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SURA'S

CHEMISTRY

+1 Standard

VOLUME - I and II

Revised as per the **2018 Public Exam Question Paper Pattern** Based on Scheme of Examination as per G.O. **(2D). No. 50 dated : 09-08-2017**

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Author :

Mrs. Punithavathi PGT (Chemistry)
Sri Sankara Vidhyashramam Matriculation Hr. Sec. School,
Chennai

Head Office:
1620, 'J' Block, 16th Main Road, Anna Nagar,
Chennai - 600 040.
Phones : 044-26162173, 26161099.
Mobile : 96001 75757 / 81242 01000 / 81243 01000
Whatsapp : 81242 01000
e-mail : orders@surabooks.com
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1 CHEMICAL CALCULATIONS

Important Terms and Definitions

- ***Formula weight (FW) :*** It is the sum of the atomic weights of all atoms in a formula unit of the compound.
- ***Avogadro number (N_A) :*** It is the number of atoms in a 12 g sample of carbon-12. One mole of a substance contains Avogadro's number of particles.
- ***Empirical formula :*** It is a simplest formula of a compound which gives the ratio of numbers of all atoms present in it.
- ***Molecular formula :*** It gives the exact number of atoms of all the elements present in a compound.
- ***Redox reaction :*** A reaction which involves both oxidation and reduction.
- ***Oxidation :*** A chemical reaction which involves addition of oxygen or removal of hydrogen.
- ***Reduction :*** It is a chemical reaction which involves addition of hydrogen or removal of oxygen.
- ***Oxidation number :*** It is a residual charge which an atom has or appears to have when all the other atoms from the molecule are removed as ions.
- ***Oxidation in terms of oxidation number :*** Increase in oxidation number of an element in a compound, during a reaction is known as oxidation.
- ***Reduction in terms of oxidation number :*** Decrease in oxidation number of an element in a compound, during a reaction is known as reduction.
- ***Concentration of solution :*** It tells the amount of solute present in a given amount of solvent or solution.
- ***Strength of a solution :*** The weight of solute in grams present in one litre of the solution.
- ***Molarity (M) :*** It is the number of moles of the solute present in one litre of the solution.

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

$$= \frac{\text{Strength in gram per litre}}{\text{Molecular mass of the solute}}$$

- ***Normality (N) :*** It is the number of gram equivalents of a solute present in one litre of the solution.

$$\text{Normality} = \frac{\text{Number of gram equivalents of the solute}}{\text{Volume of the solution in litre}}$$

Textual Questions

A. Choose the best answer.

1. The volume occupied by 16g of oxygen at S.T.P. ..... .
(a) 22.4 L (b) 44.8 L (c) 11.2 L (d) 5.6 L *[Ans. (c)]*

2. Avogadro's number represents the number of atoms in ..... .
(a) 12g of C^{12} (b) 320g of S (c) 32g of Oxygen (d) 12.7g of iodine
[Ans. (a)]

3. The value of gram molecular volume of ozone at S.T.P is ..... .
(a) 22.4 L (b) 2.24 L (c) 11.2 L (d) 67.2 L *[Ans. (a)]*

4. The number of atoms present in 0.5 gram- atoms of nitrogen is same as the atoms in .....
(a) 12g of C (b) 32g of S (c) 8g of the oxygen (d) 24g of magnesium.
[Govt. Model Question Paper 2017] [Ans. (c)]

5. The number of gram-atoms of oxygen in 128g of oxygen is ..... .
(a) 4 (b) 8 (c) 128 (d) $8\times6.02\times10^{23}$
[Ans. (b)]

6. The total number of moles present in 111 g of $CaCl_2$ is ..... .
(a) One mole (b) Two moles (c) Three moles (d) Four moles
[Ans. (a)]

7. Which of the following weighs the most?
(a) One gram-atom of nitrogen (b) One mole of water
(c) One mole of sodium (d) One molecule of H_2SO_4 *[Ans. (c)]*

8. Which of the following contains same number of carbon atoms as are in 6.0g of carbon (C-12)?
(a) 6.0g ethane (b) 8.0g methane (c) 21.0g Propane (d) 28.0g CO *[Ans. (b)]*

9. Which of the following contains maximum number of atoms?
(a) 2.0g hydrogen (b) 2.0g oxygen (c) 2.0g nitrogen (d) 2.0g methane
[Ans. (a)]

10. Which one among the following is the standard for atomic mass?
(a) H (b) ${}^{12}_{6}C$ (c) ${}^{14}_{6}C$ (d) ${}^{16}_{8}O$ *[Ans. (b)]*

11. Which of the following pair of species have same number of atoms under similar conditions ?
(a) 1L each of SO_2 and CO_2 (b) 2L each of O_3 and O_2
(c) 1L each of NH_3 and Cl_2 (d) 1L each of NH_3 and 2L of SO_2 *[Ans. (a)]*

12. 2.0 g of oxygen contains number of atoms same as in ..... .
(a) 4 g of S (b) 7 g of nitrogen (c) 0.5 g of H_2 (d) 12.3 g of Na
[Ans. (a)]

13. The number of gm-molecules of oxygen in 6.02×10^{24} CO molecules is
(a) 1 gm-molecule (b) 0.5 gm-molecule (c) 5 gm-molecule (d) 10 gm-molecule
[Ans. (d)]

14. Hydrogen phosphate of certain metal has a formula $MHPO_4$, the formula of metal chloride is....
(a) MCl (b) MCl_3 (c) MCl_2 (d) MCl_4 *[Ans. (c)]*

15. A compound contains 50% of X (atomic mass 10) and 50% Y (at. mass 20). Which formulae pertain to above data ?
(a) XY (b) X_2Y (c) X_4Y_3 (d) $(X_2)_3Y_3$ *[Ans. (b)]*

16. Which of the following compound has / have percentage of carbon same as that in ethylene (C_2H_4) ?
(a) propene (b) Cyclohexane (c) Ethyne (d) Benzene *[Ans. (a)]*

17. 5L of 0.1 M solution of sodium carbonate contains .....
(a) 53 g of Na_2CO_3 (b) 106 g of Na_2CO_3
(c) 10.6 of Na_2CO_3 (d) 5×10^2 millimoles of Na_2CO_3 *[Ans. (a)]*

Additional One Mark Questions and Answers

1. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I	LIST II
A. Victor-Meyer Method	1. + 6
B. $Cr_2O_7^{2-}$	2. Avogadro's Number
C. Molecular Formula	3. Molecular mass
D. 6.023×10^{23}	4. n × Empirical Formula

	A	B	C	D
(a)	1	2	3	4
(b)	2	4	1	3
(c)	1	3	2	4
(d)	4	3	2	1

[Ans. (b)]

2. Consider the following statements
(i) Formula weight of chloroform is 119amu.
(ii) According to volumetric law $V_1N_1 = V_2N_2$
(iii) Gaining of electrons result in oxidation
Which among the above statement(s) is/are incorrect?
(a) (i) (ii) and (iii) (b) only (ii) (c) only (iii) (d) only (ii) and (iii)
[Ans. (c)]

3. Statement I : Equivalent mass of Mg is determined by Oxide Method.
Statement II : Molecular mass is calculated using vapour density.
(a) Both the statements are individually true
(b) Both the statements are individually true and statement II is the correct explanation of statement I.
(c) Statement I is true but statement II is false.
(d) Statement I is false but statement II is true. *[Ans. (a)]*

4. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I	LIST II
A. Oxidising Agent	1. 46.1 g/mol
B. Reducing Agent	2. $K_2Cr_2O_7$
C. 0.1 N of H_2SO_4	3. H_2S
D. 1 mol of C_2H_5OH	4. 4.9 g / lit

3. 11.2 L of carbon dioxide at S.T.P contains ..... oxygen atoms.
(a) 6.02×10^{-23} (b) 6.02×10^{23} (c) 6.002×10^{32} (d) 6.626×10^{26}
[Ans. (b)]

4. Equal volumes of different gases under similar conditions of temperature and pressure contain equal number of .....
(a) atoms (b) compound (c) complexes (d) molecules
[Ans. (d)]

5. A decimolar solution of NaOH contains ..... of NaOH per litre of the solution.
(a) 0.04g (b) 0.4g (c) 4g (d) 40g *[Ans. (c)]*

6. 7 g of CO contains ..... O atoms.
(a) $\frac{1}{4} \times 6.023 \times 10^{23}$ (b) $\frac{1}{2} \times 6.023 \times 10^{23}$ (c) $\frac{1}{8} \times 6.023 \times 10^{23}$ (d) $\frac{1}{16} \times 6.023 \times 10^{23}$
[Ans. (a)]

7. The mass of 1×10^{22} formula units of $CuSO_4\ 5H_2O$ is .....
(a) 2.35 g (b) 4.74 g (c) 6.28 g (d) 0.246 g *[Ans. (b)]*

C. *Match the following-Textual questions have been converted into MCQs with relevant options.*

1. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I		LIST II	
A	CaC_2	1	John Dalton
B	Law of multiple proportions	2	Liquid element
C	Hydrargyrum	3	Calcium carbide
D	2 gm-equivalents of Na_2CO_3	4	106 g

	A	B	C	D
(a)	1	2	3	4
(b)	3	1	4	2
(c)	4	2	1	3
(d)	2	3	1	4

[Ans. (d)]

2. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I		LIST II	
A	Number of gm-molecules per litre	1	1/8 gm-molecules
B	1 gm-atom of rhombic sulphur	2	6.02×10^{23} Ne atoms
C	Centimolar solution	3	$(NH_4)_2SO_4.Fe(SO_4).6H_2O$
D	22.4 L at S.T.P	4	0.01 moles of solute in one L of solution
E	Mohr's Salt	5	Molarity of solution

	A	B	C	D
(a)	2	4	5	3
(b)	4	3	2	5
(c)	5	1	3	2
(d)	2	1	4	3
(e)	1	2	3	4

[Ans. (a)]

D. Very Short Answers : Textual Questions 2 Marks

1. Can two different compounds have same molecular formula ? Illustrate your answer with two examples.

Yes. Isomers can have same molecular formula but different structural arrangements.

For Example : Ethanol (C_2H_5OH) and dimethyl ether ($CH_3 – O – CH_3$).

Additional Very Short Answer Questions

2 Marks

1. Define Formula Weight (FW) or Formula Mass.

The formula weight of a substance is the sum of the atomic weights of all atoms in a formula unit of the compound, whether molecular or not.

Example : Formula weight of $CHCl_3$ is 119.4 amu.

2. What is Avogadro's Number?

The number of atoms in a 12-g sample of carbon - 12 is called Avogadro's number (to which we give the symbol N_A). The value is 6.023×10^{23}.

