A = Avogadro's number = 6.0221×10^{23} /mol

The following question (i-iv) are multiple choice questions. Choose the most appropriate answers :

(i) Which of the following shows relationship between Boyle's law and Charles' law?

(a) $\frac{P_1}{P_2} = \frac{T_1}{T_2}$ (b) $pV = K$

(c) $\frac{P_2}{P_1} = \frac{V_1}{V_2}$ (d) $\frac{V_2}{V_1} = \frac{P_1}{P_2} \times \frac{T_2}{T_1}$

(ii) The molar volume of CO_2 is maximum at

(a) NTP (b) 0°C and 2 atm

(c) 127°C and 1 atm (d) 273°C and 2 atm

(iii) The gas constant R is a constant.

(a) Only for real gases (b) Only for ideal gases

(c) Both for real and ideal gases (d) Neither real not ideal gas

(iv) In a closed flask of 5 L, 1.0 g of H_2 is heated from 300 to 600 K. Which statement is not correct?

(a) Pressure of the gas increases

(b) The rate of collision increases

(c) The number of moles of gas increases

(d) The energy of gaseous molecules increases

Or

Which of the following expression represents correctly the variation of density of an ideal gas with change in temperature?

(a) $d_2 = \frac{P_2 T_1 d_1}{p_1 T_2}$ (b) $d_2 = \frac{d_1 T_1}{T_2}$

(c) $d_2 = \frac{d_1 T_2}{T_1}$ (d) $d_2 = \frac{d_1 p_2 T_2}{P_1 T_1}$

2. Read the passage given below and answer the following questions : (1×4=4)

Thermodynamics is science of the relationship between heat work, temperature and energy. In broad terms, thermodynamics deals with the transfer of energy from one place to another and from one form to another. The key concept is that heat is a form of energy corresponding to a definite amount of mechanical work.

Heat was not formally recognised as a form of energy until about 1798, when Count Rumford (Sir Benjamin Thompson), a British military engineer, noticed that limitless amounts of heat could be generated in the boring of cannon barrels and that the amount of heat generated is proportional to the work done in turning a blunt boring tool.

Rumford's observation of the proportionality between heat generated and work done lies at the foundation of thermodynamics.

The zeroth law of thermodynamics, states that when two systems are each in thermal equilibrium with a third system, the first two systems are in thermal equilibrium with each other.

This property makes it meaningful to use thermometers as the "third system" and to define a temperature scale. The first law of thermodynamics, or the law of conservation of energy states that, the change in a system's internal energy is equal to the difference between heat added to the system from its surroundings and work done by the system on its surroundings.

Heat does not flow spontaneously from a colder region to a hotter region, or equivalently, heat at a given temperature cannot be converted entirely into work. Consequently, the entropy of a closed system, or heat energy per unit temperature, increase over time toward some maximum value.

Thus, all closed systems tend toward an equilibrium state in which entropy is at a maximum and no energy is available to do useful work.

The entropy of a perfect crystal of an element in its most stable form tends to zero as the temperature approaches absolute zero.

This allows an absolute scale for entropy to be established that, from a statistical point of view, determines the degree of randomness or disorder in a system.

MULTIPLE CHOICE QUESTION

Following questions (No. 3-11) are Multiple Choice Questions carrying 1 mark each.

3. The given reaction $x + e^- \rightarrow x^-$ (g) is an example of

   (a) Electron gain enthalpy (b) Electron loss enthalpy

   (c) Ionisation enthalpy (d) Both (a) and (c)

4. Ethylene reacts with HBr to form

   (a) Ethyl bromide (b) Methyl bromide

   (c) Ethylene bromide (d) ethylidene bromide

5. Chlorination of methane gives chloromethane and

   (a) Hydrogen gas (b) Ethane

   (c) Ethene (d) Hydrogen chloride

6. Only series of lines which appear in the visible region of the electromagnetic spectrum of hydrogen

   (a) Lyman series (b) Balmer series

   (c) Paschen series (d) P fund series

7. The correct order of increasing covalent character of the following is :

   (a) $SiCl_4 < AlCl_3 < MgCl_2 < NaCl$

   (b) $NaCl < MgCl_2 < AlCl_3 < SiCl_4$

   (c) $AlCl_3 < MgCl_2 < NaCl < SiCl_4$

8. A process will be Spontaneous at all temperature if

(a) $\Delta H > O$ and $\Delta S < O$ (b) $\Delta H < O$ and $\Delta S > O$

(c) $\Delta H < O$ and $\Delta S < O$ (d) $\Delta H > O$ and $\Delta S > O$

9. Which of the following oxides is strongly basic

(a) B_2O_3 (b) Al_2O_3

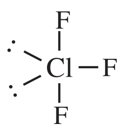
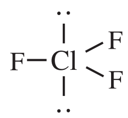
(c) Ga_2O_3 (d) Tl_2O

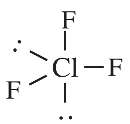
10. The correct band order in the following species are

(a) $O_2^{2+} > O_2^{+} > O_2^{-}$ (b) $O_2^{2+} < O_2^{-} < O_2^{+}$

(c) $O_2^{+} > O_2^{-} < O_2^{2+}$ (d) $O_2^{-} < O_2^{+} > O_2^{2+}$

11. Which of the following structures is most stable for ClF_3

(a)  (b) 

(c)  (d) All the three structure

Assertion-Reason

In the following questions (Q. No. 12-16) a statement of Assertion followed by a statement of Reason is given. Choose the correct answer out of the following choices.

(a) Assertion and Reason both are correct statement and Reason is correct explanation for Assertion.

(b) Assertion and Reason both are correct statement but Reason is not correct explanation for Assertion.

(c) Assertion is correct statement but Reason is incorrect statement.

(d) Assertion is incorrect statement but Reason is correct statement.

12. **Assertion :** Electromagnetic waves can move in vacuum.

Reason : They do not require medium to propagate.

13. **Assertion :** Among isomeric pentanes, 2, 2-dimethylpentane has the lowest boiling point.

Reason : Branching in hydrocarbon does not affect the boiling point.

14. **Assertion :** Molality of a solution does not change with temperature.

Reason : Mass is affected with temperature.

15. **Assertion :** Cycloheptatrienyl ion is aromatic.

Reason : Aromatic molecules have high thermodynamic stability.

16. **Assertion :** Common ion effect is defined as a shift in equilibrium on adding a substance that provides more of an ionic species already present in the dissociation equilibrium.

Reason : Common ion effect is a phenomenon based on the Le-Chatelier's principle.

Or

Assertion : pH of 10^{-8} M HCl is not equal to 8.

Reason : HCl does not dissociate properly in very dilute solution.

SECTION-B : Short Answer Type I Questions (2 Marks)

17. Find out the value of equilibrium constant for the following reaction at 298 K

$2NH_3(g) + CO_2\,(g) \rightleftharpoons NH_2CONH_2(aq) + H_2O(l)$

standard Gibbs energy change (ΔG_f°) is –13.6 kJ mol^{-1}.

18. Give reason for the following :

(i) *p*-nitrophenol is less volatile and has bigh boiling point than *o*-nitrophenol.

(ii) NF_3 is pyramidal while BF_3 is triangular planar.

19. In a 20 L reaction vessel, a mixture of 1.57 moles of N_2, 1.92 moles of H_2 and 8.13 moles of NH_3 is introduced at 500 K. At this temperature, the equilibrium constant, K_C for the reaction,

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ is 1.7×10^2.

Predict the direction of the reaction.

Or (i) The equilibrium constants for the reactions,

$SO_2(g) + 1/2\ O_2(g) \rightleftharpoons SO_3(g)$ and

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ are K_1 and K_2, respectively.

Derive the relation between K_1 and K_2.

(ii) What will be the value of pH of 0.01 mol dm^{-3} CH_3COOH ?

($K_a = 1.74 \times 10^{-5}$)

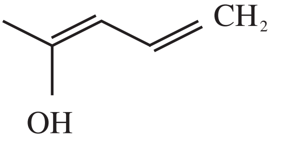
20. If the concentration of glucose ($C_6H_{12}O_6$) in blood is 0.96 gL^{-1}. What will be the molarity of glucose in blood?

Or

Calculate the molarity of a solution containing 22.5 g potassium carbonate dissolved in 500 mL of solution.

(Assume density of solution = 1 g mL^{-1})

21. (i) Write the resonance structure(s) of the following compound :



(ii) *R*NC acts only as a nucleophile but not as an electrophile. Why?

22. Being a good solvent, when water flows on the surface of the earth, it dissolves many salts in the form of hydrogen carbonate, chloride and sulphate which make the water hard. Analyse the given information and answer the following questions.

(i) How does hardness of water is removed?

(ii) Write one disadvantage of hard water.

23. 1 mole of SO_2 occupies a volume of 350 mL. at 27°C and 5×10^6 Pa pressure. Calculate the compressibility factor of the gas.

24. Give reason for the following :

(i) CO is used in the extraction of metals.

(ii) CO is poisonous.

25. The first ($\Delta_i H_1$) and the second ($\Delta_i H_2$) ionisation enthalpies (in kJ $mole^{-1}$) and also the (ΔH_{eg}) electron gain enthalpy (in kJ $mole^{-1}$) of a few elements which are written in the following table :

Elements	$\Delta_i H_1$	$\Delta_i H_2$	ΔH_{eg}
I	520	7300	– 60
II	419	3051	– 48
III	1681	3374	– 328
IV	1008	1846	– 295
V	2372	5151	+ 48
VI	738	1451	– 40

Which of the above elements is likely to be

(i) the most reactive metal?

(ii) the most reactive non-metal?

Or

Consider the following species :

N^{3-}, O^{2-}, F^-, Na^+, Mg^{2+}, and Al^{3+}

(i) What is common in all the above species?

(ii) Arrange these in the order of increasing ionic radii.

SECTION-C : Short Answer Type II Questions (3 Marks)

26. Account for the following :

(i) Out of σ-and π-bonds, which one is stronger bond and why?

(ii) Benzene ring has alternate single and double bonds yet all the C–C bonds are of equal lengths. Why?

(iii) Arrange H_2O, NH_3 and CH_4 in the decreasing order of bond angle.

27. Calculate the enthalpy change on freezing of 1 mole of water at 10.0°C to ice at –10.0°C.

$\Delta_{fus}H = 6.03$ kJ mol^{-1} at 0°C.