3. Define Mole.

The mole may be defined as the amount of the substance that contains as many specified elementary particles as the number of atoms in 12g of carbon - 12 isotope.

One mole = 6.023×10^{23} particles.

4. Define Molar mass.

The molar mass of a substance is the mass of one mole of the substance. The mass and moles can be related by means of the formula.

$$\text{Molar mass} = \frac{\text{Mass}}{\text{Mole}}$$

5. Define Empirical Formula.

An empirical formula gives the ratio of atoms of the various elements present in a compound.

Example : Empirical formula of Butanoic acid is C_2H_4O,

6. What is Stoichiometry?

(i) Stoichiometry is the calculation of the quantities of reactants and products involved in the chemical reaction.

(ii) It is the study of the relationship between the number of moles of the reactants and products of a chemical reaction.

7. Define Oxidation in terms of electronic concept.

According to electronic concept, oxidation is a process in which an atom taking part in chemical reaction loses one or more electrons.

For example : $Fe^{2+} \rightarrow Fe^{3+} + e^-$ [Increase of positive charge]

8. What are reducing agent?

The species which undergo the loss of electrons during the reactions are called reducing agents or reductants.

9. Define reduction in terms of electronic concept.

Reduction is a process in which an atom (or) a group of atoms taking part in chemical reaction gains one (or) more electrons.

$Fe^{3+} + e^- \rightarrow Fe^{2+}$ [Decrease of positive charges]

$V_1 N_1 = V_2N_2$
V_1, V_2 - Volume of solutions.
N_1, N_2 - Strength of solutions.

22. What is Basicity of an acid?

The number of replaceble hydrogen atoms present in a molecule of the acid is referred to its basicity.

23. Define Equivalent mass of an acid.

Equivalent mass of an acid is the number of parts by mass of the acid which contains 1.008 part by mass of replaceble hydrogen atom.

$$\text{Equivalent mass of an acid} = \frac{\text{molar mass of the acid}}{\text{No. of replaceble hydrogen atom}}$$

$$= \frac{\text{molar mass of the acid}}{\text{basicity of the acid}}$$

24. Define Equivalent mass of the base.

Equivalent mass of a base is the number of parts by mass of the base which contains one replaceable hydroxyl ion or which completely neutralises one gram equivalent of an acid.

$$\text{In general, equivalent mass of a base} = \frac{\text{molar mass of the base}}{\text{acidity of the base}}$$

25. Define acidity of a base.

The number of hydroxyl ions present in one mole of a base is known as the acidity of a base.

E. Short Answers : Textual Questions — 3 Marks

1. What are the informations conveyed by a chemical equation ?

The informations conveyed by a chemical equation are -

(i) Reactants and products taking part in the chemical reaction.
(ii) Conditions for a reaction such as temperature, pressure, catalyst etc.
(iii) Nature of the products.
(iv) Amount of reactants required and amount of products formed in terms of grams, number of moles, number of atoms etc.

2. Balance the following equations

i. $Fe + H_2O \rightarrow Fe_3O_4 + H_2$
ii. $Fe_2 (SO_4)_3 + NH_3 + H_2O \rightarrow Fe(OH)_3 + (NH_4)_2 SO_4$
iii. $KMnO_4 + H_2SO_4 \rightarrow K_2SO_4 + MnSO_4 + H_2O + O_2$
iv. $K_2Cr_2O_7 + H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + H_2O + O_2$

i. $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$
ii. $Fe_2 (SO_4)_3 + 6NH_3 + 6H_2O \rightarrow 2Fe(OH)_3 + 3(NH_4)_2 SO_4$
iii. $4KMnO_4 + 6H_2SO_4 \rightarrow 2K_2SO_4 + 4MnSO_4 + 6H_2O + 5O_2$
iv. $2K_2Cr_2O_7 + 8H_2SO_4 \rightarrow 2K_2SO_4 + 2Cr_2(SO_4)_3 + 8H_2O + 3O_2$

Questions are given under 2 marks or 3 marks categories based on the points of Answers. It is only for guidance. However, in the exams, the questions may be asked either in 2 marks or 3 marks.

(iii) The formulae of the products formed are written on the right side of the arrow mark. If there is more than one product, a positive sign is placed between them. The equation thus obtained is called skeleton equation.

(iv) In the skeleton equation, the numbers and kinds of particles present on both sides of the arrow are not equal.

(v) In a balanced chemical equation the numbers and kinds of particles present on both sides of the arrow must be same.

(vi) Important conditions such as temperature, pressure, catalyst etc may be noted above or below the arrow mark.

(vii) An upward arrow (↑) is placed on the right side of the formula of a gaseous product and a downward (↓) on the right side of the formula of a precipitated product.

(viii) All reactants and products should be written as molecules including elements like Hydrogen - H_2, Oxygen O_2 etc.

Additional Long Answer Questions

5 Marks

1. What are the Rules for writing stoichiometric equations?

i. In order to write the stoichiometric equation correctly, we must know the reacting substances, all the products formed and their chemical formula.

ii. The formulae of the reactant must be written on the left side of arrow with a positive sign between them.

iii. The formulae of the products formed are written on the right side of the arrow mark. If there is more than one product, a positive sign is placed between them. The equation thus obtained is called skeleton equation. For example, the Chemical reaction between Barium chloride and sodium sulphate producing $BaSO_4$ and NaCl is represented by the equation as

$$BaCl_2 + Na_2SO_4 \rightarrow BaSO_4 + 2NaCl$$

This skeleton equation itself is a balanced one. But in many cases the skeleton equation is not a balanced one.

For example : the decomposition of Lead Nitrate giving Lead oxide, NO_2 and oxygen. The skeletal equation for this reaction is

$$Pb(NO_3)_2 \rightarrow PbO + NO_2 + O_2$$

iv. In the skeleton equation, the numbers and kinds of particles present on both sides of the arrow are not equal.

v. During balancing the equation, the formulae of substances should not be altered, but the number of molecules with it only be suitably changed.

vi. Important conditions such as temperature, pressure, catalyst etc., may be noted above (or) below the arrow of the equation.

vii. An upward arrow (↑) is placed on the right side of the formula of a gaseous product and a downward arrow (↓) on the right side of the formulae of a precipitated product.

viii. All the reactants and products should be written as molecules including the elements like hydrogen, oxygen, nitrogen, fluorine, chlorine, bromine and iodine as H_2, O_2, N_2, F_2, Cl_2, Br_2 and I_2.

Calculations :

Mass of the volatile substance = wg

Volume of air displaced = Volume of vapour = V_1 m^3

Laboratory temperature = T_1 K

Let the atomospheric pressure be P

Pressure of dry vapour = Atomospheric pressure – aqueous tension at. T_1 K

Let the aqueous tension be p Nm^{-2} at that temperature.

Pressure of dry vapour = P_1 = [P–p]

Standard temperature = T_0 = 273 K

Standard pressure = P_0 = 1.013×10^5 Nm^{-2}

Let the volume of the vapour at standard temperature and pressure be V_0 m^3

From the gas equation, it follows

$$\frac{P_0V_0}{T_0} = \frac{P_1V_1}{T_1}$$

$$V_0 = \frac{P_1V_1}{T_1}\times\frac{T_0}{P_0}$$

The mass of V_0 m^3 of vapour at S.T.P is w g.

The mass of 2.24×10^{-2} m^3 of the vapour at S.T.P. is

$$\frac{2.24\times10^{-2}\times W}{V_0}$$

The value thus calculated gives the molecular mass.

Molecular mass = 2 × vapour density

$$\text{Vapour density} = \frac{\text{Molecular mass}}{2}$$

Solved Problems - Textual Examples

1. Calculate the formula weight of each of the following to three significant figures, using a table of atomic weight (AW):

(a) Chloroform $CHCl_3$ **(b) Iron (III) sulfate $Fe_2(SO_4)_3$.**

Solution

a. Chloroform $CHCl_3$

1 × AW of C = 12.0 amu

1 × AW of H = 1.0 amu

3 × AW of Cl = 3 × 35.45 = 106.4 amu

Formula weight of $CHCl_3$ = 119.4 amu

The answer rounded to three significant figures is 119 amu.

2. Atomic weight of Iron (III) Sulfate $Fe_2(SO_4)_3$.

2 × Atomic weight of Fe = 2 × 55.8 = 111.6 amu

3 × Atomic weight of S = 3× 32.1 = 96.3 amu

3 × 4 Atomic weight of O = 12 × 16 = 192.0 amu

Formula weight of $Fe_2(SO_4)_3$ = 399.9 amu

The answer rounded to three significant figures is 4.00×10^2 amu

2 GENERAL INTRODUCTION TO METALLURGY

Important Terms and Definitions

- ***Metallurgy :*** The process of extracting a metal from its principal source economically and profitably is known as metallurgy.
- ***Mineral :*** The naturally occuring compound of a metal is known as mineral.
- ***Ore :*** A mineral from which the metal can be extracted profitably in pure state is called as ore.
- ***Gangue (matrix) :*** The earthly impurities associated with the mineral or ore is known as gangue.
- ***Purification of the ore :*** Removal of the gangue or earthly impurities from the powdered ore is also known as **concentration of the ore** or **ore dressing**.
- ***Roasting :*** It is an oxidation process where the ore is converted into its oxide. The ore is heated in excess of air at high temperature below its melting point and it is done in a reverberatory furance.
- ***Calcination :*** It is the process in which the ore is heated to a high temperature in the absence of air below its melting point. This is carried out in the case of carbonate ore and hydrated ore.
- ***Smelting :*** It is a reduction method where the metal oxide is converted into metal.
- ***Refining :*** The purification of the metal obtained after the mettallurgical operations is known as refining.