$C_p[H_2O(l)] = 75.3$ J mol^{-1} K^{-1};

$C_p[H_2O(s)] = 36.8$ J mol^{-1} K^{-1}.

Or

Calculate the enthalpy change (ΔH) of the following reaction :

$2C_2H_2(g) + 50_2(g) \longrightarrow 4CO_2(g) + 2H_2O(g)$

Given, average bond enthalpies of various bonds, C—H,

$C \equiv C$, $O = O$, $C = O$, O—H as 414, 814, 499, 724 and 640 kJ mol^{-1} respectively.

28. How would you carry out the following conversions?

(i) $H_3CCH_2CH = CH_2$ to $H_3CCH_2\ CH_2\ CH_2OH$

(ii) $H_3CCH_2\text{—}CH = CH_2$ to $H_3CCH_2\ CH(OH)\ CH_2OH$

(iii) $Br_2\ CHCHBr_2$ to $CH \equiv CH$

29. (i) Arrange the following in order of increasing stability?

$CH_3\ CH_2^-$, $CH \equiv C^-$, $CH_2 = CH^-$

(ii) Why does SO_3 act as an electrophile?

Or

The order of basicity of amines expected on the basis of inductive effect is

$NH_3 < RNH_2 < R_2NH < R_3N$.

However, the observed order of basicity is

$NH_3 < RNH_2 < R_2NH > R_3N$.

How will you account for the difference?

30. (i) Complete the following for the difference?

$Na_2O_2 + 2H_2O \longrightarrow$

(ii) Why sodium fire in the laboratory should not be extinguished by pouring water?

SECTION-D : Long Answer Type Questions (5 Marks)

31. An organic compound A with molecular formula C_6H_{12} absorbs one mole of bromine to give compound B. On reduction compound B gives C, while on oxidation it yields a mixture of D of formula $C_4C_8O_2$ and acetic acid. Identify compound A, B, C and D and also give their IUPAC name.

Or

(i) How will you convert,

(a) benzene to acetophenone?

(b) 2-bromopropane to propane?

(ii) Write the structures of different isomers corresponding to the 5th member of alkyne series along with their IUPAC names.

32. A white precipitate X is obtained when aluminium metal reacts with NaOH and is soluble in excess NaOH to give compound Y. Compound X is soluble in dilute H_2SO_4 to give compound Z. The compound X on heating gives compound A which is the product in thermite reaction. Write the chemical formula of X, Y, Z and A.

Or

(i) What happens, when

(a) aluminium reacts with sodium hydroxide?

(b) boron trichloride reacts with water?

(ii) Explain, why aluminium though electropositive metal finds extensive use as a structural material?

(iii) Why do trihalides of group 13 elements fume in the moist air?

33. (i) Calculate the ratio of the energy of the electron in ground state of hydrogen to the electron in first excited state of Be^{3+}.

(ii) If the shortest wavelength of H-atom in Lyman series is X, then calculate the longest wavelength in Balmer series of He^+.

(iii) A beam of helium atoms move with a velocity of 2.0×10^3 ms^{-1}. Find the wavelength of the particle constituting the beam ($h = 6.626 \times 10^{-34}$ Js).

Or

(i) Electromagnetic radiation of wavelength 242 nm is just sufficient to ionise the sodium atom. Calculate the ionisation energy of sodium in kJ mol^{-1}.

(ii) Calculate the wavelength for the emission transition if it starts from the orbit having radius 1.3225 nm and ends at 211.6 pm. Name the series to which this transition belongs and the region of the spectrum.

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SAMPLE PAPER– III
CLASS - XI
Sub. : CHEMISTRY

Time: 3 Hours | Max. Marks : 70

General instructions

1. *All questions are compulsory*
2. *There are total 33 questions in this paper.*
3. *Section A: Q1 to Q2 are case based questions having four MCQs or Reason Assertion type based on given passage carry 1 mark each.*
4. *Section A: Q3 to Q16 are MCQs and Reason Assertion type questions carrying 1 mark each.*
5. *Section B: Q17 to Q25 are short answer type question and carry 2 marks each.*
6. *Section C: Q26 to Q30 are short answer type question and carry 3 marks each.*
7. *Section D: Q31 to Q33 are long answer type question and carry 5 marks each.*
8. *There is no overall choice. However, internal choices have been provided.*
9 *Use of calculators and log tables are not permitted.*

SECTION-A
(OBJECTIVE TYPE)

Q.1. Read the passage given below and answer the following questions: (1x4=4)

To locate the address of a person, we require name, house number, city, state, pin code. Similarly the electron in an atom can be located with the help of quantum numbers. These quantum numbers describe the energy level of an orbital and define the shape and orientation of the region in space where the electron will be found. The principal, azimuthal and magnetic quantum numbers come from the solution of Schrodinger wave equation. The fourth quantum number called spin quantum number represents the spin of the electron about its own axis.

The following questions are multiple choice questions.

Choose the most appropriate answer:

I. How many electrons in the ground state of neon have $(l + m_l) = 0$

(a) 2 (b) 4

(c) 6 (d) 10

II. g-subshell arises after f-subshell, which of the following statement is correct about g subshell

a. There are nine g orbitals which contain a maximum of 18 electrons

b. The lowest value of n for g orbital is 4

c. There are 10 electrons with same spin.

d. The value of l = 3.

OR

Based on the concept of quantum numbers mentioned in the study, which of the following value sets of quantum numbers are not possible?

(a) n=1,	l=0,	m_l= 0,	m_s= -1/2
(b) n=5,	l=3,	m_l= -4,	m_s= +1/2
(c) n=3,	l=1,	m_l= -1,	m_s= -1/2
(d) n=6,	l=1,	m_l= 0,	m_s= +1/2

III. Which of the following quantum numbers can distinguish between two electrons present in the same orbital?

e. Azimuthal quantum number

f. Principal quantum number

g. Magnetic quantum number

h. Spin quantum number

IV. Maximum number of electrons having n = 4 and l = 1 is-

(a) 14 (b) 6

(c) 10 (d) 2

Q.2. Read the passage given below and answer the following questions: (1x4=4)

Common Ion effect is the phenomenon in which weak acid or weak base dissociation is suppressed due to the presence of the common ion provided by the strong electrolyte. For example the dissociation of CH_3COOH is suppressed by the addition of the CH_3COONa. Similarly the dissociation of

NH_4OH is suppressed due to presence of NH_4Cl.This occurs due to the Le-Chatelier's principle.

In this question, a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

a) If assertion and reason both are correct statements and reason is correct explanation for assertion.

b) If assertion and reason both are correct statements but reason is not correct explanation for assertion

c) If assertion is correct statement but reason is wrong statement.

d) If assertion is wrong statement but reason is correct statement

(I) ASSERTION: The dissociation of HCN is decreased when HNO_3 is added to solution.

REASON: HNO_3 is a strong acid which provides H^+.

(II) ASSERTION: When NaOH (solid) is added to NH_4OH solution, then pH increases.

REASON: NH_4OH dissociation decreases by addition of NaOH.

(III) ASSERTION: A mixture of CH_3COOH and CH_3COONa act as buffer solution.

REASON: A buffer solution resist change in pH by addition of large amount of Base or Acid.

(IV) ASSERTION: NH_4Cl is basic salt.

REASON: NH_4Cl is produced by adding weak base NH_4OH and strong acid HCl.

Following questions (No. 3-11) are MCQs carrying 1 mark each:

Q3. The percentage of Carbon in $Ca(HCO_3)_2$ is

a) 15% b) 1.8%

c) 14.8% d) 15.2%

OR

1 Mole of CH_4 contains

a) 6.02×10^{23} atoms of H

b) 3g of carbon

c) 4 gm-atoms of hydrogen

d) 1.81×10^{23} molecules of CH_4

Q4. In the ideal gas equation, the gas constant R has the dimensions

a) mole-atm K^{-1} b) erg K^{-1}

c) litre-atm K^{-1} $mole^{-1}$ d) litre-mole

Q5. The pair of ions having same electronic configuration is

a) Cr^{3+}, Fe^{3+} b) Fe^{3+}, Mn^{2+}

c) Fe^{3+}, Co^{3+} d) Sc^{3+}, Cr^{3+}

Q6. The first ionization enthalpies of Na, Mg, Al, Si are in the order

a) Na<Mg>Al<Si b) Na>Mg>Al>Si

c) Na<Mg<Al<Si d) Na>Mg>Al<Si

OR

Which of the following has largest ionic radii?

(a) Na^+ (b) Mg^{2+}

(c) F^- (d) O^{2-}

Q.7 Which of the following is a state function?

(a) q (b) w

(c) q + w (d) None of these

OR

According to second law of thermodynamics

(a) $\Delta S_{total} = +ve$ (b) $\Delta S_{total} = -ve$

(c) $\Delta S_{system} = +ve$ (d) $\Delta S_{system} = -ve$

Q.8 Among the following, the least thermally stable is?

(a) K_2CO_3 (b) Li_2CO_3

(c) Na_2CO_3 (d) Rb_2CO_3

OR

Amphoteric hydroxides react with both alkalies and acids. Which of the following Group 2 metal hydroxides is soluble in sodium hydroxide?

(a) $Be(OH)_2$ (b) $Mg(OH)_2$

(c) $Ba(OH)_2$ (d) $Ca(OH)_2$

Q.9 Which of the following is paramagnetic?

(a) CO (b) O_2^-

(c) N_2 (d) NO^+

Q.10 Which of the following has smallest bond angle?

(a) H_2O (b) H_2S

(c) NH_3 (d) SO_2

Q.11 The shape of IBr_2^- is

(a) Tetrahedral (b) Planar

(c) Linear (d) V-shape

In the following questions (Q. No. 12 - 16) a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement

Q.12 ASSERTION: ΔH and ΔU are same for the reaction $N_2(g) + O_2(g) \rightarrow 2NO(g)$

REASON: All the reactants and products are gases.

Q.13 ASSERTION: Oxygen has zero oxidation state in O_2.

REASON: Element in their elemental form have zero oxidation state.

Q.14 ASSERTION: Silicon is water repelling in nature.

REASON: Silicon is organo silicon polymers, which have $(-R_2SiO-)$ as repeating unit

OR

ASSERTION: First ionisation enthalpy of Gallium is higher than aluminium.

REASON: Weak shielding effect of 3d subshell is Gallium.

Q.15 ASSERTION: Photochemical smog is oxidizing in nature.