Textual Questions

A. *Fill in the blanks -Textual questions have been converted into MCQs with relevant options.*

1. The earthy impurities associated with ores are .....
   (a) gangue (b) matrix (c) both (a) and (b) (d) only a ***[Ans. (c)]***
2. Froth flotation process is suitable for concentrating ..... ores. ***[Govt. Model Question Paper 2017]***
   (a) oxide (b) sulphide (c) carbonate (d) Halide ***[Ans. (b)]***
3. Highly pure metals are obtained by ..... process.
   (a) Zone refining (b) Mond's process (c) Bessemer process (d) Roasting ***[Ans. (a)]***
4. Gangue + flux → .....
   (a) slag (b) matrix (c) oxide ore (d) matte ***[Ans. (a)]***
5. A mineral from which metal can be profitably extracted is called .....
   (a) matrix (b) ore (c) slag (d) matte ***[Ans. (b)]***
6. A mixture containing sulphides of copper and iron is called .....
   (a) mineral (b) ore (c) matte (d) matrix ***[Ans. (c)]***

7. ..... is used as a foaming agent.
(a) water (b) coconut oil (c) pine oil (d) none *[Ans. (c)]*

Additional One Mark Questions and Answers

➤ Choose the correct answer

1. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I	LIST II
A Oxide ore	1 $Cu_2S.\ Fe\ S_2$
B Sulphide ore	2 $CaSO_4 . 2H_2O$
C Sulphate ore	3 $CaCO_3$
D Carbonate ore	4 $Al_2O_3 .2H_2O$

	A	B	C	D
(a)	1	2	3	4
(b)	2	3	4	1
(c)	3	4	2	1
(d)	4	1	3	2

[Ans. (b)]

2. Statement I : Electromagnetic separation is meant for separating magnetic impurities from non-magnetic ore particles.
Statement II : Magnetic impurities fall near magnet due to attraction and non - magnetic ore particles fall away from magnet due to centrifugal force.
(a) Both the statements are individually true and statement II explains statement I.
(b) Both the statements are individually true but statement II does not explain statement I.
(c) Only Statement I is true and statement II is false.
(d) Only Statement II is true and statement I is false. *[Ans. (a)]*

3. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I	LIST II
A Gravity separation	1 Tinstone
B Froth flotation	2 Bauxite
C Chemical Method	3 Zinc Blende
D Electromagnetic Separation	4 Haematite

	A	B	C	D
(a)	1	4	2	3
(b)	1	2	3	4
(c)	3	1	4	2
(d)	4	3	2	1

[Ans. (d)]

4. Identify the incorrect statement among the following.
(i) During roasting volatile impurities are oxidised. (ii) Smelting is a reduction process.
(iii) Roasting is carried out in the absence of air.
(a) only (i) (b) only (iii) (c) both (ii) and (iii) (d) none of the above
[Ans. (b)]

36. Semiconductors are purified by ..... method.
(a) Zone refining (b) Electrolytic refining
(c) Mond's process (d) Bessemerisation *[Ans. (a)]*

37. An examples of semiconductor is ..... .
(a) Fe (b) Ge (c) Pb (d) Hg *[Ans. (b)]*

38. Mond's process is generally used in the refining of metals such as ..... .
(a) Ca + Mg (b) Cu + Zn (c) Ni + Fe (d) Ag + Au *[Ans. (c)]*

39. Nickel Carbonyl decomposes at ..... temperature to yield pure nickel.
(a) 50° C (b) 180° C (c) 50° K (d) 180° K *[Ans. (b)]*

B. *Very Short Answers :* **Textual Questions** **2 Marks**

1. Distinguish between ore and mineral with suitable example. *[Govt. Model Question Paper 2017]*

S.No.	Ore	Mineral
(i)	The mineral from which the metal can be readily and profitably extracted is known as ore.	The natural material in which the metal and their compounds occur in earth is known as mineral.
(ii)	All ores are minerals.	All minerals are not ores.
(iii)	**Ex.** Bauxite is an ore of aluminium.	Clay is a mineral

2. What are the elements obtained from sea water source?

Four elements such as Na, Mg, Cl_2 and Br_2 can be extracted from the oceans or salt brines, where they are present as monoatomic ions (Na^+, Mg^{2+}, Cl^-, Br^-).

3. What are the different methods of concentration of ores?

(i) Hydraulic washing or gravity separation
(ii) Froth flotation
(iii) Electromagnetic separation
(iv) Chemical method.

4. Name the ores which are concentrated by froth floatation process.

Froth floatation is suitable for lighter sulphide ores like Zinc blende (ZnS) and Copper Pyrites ($CuFeS_2$).

5. Define Metallurgy.

Metallurgy is the process of extraction of metal in the purest form from its ores.

6. What is calcination? Give example.

The conversion of ore into metal oxide (oxidation) is called calcination. It is the process in which the ore is subjected to the action of heat at high temperature in the absence of air below its melting point. Example

$CaCO_3$ (limestone) $\rightarrow CaO + CO_2\uparrow$

$MgCO_3$ (Magnesite) $\rightarrow MgO + CO_2\uparrow$

7. What is the principle involved in Bessemer process ?

The principle involved in Bessemer process is that cold air blowed through refractory lined vessel known as converter containing molten pig iron at about 2 atmospheric pressure, oxidizing the impurities and simultaneously converting pig iron to steel.

2. What are the major steps involved in the metallurgical process ?

Metallurgy is a branch of chemistry which deals with,

(i) Extraction of metals from ores

(ii) Refining of crude metal

(iii) Producing alloys and the study of their constitution, structure and properties.

(iv) The relationship of physical and mechanical treatment of metals to alloys.

3. What is meant by electrolytic refining? Give example.

Electrolytic refining is one of the most convenient and important method of refining and gives a metal of high purity. This method is applicable to many metals such as Cu, Ag, Pb, Au, Ni, Sn, Zn etc. The blocks of impure metal form the anode and thin sheets of pure metal form the cathode. A solution of a salt of the metal is taken as an electrolyte. On passing an electric current through the solution pure metal dissolves from the anode and deposits on cathode.

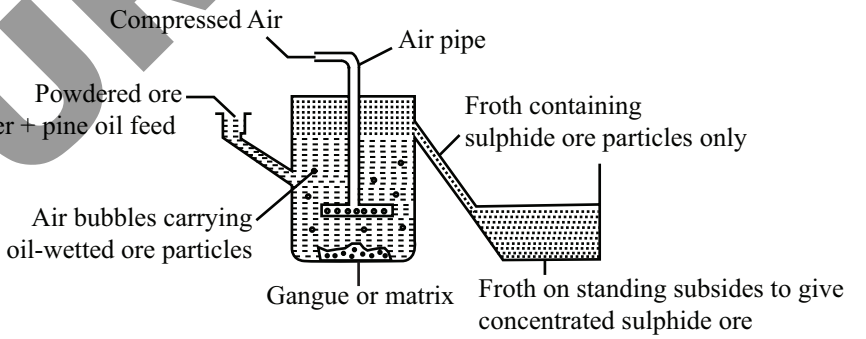
D. Long Answers : Textual Questions 5 Marks

1. Write short note on source of element in living system.

Source of element in living system: About 30 percent of enzymes have a metal atom at the active site. A large number of biomolecules contain metal ions; many of these molecules are proteins. In addition metal ions in the form of crystalline minerals or amorphous solids are important as structural materials in many organisms.

2. Explain froth flotation process with neat diagram.

Froth flotation process : This method is especially suitable for sulphide ores like zinc blende (ZnS), and copper pyrites ($CuFeS_2$). This process is based on the fact that the sulphide ore particles are only moistened by oil; while those of oxide, and gangue particles are moistened only by water. In this process, the powdered ore is mixed with water and a little pine oil (a foaming agent) and the whole mixture is then stirred vigorously by blowing compressed air. The oil forms a foam (or froth) with air. The ore particles stick to the froth, which rises to the surface; while the rocky, and earthy impurities (gangue) are left in water. (Figure). The froth is skimmed off, collected, and allowed to subside to get concentrated ore.



Froth flotation process

3. How electrolytic separation process is useful in the separation of magnetic impurities from non-magnetic ores? Draw the diagram.

Electromagnetic separation process: This method is meant for separating magnetic impurities from non-magnetic ore particles, e.g., tinstone (a tin ore) in which tinstone is non-magnetic; while impurities iron, manganese and tungstates are magnetic. The powdered

Magnetite (Iron ore) in Salem, Dharmapuri, Erode, Nilgiris, Thiruvannamalai, Tiruchirapalli & Villupuram districts.

Molybdenum in Dharmapuri, Dindigul & Vellore districts.

Pyrite in Vellore district.

Petroleum and natural gas deposits are located in Cauvery basin.

Quartz/silica sand in Chennai, Coimbatore, Cuddalore, Dharmapuri, Dindigul, Erode, Kanchipuram, Karur, Madurai, Namakkal, Periyar, Perambalur, Salem, Thiruvallur, Thiruvarur, Nagapattinam, Tiruchirapalli, Villupuram, Virudhunagar & Vellore districts.

Vermiculite in Dharmapuri, Tiruchirapalli & Vellore districts.

Zircon in Kanyakumari district have been established.

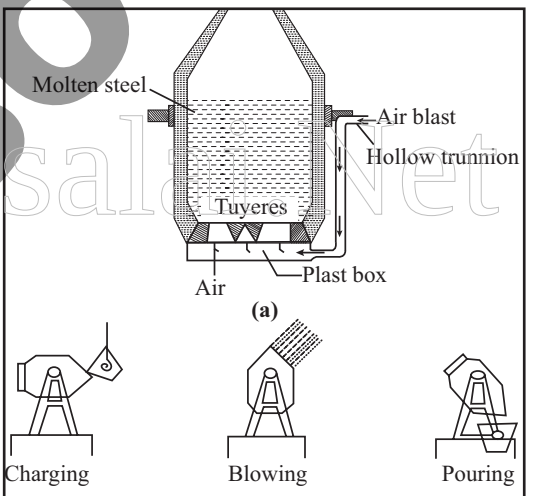
Additional Long Answer Questions

5 Marks

1. What are the various reactions take place in the manufacture of steel by Bessemer process?

Bessemerisation :

It is the process used for the manufacture of steel from pig iron. Steel is an alloy of carbon and iron and contains 0.15-1.5% of carbon. The principle involved in this process is that cold air blowed through refractory lined vessel known as converter containing molten pig iron at about 2 atmospheric pressure, oxidizing the impurities and simultaneously converting pig iron to steel.



Bessemer Converter and Bessemer Process

This process mainly differs in the use of acidic and basic refractory linings of the converters. In this process low phosphorus pig iron (below 0.09%) is treated by acidic Bessemer process and high phosphorus pig iron (more than 1.5%) is treated in basic.

The converter is a pear shaped furnace about 6m high and 3m in diameter. It is made of steel plates and is lined inside with silica or magnesia (MgO), depending upon the nature of impurities present in the pig iron. If the impurities present in the pig iron are basic, e.g., manganese, a lining of silica brick is used and the process is known as acid Bessemer process. If impurities are acidic, e.g., sulphur, phosphorus etc., a basic lining of lime (CaO) or magnesia (MgO) is used in the converter and process is then known as basic Bessemer process.

The capacity of the converter is from 10-25 tonnes of charge at a time. The converter is mounted on shafts or trunnions, one of which is hollow and serves as a wind pipe and upon which the converter can rotate in any position. The converter is also provided with a number of holes at the bottom through which a hot blast of air can be introduced.