REASON: Photochemical smog contains NO_2 and O_3, which are formed during the sequence of reactions.

Q.16 ASSERTION: Washing soda (Na_2CO_3) is use to remove temporary hardness.

REASON: Clark's method is used to remove temporary hardness.

SECTION B

The following questions, Q.No. 17-25 are short answer type and carry 2 marks each.

Q17. Explain why O has lower $\Delta_i H$ than N and F?

OR

$PbCl_2$ is more stable than $PbCl_4$. Why?

Q18. What volume of 10M HCl and 3M HCl should be mixed to get 1L of 6M HCl solution?

Q19. (a) In the given compounds which is more covalent and why?

Na_2O or Cu_2O

(b) BeF_2 and SF_2 are not isostructural. Why?

OR

N_2 is diamagnetic while O_2 is paramagnetic. Explain on the basis on Molecular orbital theory.

Q.20. Explain why the electron gain enthalpy of fluorine is less negative than of chlorine.

OR

Account for the following:

(a) Halogens have very high negative electron gain enthalpy

(b) The electron gain enthalpy of Cl (Z = 17)is more negative than that of Fluorine (Z= 9).

Q.21. Give IUPAC name of the following compounds:

(i) $(CH_3)_2\ CH_2\ CH_2\ CHO$

(ii) $CH_3 - CH - C - CH - CH_3$

| || |

Br O CH_3

Q.22. Convert But-2-yne into:

(i) cis-But-2-ene

(ii) trans-But-2-ene

Q.23. The equilibrium constant for

$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ is K, then calculate equilibrium constant for

$\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons NO(g)$.

Q.24. Why does water with excessive algae growth become polluted?

Q.25. Complete the reactions:

(i) $H_2 + CO + RCH = CH_2 \rightarrow$

(ii) $H_2 + RCH_2CH_2CHO \rightarrow$

SECTION-C

The following questions, Q.No. 26-30 are Short Answer Type II and carry 3 marks each

Q.26. (a) Why is H_2O a liquid and H_2S a gas?

(b) How many nodal planes are present in $\pi(2px)$ and $\pi^*(2px)$ molecular orbitals ?

(c) Predict the shape of ClF_3 according to VSEPR theory.

OR

(a) Use molecular orbital theory to predict why the He_2 molecule does not exist?

(b) Compare the stability of O_2 and O_2^+ on the basis of molecular theory.

Q.27. $CaCO_3(s) + 2HCl\,(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$

What mass of $CaCl_2$ will be formed when 250ml of 0.76M HCl reacts with 1000g of $CaCO_3$? Name the limiting reagent. Calculate number of moles of $CaCl_2$ formed.

Q.28. (a) Out of NH_3 and N_2, which will have larger value of vanderwaal constant 'a' and Why?

(b) 1 mole of sulphur dioxide occupies a volume of 350mL at 27˚C and 5 X 10^6Pa pressure. Calculate the compressibility factor of the gas. Is it more or less compressible than an ideal gas?

OR

Pressure of one gram of an ideal gas A at 27°C is found to be 2 bar. When 2 g of another ideal gas B is introduced in the same flask at same temperature, the pressure becomes 3 bar. Find the relationship between their molar masses.

Q.29. (i) What is the effect of introducing an alkyl group on the stability of carbocation?

(ii) Out of Benzyl and ethyl carbocation which is more stable and why?

(iii) Arrange the following in increasing order of acidic strength:

$ClCH_2COOH$, CH_3CH_2COOH, $ClCH_2CH_2COOH$

Q.30. Balance the following equation by ion electron method:

$C1_2O_7 (g) + H_2O_2 (1) \longrightarrow ClO_2^- (aq) + O_2 (g)$ [*Basic medium*]

SECTION-D

The following questions, Q.No. 31-33 are long answer type questions and carry 5 marks each

Q.31. (a) Differentiate the terms Bond dissociation enthalpy & Bond Enthalpy.

(b) Calculate enthalpy change for the process $CCl_4(g) \rightarrow C(g) + 4Cl(g)$

and calculate Bond enthalpy of C – Cl bond in CC14.

Given: $\Delta_{vap} H = 30.5$ kJ mol^{-1}; $\Delta_f H(CCl_4) = -135.5$ kJ mol^{-1};

$\Delta_a H(C) = 715$ kJ mol^{-1} and $\Delta_a H(Cl_2) = 242$ kJ mol^{-1}

OR

(i) Define Gibbs Energy. Give its mathematical expression. What is Gibb's energy criteria of Spontaneity.

(ii) For the reaction:

$2A(g) + B (g) \rightarrow 2D(g)$, $\Delta U = -10.5$ kJ and $\Delta S = -44.1$ JK^{-1}.

Calculate ΔrG for the reaction, and predict whether the reaction will occur spontaneously.

Q.32. (a) Draw Newman projection formula for conformations of ethane.

(b) An organic compound 'A' with formula C_4H_9Br on treatment with KOH(alc.) gave two isomeric compounds 'B' and 'C' with formula C_4H_8. Ozonolysis of 'B' gave only one product CH_3CHO while 'C' gave two different products. Identify A, B and C.

OR

(a) Draw the structures of cis and trans Hex-2-ene.

(b) Explain with the help of equation : Ozonolysis of propene.