3 ATOMIC STRUCTURE – I

Important Terms and Definitions

- ***Atoms :*** The smallest chemically indivisible particles of matter.
- ***Electron :*** A negatively charged particle, which is moving around the nucleus of the atom.
- ***Proton :*** A positively charged particle which is present inside the nucleus of the atom.
- ***Neutron :*** A neutral particle, which is present in the nucleus, having the mass equal to that of a proton.
- ***Mass number (A) :*** The total number of protons and neutrons (nucleons) present in the nucleus.
- ***Atomic number (Z) :*** The number of protons or the number of electrons present in the nucleus.
- ***Zeeman effect :*** The splitting up of spectral lines in the presence of a magnetic field is known as Zeeman effect.
- ***Stark effect :*** The splitting up of spectral lines in the presence of an electric field is known as Stark effect.
- ***Quantum numbers :*** These are a set of values, which describe energy size, shape and orientation of the orbital in space.
- ***Pauli's Exclusion principle :*** It is impossible for any two electrons in a given atom to have all the four quantum numbers identical.
- ***Aufbau principle :*** In the ground state of the atoms, the orbitals are filled in order of their increasing energies.
- ***Hund's Rule :*** No pairing occurs until all orbitals of a given sub-level are half filled.

Textual Questions

A. Choose the best answer.

1. Atomic mass of an element is not necessarily a whole number because :
   (a) It contains electrons, protons and neutrons
   (b) It contains allotropic forms
   (c) Atoms are no longer considered indivisible
   (d) It contains isotopes (e) None of these. ***[Ans. (d)]***
2. No two electrons in an atom will have all four quantum numbers equal. The statement is known as ..... .
   (a) Exclusion principle (b) Uncertainty principle
   (c) Hund's rule (d) Aufbau principle
   (e) Newlands law. ***[Ans. (a)]***
3. When the 3d orbital is complete, the new electron will enter the ..... .
   (a) 4p orbital (b) 4f orbital (c) 4s orbital (d) 4d orbital
   (e) 5s orbital. ***[Ans. (a)]***

45. The electronic configuration of Al^{3+} is ..... .
(a) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$ (b) $1s^2\ 2s^2\ 2p^6$ (c) $1s^2\ 2s^2\ 2p^6\ 3s^2$ (d) $1s^2 2s^2 2p^6 3s^3$
[Ans. (b)]

46. Pick the odd one out.
(a) Nucleus (b) Protons (c) Molecule (d) Neutron *[Ans. (c)]*

B. *Fill in the blanks -Textual questions have been converted into MCQs with relevant options.*

1. The decomposition of an electrolyte by passage of electricity is known as ..... .
(a) electrolysis (b) conduction (c) insulation (d) None of these
[Ans. (a)]

2. Neutrons are discovered by ..... . *[Ans. chadwick]*
(a) Rutherford (b) Chadwick (c) Bohr (d) Thomson
[Ans. (b)]

C. *Very Short Answers :* **Textual Questions** **2 Marks**

1. What is the charge of an electron, proton and a neutron ?

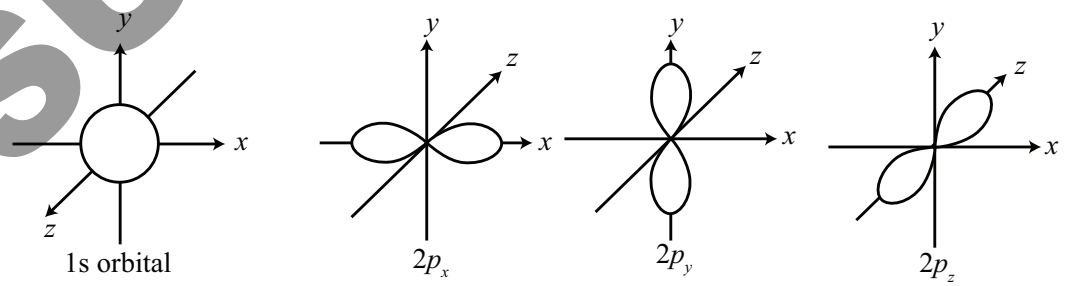
Subatomic particles	Charge
Electron	Negative
Proton	Positive
Neutron	Electrically Neutral

2. What is atomic number?
The number of protons in an atom is called its atomic number(Z).

3. What is the maximum number of electrons that an orbital can have?
The maximum number of electrons an orbital can accommodate is $2(2l+1)$.

4. How many orbitals are there in the second orbit? How are they designated?
For Second orbit, Principal quantum number n = 2, the possible azimuthal quantum numbers (l) are 0 and 1. So, the number of orbitals in the second orbit is four.
They are designated as $2s$ and $2p_x$, $2p_y$, $2p_z$.

5. Sketch the shape of s and p-orbital indicating the angular distribution of electrons.



s and p orbitals

Additional Very Short Answer Questions

2 Marks

1. Define atom.

According to Dalton's theory, all matter is composed of very small particles called atoms. The atoms were regarded to be structureless, hard, impenetrable particles which cannot be subdivided.

2. What are the drawbacks of Thomson's model of an atoms?

Thomson's model of atom could account the electrical neutrality of atom, but it could not explain the results of gold foil scattering experiment carried out by Rutherford.

3. What are the nucleons?

Protons and neutrons present in the nucleus are collectively known as nucleons.

4. Define mass number.

The total number of nucleons is termed as mass number (A) of the atom.

5. Define atomic number.

The number of protons in an atom is called its atomic number (Z).

6. State Heisenberg's uncertainty principle.

Heisenberg's Uncertainty Principle states that it is impossible to determine simultaneously with certainty the position and the momentum of a particle.

7. What is Zeeman effect?

If a substance which gives a line emission spectrum, is placed in a magnetic field, the lines of the spectrum get split up into a number of closely spaced lines. This phenomenon is known as Zeeman effect.

8. What is Stark effect?

If a substance which gives a line emission spectrum is placed in an external electric field, its lines get spilt into a number of closely spaced lines. This phenomenon is known as Stark effect.

9. What are Quantum Numbers?

The quantum numbers are nothing but the details that are required to locate an electron in an atom.

10. What is the total number of orbitals associated with the principal quantum number n=3 ?

For n = 3, the possible values of l are 0,1 and 2. Thus, there is one 3s orbital (n = 3, l = 0 and m_l = 0); there are three p orbitals (n = 3, l = 1 and m_l = –1, 0, 1) there are five 3d orbitals (n = 3, l = 2, m_l = –2, –1, 0, 1, 2).

Therefore, the total number of orbitals is 1+3+5 = 9.

11. Using *s*, *p*, *d*, *f* notations, describe the orbital with the following quantum numbers (a) n=2, *l* = 1 (b) n = 4, *l* = 0 (c) n = 5, *l* = 3 (d) n = 3, *l* = 2.

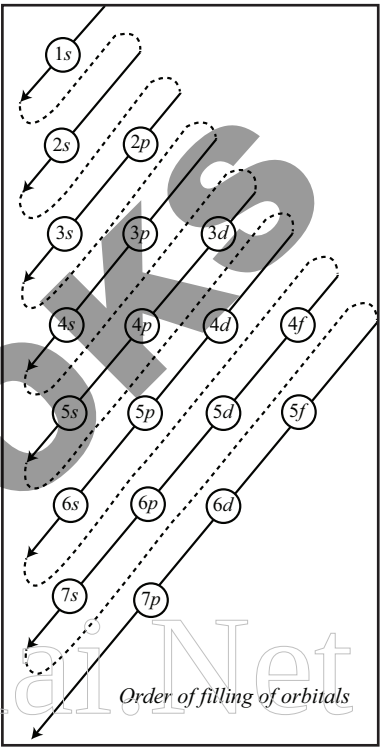
	n	l	orbital
(a)	2	1	2p
(b)	4	0	4s
(c)	5	3	5f
(d)	3	2	3d

E. Explain briefly on the following: Textual Questions 5 Marks

1. Describe Aufbau principle. Explain its significance in the electronic build up of atoms.

The word 'aufbau' in German means 'building up'. The building up of orbitals means the filling up of orbitals with electrons. The principle states: In the ground state of the atoms, the orbitals are filled in order of their increasing energies. In other words, electrons first occupy the lowest-energy orbital available to them and enter into higher energy orbitals only after the lower energy orbitals are filled. The order in which the energies of the orbitals increase and hence the order in which the orbitals are filled is as follows:

1*s*, 2*s*, 2*p*, 3*s*, 3*p*, 4*s*, 3*d*, 4*p*, 5*s*, 4*d*, 5*p*, 6*s*, 4*f*, 5*d*, 6*p*, 7*s* …….



Order of filling of orbitals

This order may be remembered by using the method given in Figure. Starting from the top, the direction of the arrows gives the order of filling of orbitals. Alternatively, the order of increase of energy of orbitals can be calculated from (n + *l*) rule, explained below:

The lower the value of (n + *l*) for an orbital, the lower is its energy. If two orbitals have the same (n + *l*) value, the orbital with lower value of n has the lower energy.

2. Using the *s*, *p*, *d*, notation, describe the orbital with the following quantum numbers. (a) n = 1, *l* = 0; (b) n = 2, *l* = 0; (c) n = 3, *l* = 1; (d) n = 4, *l* =3.

S.No	n value	*l* value	Designation of Orbital
(a)	n = 1	*l* = 0	1*s*
(b)	n = 2	*l* = 0	2*s*
(c)	n = 3	*l* = 1	3*p*
(d)	n = 4	*l* = 3	4*f*

3. Using the Aufbau principle, write the electronic configuration in the ground state of the following atoms : Boron (Z = 5) Neon (Z = 10) and Aluminium (Z = 13).