(c) Give a chemical test to distinguish between ethene and ethane.

Q.33. When metal X is treated with NaOH, a white precipitate 'A' is obtained, which is soluble in excess of NaOH to give soluble complex (B). Compound 'A' is soluble in dilute HCl to form compound 'C'. The compound 'A'when heated strongly gives 'D', which is used to extract metal. Identify X, A, B, C and D. Write suitable equations to support their identities.

OR

(i) Identify the compounds X and Y in the following reactions:

(a) $Na_2B_4O_7 + 2HCl + 5H_2O \rightarrow 2NaCl + X$

(b) $X \xrightarrow[370K]{\Delta} HBO_2 \xrightarrow[>370K]{\Delta} Z$

(ii) Write the name of group 13 element which is used to measure high temperature.

(iii) Why in case of thallium + 1 oxidation state is more stable than + 3?

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SAMPLE PAPER (2020-21) – IV
CLASS - XI
Sub. : CHEMISTRY

Time: 3 Hours | Max. Marks : 70

General Instructions:

i) There are 33 questions in this question paper. All questions are compulsory.

ii) Section-A : Q. No. 1 to 16 are objective type questions. Q. No. 1 and 2 are passage based questions carrying 4 marks each while Q. No. 3 to 16 carry 1 mark each.

ii) Section B: Q. No. 17 to 25 are short answer questions and carry 2 marks each.

iv) Section C: Q. No. 26 to 30 are short answer questions and carry 3 marks each.

v) Section D: Q. No. 31 to 33 are long answer questions carrying 5 marks each.

vi) There is no overall choice. However, internal choices have been provided.

vii) Use of calculators and log tables is not permitted.

SECTION-A

1. Read the given passage and answer questions 1 to 5 that follow :

Oxo acids are those in which the acidic proton is on a hydroxyl group with an oxo group attached to the same atom, e.g., carbonic acid $H_2CO_3[OC(OH)_2]$; sulphuric acid, $H_2SO_4[O_2S(OH)_2]$. The alkali metals form salts with all the oxo acids. They are generally soluble in water and thermally stable. Their carbonates (M_2CO_3) and in most cases the hydrogencarbonates ($MHCO_3$) also are highly stable to heat. As the electropositive character increases down the group, the stability of the carbonates and hydrogencarbontes increases. Lithium carbonate is not so stable to heat, lithium being very small in· size polarises a large CO_3^{2-} ion leading to the formation of more stable Li_2O and CO_2. Its hydrogencarbonate does not exist as a solid.

i. Write the structure of carbonic acid.

ii. How does the stability of carbonates and hydrogencarbonates change with increase in electropositive nature of the metal ?

iii. Out of Li_2CO_3 and Li_2O, which is more stable?

iv. Out of Li_2CO_3 and K_2CO_3 which is more stable?

OR

Out of Li_2SO_4 and Rb_2SO_4 which is more soluble?

2. **Read the passage given below and answer the following questions:**

The presence of a positive charge on the nucleus is due to the protons in the nucleus. The number of electrons in an atom is equal to the number of protons (atomic number, Z). The positive charge of the nucleus is due to protons, the mass of the nucleus, due to protons and 'neutrons. The composition of any atom is represented by using the normal element symbol (X) with super-script on the left-hand side as the atomic mass number (A) and subscript (Z) on the left-hand side as the atomic number. Isotopes are the chemical properties of atoms that are controlled by the number of electrons, which are determined by the number of protons in the nucleus. Isobars are atoms with the same mass number but a different atomic number. Atoms with identical atomic number but a different atomic mass number are known as Isotopes. Number of neutrons present in the nucleus have very little effect on the chemical properties of an element.

In these questions, a statement of assertion followed by the statement of reason-is given. Choose the correct answer out of the following choices:

(a) Assertion and reason both are correct statements and reason is the correct explanation for assertion.

(b) Assertion and reason both are correct statements and reason is not the correct explanation for assertion.

(c) Assertion is the correct statement but reason is wrong statement.

(d) Assertion is the wrong statement but reason is correct statement.

i. **Assertion:** Chlorine atoms contain 17 protons and 28 neutrons.

Reason: The total number of nucleons is termed as mass number (A) of the atom.

it. **Assertion:** ^{1}H, ^{2}H, and ^{3}H are isotopes.

Reason : Atoms with identical atomic number but different atomic mass number are known as Isotopes.

iii. **Assertion :** The charge on the proton is equal but opposite to that of the electron.

Reason: The number of protons present in the nucleus is equal to the atomic number (Z).

iv. **Assertion:** Carbon atoms generally have 6, 7 and 8 neutrons besides 6 protons.

Reason : Number of electrons in the hydrogen atom and sodium atom are 2 and 13 respectively.

OR

Assertion : All the isotopes of a given element show same chemical behaviour.

Reason : Protons and neutrons present in the nucleus are collectively known as nucleons.