Element	Atomic number (Z)	Electronic configuration
Boron	5	$1s^2\ 2s^2\ 2p^1$
Neon	10	$1s^2\ 2s^2\ 2p^6$
Aluminium	13	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$

4 PERIODIC CLASSIFICATION – I

Important Terms and Definitions

- ***Periodic table :*** Periodic table may be defined as the arrangement of various elements according to their properties in a tabular form.
- ***Triad :*** A group of three elements having similar properties.
- ***Dobereiner's law of triads :*** When elements are arranged in the order of increasing atomic mass in a triad, the atomic mass of the middle element is approximately equal to the arithmetic mean of the other two elements.
- ***Newlands law of Octaves :*** If the elements were arranged in order of their increasing atomic weights, the eighth element starting from a given one, possessed properties similar to the first, like the eighth note in an octave of music.
- ***Lother Meyer's Arrangement :*** When a plot of atomic volumes versus atomic weights of elements were plotted, a curve was obtained. Lother Meyer pointed out that elements occupying similar positions in the curve possessed similar properties.
- ***Mendeleev's Periodic law :*** The properties of the elements are the periodic function of their atomic weights".
- ***Modern Periodic Law :*** The physical and chemical properties of the elements are periodic function of their atomic numbers.
- ***Representative Elements :*** Elements belonging to '*s*' and '*p*' block elements together are known as representative or main group elements.
- ***Trans Uranium elements :*** Elements after uranium (Atomic. No. 92) are known as Trans uranium elements.
- ***Periodic properties :*** The properties of elements which occur at repeated intervals are called periodic properties.
- ***Atomic radii :*** It is the distance between the centre of the nucleus and the outermost shell of electron in an atom.
- ***Ionic radii :*** It is the distance between the centre of the nucleus and the outermost shell of electron in an ion.
- ***Isoelectronic :*** Atoms or ions which contains the same number of electrons are said to be isoelectronic. eg. O^{2-}, F^{-}, Na^{+}, Mg^{2+}.
- ***Ionisation energy (Ionisation enthalpy) :*** The energy required to remove the most loosely bound electron from an isolated gaseous atom is known as ionisation enthalpy.
- ***Electron affinity (Electron gain enthalpy) :*** It is the amount of energy released when an isolated gaseous atom accepts an electron to form a mono valent gaseous anion.
- ***Electronegativity :*** It is the tendency of an atom in a molecule to attract the shared pair of electrons towards itself.

Textual Questions

A. Choose the best answer :

1. The elements with atomic numbers 31 belongs to :
   (a) *d*-block (b) *f*-block (c) *p*-block (d) *s*-block **[Ans. (c)]**
2. Representative elements are those which belong to :
   (a) *s* and *d*-blocks (b) *s* and *p*-blocks (c) *p* and *d*-blocks (d) *d* and *f*-blocks **[Ans. (b)]**
3. The most electronegative element of the periodic table is :
   (a) Iodine (b) Flourine (c) Chlorine (d) Oxygen **[Ans. (b)]**
4. Which of the following forms stable gaseous negative ion?
   (a) F (b) Cl (c) Br (d) I **[Ans. (b)]**
5. The elements having highest ionization energies within their periods are called :
   (a) Halogens (b) Noble gases
   (c) Alkali metals (d) Transition elements **[Ans. (b)]**
6. A property which progressively increases down a group in the periodic table is :
   (a) Ionization enthalpy (b) Electronegativity
   (c) Electron gain enthalpy (d) Strength as a reducing agent. **[Ans. (d)]**
7. Elements whose atoms have their s and p-sub-levels complete are the:
   (a) Normal elements (b) Transition elements
   (c) Halogens (d) Inert gases. **[Ans. (d)]**
8. The law of triad is applicable to :
   (a) Chlorine, bromine and iodine (b) Hydrogen, oxygen and nitrogen
   (c) Sodium, neon and calcium (d) All of the above **[Ans. (a)]**
9. The law of octaves was stated by :
   (a) Dobereiner (b) Mendeleev (c) Moseley (d) Newland **[Ans. (d)]**
10. Which of the following property decreases down a group?
    (a) Ionization enthalpy (b) Atomic radii (c) Valency **[Ans. (a)]**
    (d) All the above properties
11. Which of the following has the lowest melting point?
    (a) CsCl (b) RbCl (c) KCl (d) NaCl
    (e) LiCl **[Ans. (e)]**
12. Which of the following hydroxide is most basic?
    (a) $Mg(OH)_2$ (b) $Ba(OH)_2$ (c) $Ca(OH)_2$ (d) $Be(OH)_2$ **[Ans. (b)]**
13. Excluding hydrogen and helium, the smallest element in the periodic table is :
    (a) Lithium (b) Oxygen (c) Fluorine (d) Chlorine **[Ans. (c)]**
14. Which one among the following species has the largest atomic radius?
    (a) Na (b) Mg (c) Al (d) Si **[Ans. (a)]**
15. Which of the following is the lightest metal?
    (a) Calcium (b) Lithium (c) Magnesium (d) Sodium **[Ans. (b)]**
16. Which of the following has highest ionization potential?
    (a) Sodium (b) Magnesium (c) Carbon (d) Fluorine **[Ans. (d)]**

C. Very Short Answers : Textual Questions 2 Marks

1. Arrange F, Cl, Br and I in the order of increasing electronic gain enthalpy.

From the electron gain enthalpy data of halogens it is clear that, contrary to expectation, the electron gain enthalpy of fluorine is lower than that of chlorine.

I < Br < F < Cl

2. Write electronic configurations for the elements of atomic numbers 6 and 14 and from this find out of which group in the periodic table each elements belongs.

(i) Atomic Number 6

$1s^2\ 2s^2\ 2p^2$ (or) [He] $2s^2\ 2p^2$

(ii) Atomic Number 14

$1s^2\ 2s^2\ 2p^2\ 3s^2\ 3p^2$ (or) [Ne] $3s^2\ 3p^2$

(i) is Carbon (ii) is Silicon. They belong to 14th group in the periodic table.

3. Which of the following electronic configurations has the lowest ionization enthalpy? (a) $1s^2, 2s^2, 2p^5$; (b) $1s^2, 2s^2, 2p^6$; (c) $1s^2, 2s^2, 2p^6, 3s^2$.

As we move down the group, Ionisation enthalpy decreases. 3rd orbit is far away from nucleus than the others (*a* and *b*).

4. State Modern Periodic Law.

The physical and chemical properties of the elements are periodic function of their atomic numbers.

5. Why Noble gases have zero electron gain enthalpy?

In the case of noble gases, the outer s-and p-orbitals are completely filled. No more electrons can be accommodated in these orbitals. Noble gases, therefore, show no tendency to accept electrons. Their electron gain enthalpies are zero.

6. Which of the following pairs of elements would you expect to have lower first ionization enthalpy? (a) Cl or F; (b) Cl or S; (c) K or Ar; (d)Kr or Xe.

(a) Cl or F

7. Why do elements in the same group have generally similar properties?

Elements in the same vertical column or group have similar electronic configurations, have the same number of electrons in the outer orbitals, and similar properties. Group 1 (the alkali metals) is an example.

8. Name any two transition elements and any two inner transition elements.

Two transition elements are Chromium and Iron.

Inner transition elements are Uranium and Thorium.

9. Arrange the order of increasing atomic volumes in : (a) Li, Na and K; (b) C, N and O; (c) Ca, Sr and Ba.

(a) Li, Na, K; (b) O, N, C; (c) Ca, Sr, Ba

10. Name the different blocks of elements in periodic table. Give the general electronic configuration of each block.

The different blocks of elements in a periodic table are *s*, *p*, *d*, *f* blocks

Questions are given under 2 marks or 3 marks categories based on the points of Answers. It is only for guidance. However, in the exams, the questions may be asked either in 2 marks or 3 marks.

16. How does electronegativity vary across a period and along the group?

In a period electronegativity increases in moving from left to right. This is due to the reason that the nuclear charge increases whereas atomic radius decreases as we move from left to right in a period.

In a group electronegativity decreases on moving down the group. This is due to the effect of the increased atomic radius.

D. Short Answer : Textual Questions 3 Marks

1. Why nitrogen has higher I.E. value than oxygen?

Oxygen has lower ionisation energy than nitrogen because oxygen ($1s^2\ 2s^2\ 2p^4$) loses an electron more easily to acquire the stable half filled configuration. It is as per Aufbau principle.

2. Out of fluorine and chlorine, which has greater electron gain enthalpy?

In chlorine atom, $3p$-orbitals are not as compact as the $2p$-orbitals in fluorine atom. The incoming electron is more readily accepted by the chlorine atom because of weaker electron-electron repulsion. The electron gain enthalpy of chlorine is, therefore, higher than that of fluorine.

3. Among the elements Li, K, Ca, S and Kr which one has the lowest first ionization enthalpy? Which has the highest first ionization enthalpy?

Li	$1s^2\ 2s^1$
K	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$
Ca	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$
S	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$
Kr	$4s^2\ 4p^6$

Lowest first Ionisation enthalpy K. Highest First Ionisation enthalpy Kr.

Additional Short Answer Questions

3 Marks

1. Explain Dobereiner's law of Triads.

(i) In 1829, John Dobereiner (German Chemist) classified elements having similar properties into groups of three. These groups were called triads. According to this law when elements are arranged in the order of increasing atomic mass in a triad, the atomic mass of the middle element was found to be approximately equal to the arithmetic mean of the other two elements.

(ii) For example: lithium, sodium and potassium constituted one triad. However, only a limited number of elements could be grouped into traids.

2. Write short notes on Newlands Law of Octaves.

In 1865, John Newlands (English Chemist) observed that if the elements were arranged in order of their increasing atomic weights, the eighth element starting from a given one, possessed properties similar to the first, like the eighth note in an octave of music. He called it the law of octaves. It worked well for the lighter elements but failed when applied to heavier elements.

18. Which of the following will have the most negative electron gain enthalpy and which has the least negative? P, S, Cl, F. Explain your answer.

Electron gain enthalpy generally becomes more negative across a period as we move from left to right. Within a group, electron gain enthalpy becomes less negative down a group. However, adding an electron to the 2*p* orbital leads to greater repulsion than adding an electron to the larger 3*p* orbital. Hence the element with most negative electron gain enthalpy is chlorine; the one with the least negative electron gain enthalpy is phosphorus.

E. *Explain briefly on the following:* Textual Questions 5 Marks

1. Why does the first ionization enthalpy would have higher electron gain enthalpy?

First ionisation enthalpy is defined as the amount of energy required to remove the loosely bound electron from the isolated gaseous atom.

Electron affinity is the amount of energy released when an isolated gaseous atom accepts an electron to form a monovalent gaseous anion.

Higher ionisation enthalpy means the nuclear charge is high and size of the atom is small. Similarly when nuclear charge is high, electron gain enthalpy will also be higher.

2. Which of the following pairs of elements would have higher electron gain enthalpy? (a) N or O; (b) F or Cl . Explain.

F or Cl will have greater electron gain enthalpy than N or O, because F by gaining an electron attains stable inert gas configuration. But when comparing with chlorine, only chlorine has greater electron affinity because of its bigger size and attracting electron.

In the case of N or O the electron gain enthalpy is less because O has to gain $2e^-$ to acquire noble gas configuration.

3. Lanthanides and actinides are placed in separate rows at the bottom of the periodic table. Explain the reason for this arrangement ?

In order to avoid undue extension of the periodic table the 4*f* and 5*f* - inner transition elements are placed separately. Lanthanides an actinides have three outermost shells incomplete *n*, (*n*–1) and (*n*–2). They are called '*f*' block elements because the electrons enter in the inner '*f*' orbital.The characteristics of these elements are different from others. Hence, they are placed below. Lanthanides are 4*f* group of elements. Actinides are 5*f* group of elements. All are metals. Actinids are radioactive.