3. 16g of oxygen has same number of molecules as in.

a. 16gof CO b. 28g of N_2 c. 14g of N_2 d. 1.0 g of H_2

4. The orbital with n = 3 and 1 = 2 is

a. 3p b. 3d c. 3s d. 3f

OR

The number of radial nodes for 3p orbital is __ .

a. 1 b. 2 c. 4 d. 3

5. Ozonolysis of an organic' compound gives formaldehyde as one of the products. This confirms the presence of:

a. a vinyl group b. two ethylenic double bonds

c. anisopropylgroup d. an acetylenic triple bond

6. For the process to occur under adiabatic conditions, the correct condition is:

a. $q = O$ b. $\Delta T = O$ c. $\Delta p = 0$ d . $w = O$

OR

According to the first law of thermodynamics $\Delta U = q + w$, here what is a sign of q and w?

(a) q is negative if heat is transferred into the system and w is negative if work is done on the system.

(b) q is positive if heat ·is transferred into the system and w is positive if work is done by the system.

(c) q is negative if heat is transferred from the system and w is negative if work is done by the system.

(d) q is positive if heat is transferred into the system and w is positive if work is done by the system.

7. The by-product in Solvay ammonia process is

a. Carbon dioxide b. Ammonia

c. Calcium chloride d. Calcium carbonate

OR

The general electronic configuration of ns^2 exists in:

a. transition elements

h. alkali metals

c. alkaline earth metals

d. coordination compounds

8. The increasing order of reduction of alkyl halides with zinc and dilute HCl is

a. $R-Cl < R - Br < R-I$

b. $R-I < R-Br < R-C1$

c. $R-Br < R-I < R-Cl$

d. $R-Cl < R-I < R-Br$

9. On the basis of standard electrode potential of redox couples given below find out which of the following is the strongest oxidising agent.

E° values : $Fe^{3+} | Fe^{2+} = +0.77$; $I_2(s) | I^- = +0.54$;

$Cu^{2+} | Cu = +0.34$; $Ag^+ | Ag = +0.80V$

a. Fe^{3+}

b. $I_2(s)$

c. Cu^{2+}

d. Ag^+

10. Arrange the following hydrogen halides in order of their decreasing reactivity with propene.

a. HCl > HBr > HI

b. HI > HBr > HCl

c. HC1 > HI > HBr

d. HBr > HI > HCl

11. Based on VSEPR theory, the number of 90° F - Br – F angles in BrF_5 is:

a. 8

b. 2

c. 4

d. 0

12. **Assertion :** Vapour density of sulphur relative to oxygen is 2 because sulphur atom is twice as heavy as that of the oxygen atom.

Reason : Vapour density depends upon the molecular state of the substance in the vapour state.

(a) Both assertion and reason are CORRECT and reason is the CORRECT explanation of the assertion.

(b) Both assertion and reason are CORRECT but, reason is NOT THE CORRECT explanation of the assertion.

(c) Assertion is CORRECT but, reason is INCORRECT.

(d) Assertion is INCORRECT but, reason is CORRECT.

13. **Assertion :** Glass is not an example of silicates.

Reason : All silicates have tetrahedral $SiO4^{4-}$ unit.

(a) Both assertion and reason are CORRECT and reason is the CORRECT explanation of the assertion.

(b) Both assertion and reason are CORRECT but, reason is NOT THE CORRECT explanation of the assertion.

(c) Assertion is CORRECT but, reason is INCORRECT.

(d) Assertion is INCORRECT but, reason is CORRECT.

14. **Assertion (A) :** At critical temperature liquid passes into gaseous state imperceptibly and continuously.

Reason (R): The density of liquid and gaseous phase is equal to critical temperature.

(a) Both A and R are true and R is the correct explanation of A.

(b) Both A and R are true but R is not the correct explanation of A.

(c) A is true but R is false.

(d) A is false but R is true.

OR

Assertion : The root mean square velocity of an ideal gas at constant pressure varies with density as $\left(1/\sqrt{d}\right)$.

Reason : Average kinetic energy of a gas is directly proportional to the absolute temperature.

(a) Both assertion and reason are CORRECT and reason is the CORRECT explanation of the assertion.

(b) Both assertion and reason are CORRECT but; reason is NOT THE CORRECT explanation of the assertion.

(c) Assertion is CORRECT but, reason is INCORRECT.

(d) Assertion-is INCORRECT but, reason is CORRECT.

15. **Assertion :** Oxidation number of C in HCHO is zero.

Reason : Formaldehyde is a covalent compound.

(a) Both assertion and reason are CORRECT and reason is the CORRECT explanation of the assertion.

(b) Both assertion and reason are CORRECT but, reason is NOT THE CORRECT explanation of the assertion.

(c) Assertion is CORRECT but, reason is INCORRECT.

(d) Assertion is INCORRECT but, reason is CORRECT.

16. **Assertion :** Terminal alkynes on oxidation with, Bayer's reagent give a mixture of carboxylic acid and CO_2.

Reason : Terminal alkynes show acidic character.

(a) Both assertion and reason are CORRECT and reason is the CORRECT explanation of the assertion.

(b) Both assertion and reason are CORRECT but, reason is NOT THE CORRECT explanation of the assertion.

(c) Assertion is CORRECT but, reason is INCORRECT.

(d) Assertion is INCORRECT but, reason is CORRECT.

SECTION-B

17. How do alkali and alkaline earth metals react with water?

OR

On the basis of quantum numbers, justify that the sixth period of the periodic table should have 32 elements.

18. Why is sp hybrid orbital more electronegative than sp^2 or sp^3 hybridized orbitals?

19. The species H_2O, HCO_3^-, HSO_4^- and NH_3 can act both as Bronsted acid and base. For each case, give the corresponding conjugate acid and base.

OR

For the reaction, $NO(g) + O_3(g) \rightleftharpoons NO_2(g) + O_2(g)$, $Kc = 6.3 \times 10^{14}$ at 1000 K. Both the forward and reverse reactions are elementary bimolecular reactions in equilibrium. What is Kc for the reverse reaction?

20. Classify the following reactions in one of the reaction type studied in this unit.

a. $CH_3CH_2Br + HS^- \longrightarrow CH_3CH_2SH + Br^-$

b. $(CH_3)_2C = CH_2 + HCl \longrightarrow (CH_3)_2CC1 - CH_3$

c. $CH_3CH_2Br + HO^- \longrightarrow CH_2 = CH_2 + H_2O + Br^-$

d. $(CH_3)_3C\text{–}CH_2OH + HBr \longrightarrow (CH_3)_2C\,Br\,CH_2CH_3 + H_2O$

OR

Why does SO_3 act as an electrophile?

21. Resonance structures of propenal are given below. Which of these resonating structures is more stable? Give reason for your answer.

$$\underset{\text{I}}{CH_2 = CH - CH = O} \longleftrightarrow \underset{\text{II}}{\overset{+}{C}H_2 - CH = CH - \overset{-}{O}}$$

22. Second and third ionization enthalpies of an element are always greater than its first ionization enthalpy. Explain.

23. Complete the following reactions:

i. Isopropyl bromide $\xrightarrow[\text{Heat}]{\text{alc KOH}}$ A $\xrightarrow[\text{Peroxide}]{\text{HBr}}$ B

ii. n-Propyl alcohol $\xrightarrow[\text{443 K}]{\text{Conc. } H_2SO_4}$ A $\xrightarrow[\text{Heat}]{O_2\text{, Ag}}$ B

24. Calculate the number of protons, neutrons and electrons in $^{80}_{35}Br$.

25. What are the net charges on the left and right sides of the following equations? Add electrons as necessary to make each of them balanced half-reactions.

i. $NO_3 + 10H^+ \longrightarrow NH_4^+ + 3H_2O$

ii. $Cl_2 + 4H_2O \longrightarrow 2ClO_2^- + 8H^+$

SECTION-C

26. The drain cleaner, Drainex contains small bits of aluminium which react with caustic soda to produce dihydrogen. What volume of dihydrogen at 20°C and one bar will be released when 0.15 g of aluminium reacts?

OR

A flask was heated from 27°C to 227°C at constant pressure. Calculate the volume of the flask if a volume of air, measured at 227°C was expelled from the flask.

27. A flask P contains 0.5 mole of oxygen gas. Another flask Q contains 0.4 mole of ozone gas. Which of the two flasks contains greater number of oxygen atoms?

OR

Chlorine is prepared in the laboratory by treating manganese dioxide (MnO_2)with aqueous hydrochloric acid as given in reaction,

$$4HCl(aq) + MnO_2(s) \rightarrow 2H_2O(l) + MnCl_2(ag) + Cl_2(g).$$

Calculate how many gram of HCl reacts with 5.0 g of manganese dioxide?

28. The dipole moment of trans 1, 2-dichloroethene is less than the cis–isomer. Explain.

29. What are allotropes? Sketch the structure of two allotropes of carbon namely diamond and graphite. What is the impact of structure on physical properties of two allotropes?

30. For the reaction, $2A(g) + B(g) \longrightarrow 2D(g)$; $\Delta U° = -10.5$ kJ and $\Delta S° = -44.1$ JK^{-1}. Calculate $\Delta G°$ for the reaction and predict whether the reaction may occur spontaneously. ($R = 8.314\times10^{-3}$ kJ mol^{-1}, $T = 298$ K).

SECTION-D

31. The energy of $\sigma 2p_z$ molecular orbital is greater than $\pi 2p_x$ and $\pi 2p_y$ molecular orbitals in nitrogen molecule. Write the complete sequence of energy levels in the increasing order of energy in the molecule. Compare the relative stability and the magnetic behaviour of the following species: N_2, N_2^+, N_2^-, N_2^{2+}.

OR

Write the Lewis structure of the nitrite ion, NO_2^-.

32. At 1127 K and 1 atmosphere pressure, a gaseous mixture of CO and CO_2 in equilibrium with solid carbon has 90.55% CO by mass. $C(s) + CO_2(g) \rightleftharpoons 2CO(g)$. Calculate Kc for the reaction at the above temperature.

OR

The value of Kc = 4.24 at 800K for the reaction, $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$. Calculate equilibrium concentrations of CO_2, H_2, CO and H_2O at 800 K, if only CO and H_2O are present initially at concentrations of 0.10M each.

33. (a) Give the main product of the reaction :

(i)  $+ CH_3 - Cl \xrightarrow{\text{Anhy.}AlCl_3}$

(ii) $CH_3 - \underset{\displaystyle CH_3}{\underset{|}{C}} = CH_2 + H_2O \xrightarrow{H^+}$

(b) How can you convert the following:

(i) Acetylene to nitrobenzene.

(ii) 2-Bromopropane to 1-Bromopropane.

(c) Give a chemical test to distinguish between ethene and ethane.

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