4. What do you mean by representative elements? Name the groups of the periodic table, which contain representative elements.

The *p*-Block Elements comprise those belonging to groups 13 to 18 and together with the *s*-block elements are called the Representative Elements or Main Group Elements. *s*-block groups 1 and 2 and *p* block groups 13 to 18 are the groups of the periodic table containing representative elements.

The elements of group 1 (alkali metals) and group 2 (alkaline earth metals) which have ns^1 and ns^2 outermost electronic configuration belong to the s-block elements. They are all reactive metals with low ionization enthalpies. They lose the outermost electron(s) readily to form 1+ (in the case of alkali metal) or 2+ ions (in the case of alkaline earth metals). The metallic character and the reactivity increase as we go down the group.

The outermost electronic configuration varies from ns^2np^1 to ns^2np^6 in each period. Each period ends in a noble gas with a closed shell ns^2np^6 configuration.

18. What are the essential features of the periodic table of Mendeleev? Discuss how his table has been modified subsequently.

In 1869, Dimitriv Mendeleev (Russian Chemist) arranged the 63 chemical elements, then known, according to their increasing order of atomic weights. He gave his famous scheme of the periodic classification of elements known as the periodic law. The law states that " the properties of the elements are the periodic function of their atomic weights". It means that when elements are arranged in order of increasing atomic weights, the elements with similar properties recur after regular intervals. On the basis of this periodic law Mendeleev constructed a periodic table in such a way that the elements were arranged horizontally in order of their increasing atomic weights. Mendeleev, while studying his Periodic Table had found that in certain cases the regularity in behaviour between two succeeding elements was not observed. In order to overcome this he had kept gaps between such elements and had predicted that the gaps would be filled by new elements, to be discovered in future.

The Mendeleev's modified periodic table consists of:

(i) Nine vertical columns called groups. These are numbered from I to VIII and zero. (The members of zero group were not discovered at the time of Mendeleev). Each group from I to VII is further sub-divided into two sub-groups designated as A and B. Group VIII consists of three sets, each one containing three elements. Group zero consists of inert gases.

(ii) Seven horizontal rows, called periods. These are numbered from 1 to 7. First period contains two elements. Second and third periods contain eight elements each. These periods are called short periods. Fourth and fifth contains eighteen elements each. These periods are called long periods. Sixth period contains thirty two elements and is called longest period. Seventh period is incomplete and contains nineteen elements according to early classification.

Additional Long Answer Questions

5 Marks

1. What are the factors that affect ionisation enthalpy?

The ionization enthalpy of an atom depends on the following factors.

(i) ***Size of the atom :*** As the distance between the electron and the nucleus increases, i.e., as the size of the atom increases, the outermost electrons are less tightly held by the nucleus. Thus, it becomes easier to remove an outermost electron. Thus ionization enthalpy decreases with increases in atomic size.

(ii) ***Charge on the nucleus :*** Ionization enthalpy increases with increase in nuclear charge because of the increase in the attractive force between the nucleus and the electron.

(iii) ***Screening effect of inner electrons :*** Ionization enthalpy decreases when the shielding effect of inner electrons increases. This is because when the inner electron shells increases, the attraction between the nucleus and the outermost electron decreases.

5 GROUP 1 *S* -BLOCK ELEMENTS

Important Terms and Definitions

- ***Protium :*** Common form of hydrogen. Atomic number = 1 and Mass number = 1.
- ***Deuterium (heavy hydrogen) :*** An isotope of hydrogen with mass number 2 and atomic number 1.
- ***Tritium :*** Another isotope of hydrogen with mass number 3 and atomic number 1.
- ***Orthohydrogen :*** If the protons in the nuclei of both hydrogen atoms in a hydrogen molecule spin in the same direction, it is known as ortho hydrogen.
- ***Para hydrogen :*** If the protons in the nuclei of both hydrogen atoms in a hydrogen molecule spin in opposite direction, it is termed as para hydrogen.
- ***Exchange reactions :*** Heavy hydrogen (deuterium) and hydrogen atoms, readily exchange their hydrogens either partly or completely at high temperatures. These reactions are known as exchange reactions.
- ***Heavy water :*** It is deuterium oxide. The oxide of deuterium is D_2O.
- ***Hydrogen peroxide :*** H_2O_2 is a colourless syrupy liquid in the anhydrous state. It is miscible with water, alcohol and ether in all proportions.
- ***Alkali metals :*** Group I of the periodic table Lithium, sodium, potassium, rubidium, cesium and francium constitute alkali metals.
- ***General characteristics of alkali metals :***
  - ***Electronic configuration :*** All these elements have one electron (ns^1) in its valence shell.
  - They readily from M^+ ions because of their low ionisation enthalpy.
  - The ionisation enthalpy decreases down the group. Because of this, the electropositive character increases down the group.
  - They exhibit +1 oxidation state in all their compounds.
  - Because of their low ionisation enthalpy, the elements are good reducing agents.
  - The metallic character increases down the group. All metals except Li, exhibit photo electric effect. K, Rb, Cs, are preferred over Li and Na in photo electric cells because of their lower ionisation enthalpies.
- ***Chemical reactivity :*** Alkali metals are highly reactive and their reactivity increases down the group.
  - ***With air :*** Alkali metals tarnish in air due to formation of oxides or hydroxides on the surface.
  - ***With H_2O :*** Alkali metals form their hydroxides and liberate H_2 gas. The reactivity follows the order Cs > Rb > K > Na > Li.
  - ***With H_2 :*** Alkali metals form binary compounds known as hydrides, which contains H^- ions. These hydrides are ionic.

Textual Questions

A. Choose the best answer:

1. Atoms of the same element having same atomic number but different mass number are called
   (a) isotopes (b) isobars (c) isotones (d) isomerism
   [Ans. (a)]
2. Deuterium nucleus consists of
   (a) 2 protons only (b) one neutron
   (c) one proton and one neutron (d) 2 protons and one neutron *[Ans. (c)]*
3. Deuterium with oxygen gives
   (a) oxydeuterium (b) water (c) heavy water (d) all the above
   [Ans. (c)]
4. Tritium is prepared by bombarding lithium with
   (a) deutrons (b) mesons (c) slow neutrons (d) helium *[Ans. (c)]*
5. At room temperature, ordinary hydrogen consists of about
   (a) 25% para and 75% ortho (b) 75% para and 25% ortho
   (c) 99% para and 1% ortho (d) 1% para and 99% ortho *[Ans. (a)]*
6. D_2O reacts with P_2O_5 and gives
   (a) DPO_4 (b) D_2PO_4 (c) D_3PO_3 (d) D_3PO_4 *[Ans. (d)]*
7. ..... is used for the preparation of deuterium
   (a) deuterium oxide (b) heavy water (c) both *a* and *b* (d) deuterium peroxide
   [Ans. (c)]
8. H_2O_2 is a powerful ..... agent.
   (a) dehydrating (b) oxidising (c) reducing (d) desulphurising
   [Ans. (b)]
9. ..... is used as a propellant in rockets
   (a) H_2O_2 (b) D_2O (c) ND_3 (d) $CH_2 = CH_2$
   [Ans. (a)]
10. The oxidation state of alkali metals is
    (a) +2 (b) 0 (c) +1 (d) +3 *[Ans. (c)]*
11. When heated in bunsen flame, lithium gives ..... colour
    (a) yellow (b) blue (c) lilac (d) crimson red
    [Ans. (d)]
12. On moving down the group, density of the alkali metals
    (a) increases (b) decreases
    (c) increases and then decreases (d) decreases and then increases *[Ans. (a)]*
13. If the element can lose an electron readily, they are said to be
    (a) electronegative (b) electropositive (c) electronative (d) electrovalent
    [Ans. (b)]

Additional One Mark Questions and Answers

1. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I	LIST II
A $D_2 + Cl_2$	1 At 25 K
B 99% para & 1% ortho	2 $_1T^3$
C Para hydrogen	3 In light
D 12.4 years	4 Magnetic moment is zero

	A	B	C	D
(a)	3	2	4	1
(b)	4	3	2	1
(c)	2	3	1	4
(d)	2	4	1	3

[Ans. (d)]

2. Statement I : Ortho and para hydrogen differ in some of the physical properties
Statement II : The vapour pressure of para hydrogen is 20.26K and ordinary hydrogen is 20.39K
(a) Both statement I and II are incorrect
(b) Statement II explains statement I
(c) Both the statement I and II are correct but statement II does not explain statement I.
(d) Only statement I is true and statement II is false. *[Ans. (b)]*

3. Consider the following statements.
(i) H_2O_2 is a powerful oxidising agent
(ii) H_2O is used as a neutron moderator, in nuclear reactors
(iii) $_1T^3$ is used in nuclear fusion reaction
(iv) Para hydrogen cannot be converted to ortho hydrogen.
Which among the above statement(s) is/are incorrect?
(a) only (iv) (b) (i) and (ii) (c) (ii) and (iii) (d) (ii) only (iv)
[Ans. (d)]

4. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I	LIST II
A Alkali metals	1 Francium
B Radioactive	2 gas-coke splinter
C Anode	3 Na
D Down's process	4 shiny white

	A	B	C	D
(a)	2	3	4	1
(b)	4	1	3	2
(c)	3	2	4	1
(d)	3	4	1	2

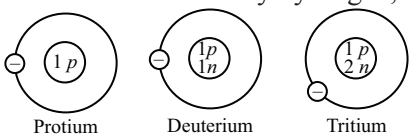
[Ans. (a)]

C. Very Short Answers : Textual Questions **2 Marks**

1. What are isotopes? Mention the isotopes of hydrogen.

Atoms of the same element having same atomic number but different mass number are called isotopes. There are three isotopes for hydrogen with mass numbers 1, 2 and 3, each possessing an atomic number of one.

1. Protium or hydrogen, 2. Deuterium or heavy hydrogen, 3. Tritium.



Isotopes of hydrogen

2. Write a short note on tritium.

Tritium, $_1H^3$ or $_1T^3$: It occurs in the upper atmosphere only where it is continuously formed by nuclear reactions induced by cosmic rays. Unlike deuterium, it is radioactive, with a half-life of ~ 12.3 years. It's nucleus consists of one proton and two neutrons.

3. How does deuterium react with nitrogen?

Reaction with nitrogen: Like hydrogen, it combines with nitrogen in the presence of a catalyst to form heavy ammonia or deutero ammonia. $3D_2 + N_2 \rightarrow 2ND_3$

4. How does deuterium react with metals?

Deuterium reacts with alkali metals at high temperatures (633 K) to form deuterides.

$$2Na + D_2 \rightarrow 2NaD$$
$$NaD + H_2O \rightarrow NaOH + HD.$$

5. How is tritium prepared? *[Govt. Model Question Paper 2017]*

Tritium is prepared by

(i) By bombarding lithium with slow neutrons. $_3Li^6 + {}_0n^1 \rightarrow {}_1T^3 + {}_2He^4$

(ii) By bombarding beryllium with deuterons.

$$_4Be^9 + {}_1D^2 \rightarrow {}_1T^3 + {}_4Be^8$$
$$_4Be^9 + {}_1D^2 \rightarrow {}_1T^3 + 2\ {}_2He^4$$

6. How does heavy water react with metals?

D_2O reacts slowly with alkali and alkaline earth metals liberating heavy hydrogen.

$$2Na + 2D_2O \rightarrow 2NaOD + D_2$$
Sodium deuteroxide

$$Ca + 2D_2O \rightarrow Ca(OD)_2 + D_2$$
Calcium deuteroxide

7. How is hydrogen peroxide prepared in the laboratory?

By the action of dilute sulphuric acid on sodium peroxide, calculated quantity of Na_2O_2 is added in small proportions to a 20% ice cold solution of sulphuric acid.

$$Na_2O_2 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O_2$$

30% solution of H_2O_2 is obtained by this process.

Questions are given under 2 marks or 3 marks categories based on the points of Answers. It is only for guidance. However, in the exams, the questions may be asked either in 2 marks or 3 marks.

2. How do you convert para hydrogen to ortho hydrogen?

Ortho hydrogen is more stable than para hydrogen. The para form is transformed into ortho form by the following methods.

(i) By treatment with catalysts like platinum or iron.
(ii) By passing an electric discharge.
(iii) By heating to 800°C or more.
(iv) By mixing with paramagnetic molecules like O_2, NO, NO_2.
(v) By mixing with nascent hydrogen or atomic hydrogen.

3. Mention two important uses of H_2O_2.

(i) It destroys bacteria and hence it is used as an antiseptic and germicide for washing wounds, teeth and ears.
(ii) It destroys the colour of some organic compounds and is used in bleaching delicate things like hair, wool, silk, ivory and feathers.
(iii) It is used as an oxidizing agent.
(iv) It is also used as a propellant in rockets.

4. Why alkali metals have low melting and boiling points?

All alkali metals have low melting and boiling point due to the weak bonding in the crystal lattice. The weak interatomic bonds are attributed to their large atomic radii and to the presence of one valence electron. With the increase in the size of the metal atoms, the repulsion of the non-bonding electron gets increased and therefore melting and boiling points decreases on moving down the group from Li to Cs.

5. Why alkali metals have strong electropositive character?

As alkali metals have low ionization energies, they have a great tendency to lose electrons forming unipositive ions. Therefore they have strong electropositive character.

$$M \rightarrow M^+ + 1e^-$$

Electropositive character increases as we go down the group. The alkali metals are so highly electropositive that they emit electrons when irradiated with light. This effect is known as photoelectric effect.

Additional Short Answer Questions

3 Marks

1. Write notes on heavy hydrogen.

$_1H^2$ or $_1D^2$. It occurs naturally in very small traces. The proportion present in naturally occurring hydrogen is in the approximate ratio: D: H~ 1:6000. It's nucleus consists of a proton and a neutron. However only a solitary electron is revolving around the nucleus. Its chemical properties are similar to those of protium but their reaction rates are different.

2. How is deuterium prepared from heavy water?

By electrolysis of heavy water: As water contains about one part of heavy water in 6000 parts, at first, the concentration of heavy water is increased by fractional electrolysis of water containing an alkali between nickel electrodes. For example 1 ml of heavy water is obtained from about 20 litres by this method.

9. How is lithium extracted from its ore?

Extraction of Lithium - Electrolysis of Lithium Chloride.

Lithium metal is obtained by the electrolysis of moisture free lithium chloride in a crucible of thick porcelain using gas-coke splinter anode and iron wire cathode. For the preparation of the metal on a large scale, a fused mixture of equal parts of lithium and potassium chloride is used, as it melts at a lower temperature of 720 K.

Lithium is also obtained by the electrolysis of a concentrated solution of lithium chloride in pyridine or acetone.

Additional Long Answer Questions

5 Marks

1. How does deuterium react with the following (i) O_2, (ii) Cl_2, (iii) N_2 (iv) Na.

(i) ***Burning in oxygen:*** Like hydrogen, deuterium is combustible and burns in oxygen or air to give deuterium oxide which is also known as heavy water.

$$2D_2 + O_2 \rightarrow 2D_2O.$$

(ii) ***Reaction with halogens:*** Like hydrogen, it combines with halogens under suitable conditions to form their deuterides.

$$D_2 + Cl_2 \xrightarrow{\text{in light}} 2DCl$$

Deuterium chloride

(iii) ***Reaction with nitrogen :*** Like hydrogen, it combines with nitrogen in the presence of a catalyst to form nitrogen deuteride which are also known as heavy ammonia or deutero ammonia.

$$3D_2 + N_2 \rightarrow 2ND_3$$

(iv) ***Reaction with metals:*** Like hydrogen, it reacts with alkali metals at high temperatures (633K) to form deuterides.

$$2Na + D_2 \rightarrow 2NaD$$

2. Explain the characteristics properties of alkali metals.

(i) Alkali metals are shiny, white and soft.

(ii) They can be readily cut with a knife.

(iii) They are extremely reactive metals and form strong alkaline oxides and hydroxides.

(iv) The last metal of this group, francium is radioactive.

(v) Since the alkali metals are extremely reactive they occur only as compounds in nature.

(vi) All the alkali metals exhibit an oxidation state of +1. This is because the metals can easily lose their single outermost electron.

(vii) The alkali metals give characteristic colour in bunsen flame. The colours given by Li, Na and K are crimson red, yellow, lilac respectively. This is because when the alkali metal or any of its compounds are heated in a bunsen flame, the ns′ electron gets excited to higher energy levels and while returning to their ground state the excitation energy absorbed by them is released as light in the visible region.

3. Explain Down's process of extraction of sodium.

Down's process : It is now manufactured by electrolysis of fused sodium chloride.

Down's electrolytic cell, consists of an iron box through the bottom of which rises a circular

6 GROUP 2 *s*-BLOCK ELEMENTS

Important Terms and Definitions

- ***Alkaline earth metals :*** Group II metals viz Beryllium (Be), Magnesium (Mg), Calcium (Ca), Strontium (Sr), Barium (Ba) and Radium (Ra) are known as alkaline earth metals.
- ***Electronic configuration :***
  Be - $1s^2\ 2s^2$
  Mg - $1s^2\ 2s^2\ 2p^6\ 3s^2$
  Ca - $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$
  Sr - $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 5s^2$
  Ba - $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s^2\ 5p^6\ 6s^2$
- ***General characteristics of alkaline earth metals:***
  - ***Metallic properties :*** The alkaline earth metals are harder than alkali metals - possess high electrical and thermal conductivity.
  - ***Atomic and ionic radii :*** The atomic and ionic radii increases down the group.
  - ***Ionisation energy :*** The first ionisation enthalpy of alkaline earth metals are higher than those alkali metals because of smaller size and higher effective nuclear charge. Ionisation enthalpies, decrease down the group. The second ionisation enthalpy is nearly double than the first IE, because it is more difficult to remove an electron from a more positive ion.
- ***Oxidation state :*** The alkaline earth metals exhibit +2 oxidation state. The divalent ions are diamagnetic and colourless.
- ***Flame coloration :*** The alkaline earth metals impart characteristic colour to bunsen flame. This is due to excitation of the valence electrons when these electrons return to the ground state, the aborbed radiations are emitted in the form of radiations of specific wavelength.
- ***Diagonal relationship :*** Be and Al which are diagonally opposite to each other in the periodic table exhibit similarities in their properties. This is known as diagonal relationship. This is due to their similarity in their size and high electronegativity.
- ***Magnesium :*** Important ores :
  - Magnesite - $MgCO_3$
  - Dolomite - $MgCO_3.CaCO_3$
  - Epsom salt - $MgSO_4.7H_2O$
  - Carnallite - $MgCl_2KCl.6H_2O$
- ***Compounds of alkaline earth metals :***
  - ***Epsom salt :*** $MgSO_4\ 7H_2O$ - used as a purgative, and in dyeing and tanning processes.
  - ***Quick lime CaO (Calcium oxide) :*** A white porous solid, readily dissolves in water, producing heat. The calcium hydroxide formed is known as slaked lime.
  - ***Lime water :*** The paste of lime $Ca(OH)_2$ in water is called milk of lime. While the filtered and clear solution is known as lime water.

- ***Plaster of Paris :*** On heating gypsum $CaSO_4 2H_2O$, it loss 1½ molecules of water, forming $CaSO_4$ ½H_2O (Calcium sulphate hemihydrate). This substance is known as plaster of paris.

Textual Questions

A. Choose the best answer:

1. Among the following, which is known as `alkaline earth metal'?
   (a) Sodium (b) Calcium (c) Lithium (d) Potassium
   [Ans. (b)]
2. Alkaline earth metals are ..... .
   (a) monovalent (b) trivalent (c) divalent (d) zerovalent
   [Ans. (c)]
3. Among alkaline earth metals ..... is having the highest ionization energy.
   (a) Beryllium (b) Magnesium (c) Calcium (d) Barium ***[Ans. (a)]***
4. The colour given by barium in flame is ..... .
   (a) Brick red (b) Apple Green (c) Red (d) Blue ***[Ans. (b)]***
5. The third most abundant dissolved ion in the ocean is ..... .
   (a) Beryllium (b) Barium (c) Calcium (d) Magnesium
   [Ans. (d)]
6. Quick lime is ..... .
   (a) Calcium oxide (b) Calcium hydroxide (c) Calcium nitrate (d) Calcium sulphate
   [Ans. (a)]
7. The formula of bleaching powder is ..... .
   (a) $CaCl_2 . H_2O$ (b) $CaOCl_2 . H_2O$ (c) $CaSO_4 . 2H_2O$ (d) $CaSO_4 . ½H_2O$
   [Ans. (b)]
8. Plaster of paris is ..... .
   (a) $CaSO_4 . 2H_2O$ (b) $CaCl_2$ (c) $CaSO_4$ (d) $CaSO_4 . ½H_2O$
   [Ans. (d)]
9. The compound used in making moulds for statues is ..... .
   (a) Epsom salt (b) Calcium sulphide (c) Plaster of paris (d) Gypsum
   [Ans. (c)]
10. The element used in pyrotechnics is ..... .
   (a) Magnesium (b) Barium (c) Calcium (d) Beryllium
   [Ans. (a)]

Additional One Mark Questions and Answers

1. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I	LIST II
A. $MgCO_3$	1. Epsomsalt
B. $MgCO_3 . CaCO_3$	2. Carnallite
C. $MgSO_4 . 7H_2O$	3. Magnesite
D. $Mg Cl_2 . KCl . 6H_2O$	4. Dolomite

	A	B	C	D
(a)	3	4	1	2
(b)	4	3	2	1
(c)	2	4	1	3
(d)	4	1	3	2

[Ans. (a)]

2. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I	LIST II
A. Ba	1. Brick red
B. Ca	2. Apple green
C. Ra	3. Blue
D. Cu	4. Crimson red

	A	B	C	D
(a)	2	3	4	1
(b)	2	1	4	3
(c)	4	2	3	1
(d)	3	1	4	2

[Ans. (b)]

3. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I	LIST II
A. Plaster of paris	1. White washing
B. Gypsum	2. Tanning
C. Quick lime	3. Plaster making
D. Epsom salt	4. Dentistry

	A	B	C	D
(a)	1	2	3	4
(b)	4	3	2	1
(c)	3	4	2	1
(d)	2	1	4	3

[Ans. (c)]

4. Identify the incorrect statement(s).
   (i) Magnesium is used in fireworks (ii) Mg is used as purgative
   (iii) Mg has low density (iv) Magnesium is prepared from magnesia
   (a) only (iv) (b) (i) and (iv) (c) (ii) and (iii) (d) only (ii) *[Ans. (d)]*
5. $Mg + 2AgNO_3 \rightarrow ?$
   (a) $Mg(NO_3)^2 + 2Ag$ (b) $Mg(NO_3)^2 + NH_4NO_3 + Ag$
   (c) $Mg(SO_4) + H_2O$ (d) $MgO + AgNO_3$ *[Ans. (a)]*
6. The radioactive element of second group is ..... .
   (a) Fr (b) Ra (c) Rf (d) Hf *[Ans. (b)]*
7. The general electronic configuration of group II elements is ..... .
   (a) $ns^2\ np^2$ (b) ns^2 (c) ns^1 (d) none of the above
   [Ans. (b)]
8. In flame, calcium gives ..... colour.
   (a) apple green (b) crimson red (c) brick red (d) lilac *[Ans. (c)]*

9. The formula of epsom salt is ..... .
(a) $MgSO_4 7H_2O$ (b) $MgCO_3$ (c) $MgCO_3\ CaCO_3$ (d) $MgCl_2.KCl.bH_2O$
[Ans. (a)]

10. Epsom salt is used as ..... . *[Ans. purgative]*
(a) flashlight photography (b) purgative
(c) catalyst (d) None *[Ans. (b)]*

C. *Match the following - Textual Questions have been converted into MCQs with relevant options.*

LIST I	LIST II
A. Magnesite	1. $CaSO_4 . 2H_2O$
B. Dolomite	2. $Mg\ Cl_2 . KCl . 6H_2O$
C. Epsom salt	3. $MgCO_3$
D. Carnallite	4. $MgCO_3 . CaCO_3$
E. Gypsum	5. $MgSO_4 . 7H_2O$

	A	B	C	D	E
(a)	3	4	2	5	1
(b)	4	2	3	1	5
(c)	5	4	1	2	3
(d)	2	5	3	4	1
(e)	1	3	5	1	4

[Ans. (c)]

D. *Very Short Answers :* Textual Questions **2 Marks**

1. Why a precipitate of $Mg(OH)_2$ is not formed when aqueous ammonia, NH_4OH is added to a solution of $MgCl_2$?

Magnesium hydroxide is basic in nature and dissolves in acids forming corresponding salts. Magnesium hydroxide is only sparingly soluble in water but dissolves in ammonium chloride solution and is therefore not precipitated in group III of qualitative analysis.

2. Why do beryllium halides fume in air?

Beryllium halides are covalent, hygroscopic and fume in air due to hydrolysis forming hydrates.

3. Why group 2 elements are harder than alkali metals?

Group 2 elements - The alkaline earth metals are harder than alkali metals. Since in alkali metals there is a single electron per atom, in alkaline earth metal there are two electrons per atom. The metallic bonding in group 2 elements is therefore stronger than in group 1 elements. As a result of it, elements of group 2 are harder than those of group 1.

7. The basic strength of the oxides of group 2 elements increases from Be to Ba. Why?

Basic nature of their oxides increases gradually from BeO to BaO. BeO is amphoteric, MgO is weakly basic, CaO is more basic while SrO and BaO are strongly basic.

BeO is insoluble in water. But dissolves both in acid (to give salts) and in alkali (to give beryllates). The stability of the oxides towards thermal dissociation increases with increasing cation size on descending the group.

Additional Short Answer Question

3 Marks

1. What is slaking of lime?

On adding water, lime gives a hissing sound and becomes very hot. The fine powder obtained is known as slaked lime and consists of calcium hydroxide $Ca(OH)_2$. This process is called slaking of lime.

$CaO + H_2O \rightarrow Ca(OH)_2$

The paste of lime in water is called milk of lime whereas the filtered and clear solution is known as lime water.

F. Explain briefly on the following: Textual Questions 5 Marks

1. What are alkaline earth metals? Why are they called so?

The second group of the periodic table contains Beryllium (Be), Magnesium (Mg), Calcium (Ca), Strontium (Sr), Barium (Ba) and Radium (Ra). These elements are also known as "Alkaline Earth Metals". The word earth was applied in old days to a metallic oxide and because the oxides of calcium, strontium and barium produced alkaline solutions in water, these metals are called the alkaline earth metals.

2. In what respects Be and Mg differ from all the other metals of group 2?

Beryllium is unfamiliar, partly because it is not very abundant and partly because it is difficult to extract. Magnesium is abundant among the eight most common elements in the earth's crust.

Beryllium and Magnesium differ from other alkaline earth metals in following respects :

(i) They are not easily affected by dry air and do not decompose water at ordinary temperature.

(ii) Beryllium dissolves in alkali solutions forming alkali beryllates.

(iii) The sulphates of Be and Mg are soluble in water.

(iv) Their carbonates are not precipitated by ammonium carbonate in presence of ammonium chloride.

(v) Their salts do not impart any colour to the flame like those of Ca, Sr, and Ba which impart brick red, crimson and apple green colourations respectively.

2. Explain the diagonal relationship between Beryllium and Aluminium.

In case of beryllium, a member of second period of the periodic table, which resembles more with Aluminium group (group 13) than the member of its own group (2nd). The anamolous behaviour of beryllium is due ascribed to its very small size and partly due to its high electronegativity. These two factors tend to increase the polarising power of Be^{2+} tends to form ions to such extent that it is significantly equal to the polarising power of Al^{3+} ions. Thus the two elements resemble very much.

3. How does magnesium react with the following (i) Steam, (ii) Conc HNO_3 (iii) $AgNO_3$

(i) Action of Water : When heated with steam, it burns brilliantly producing magnesium oxide and hydrogen.

$$Mg + \underset{\text{steam}}{H_2O} \longrightarrow MgO + H_2$$

(ii) Action of Acids : Dilute HCl or H_2SO_4 gives hydrogen with magnesium. With dilute HNO_3, part of the hydrogen liberated is oxidised by nitric acid, which itself is reduced to a variety of products depending upon the concentration. With concentrated HNO_3, it gives ammonium nitrate.

$$4Mg + 10HNO_3 \rightarrow 4\,Mg(NO_3)_2 + NH_4NO_3 + 3H_2O$$

(iii) Displacement of Metals : Magnesium is a strongly electropositive metal and hence Mg displaces nearly all the metals from the solutions of their salts. eg.

$$Mg + 2AgNO_3 \rightarrow Mg(NO_3)_2 + 2Ag$$

Problem - Textual Question

1. An element occupies group number 2 and period number 3. This element reacts with oxygen and nitrogen to form compound A and B. It is a strong electropositive metal so it displaces Ag from $AgNO_3$ solution. With concentrated nitric acid, it forms compound C. Identify the element, compound A, B and C.

Solution :

Group 2 is alkaline earth metals.

Period 3 the metal should be magnesium.

Hence, *x* is magnesium.

The reactions are

$$2Mg + O_2 \rightarrow \underset{(A)}{2MgO}$$

$$3Mg + N_2 \rightarrow \underset{(B)}{Mg_3N_2}$$

$$Mg + 2AgNO_3 \rightarrow Mg(NO_3)_2 + 2Ag$$

$$4Mg + 10HNO_3 \rightarrow \underset{(C)}{4Mg(NO_3)_2} + NH_4NO_3 + 3H_2O$$

The element is magnesium. Compound A is Magnesium oxide, Compound B is Magnesium nitride, Compound C is Magnesium nitrate.

7 *p* -BLOCK ELEMENTS

Important Terms and Definitions

- ***General characteristics of 'p' block elements :***
  (i) Elements belonging to group 13 to 18 in the periodic table are known as '*p*' block elements. In these elements, the *p* sub shell is gradually filled and hence these elements have a general electronic configuration $ns^2\ np^{1-6}$.
  (ii) **Oxidation states :** Mainly they exhibit two oxidation states. The higher oxidation state is obtained by the loss of both the electrons present in '*s*' and '*p*' sub shell and the lower oxidation state is obtained by the loss of *p* electrons in the '*p*' sub shell. For example, Group 13 elements exhibit +3 and +1 oxidation states. Group 14 elements exhibit +4 and +2 oxidation states. Group 15 elements exhibit +5 and +3 oxidation states.
  (iii) **Inert pair effect :** As we go down the group, the two electrons present in the '*s*' orbital become inert, and the electrons in the '*p*' orbital are involved in chemical reactions. This is known as inert pair effect.
  (iv) They form acidic, basic or amphoteric oxides. In all the groups, acidic character of the oxides decreases down the group, while it increases in the same period.
  (v) They form hydrides. In any group, the stability of the hydrides decreases down the group. Its strength as an acid also increases in this order.
- ***Group B elements (Boron family) :*** Boron (B), Aluminium (Al), Gallium (Ga), Indium (In) and Thallium (Tl) belong to this group.
- ***Borax Bead test :*** On heating borax ($Na_2B_4O_2$), it forms a colourless glassy substance known as borax glass which decomposes to give sodium metaborate ($NaBO_2$) and boron (III) oxide (B_2O_3).

$$Na_2B_4O_7.10H_2O \xrightarrow{\Delta} Na_2B_4O_7 + 10H_2O$$

$$Na_2B_4O_7 \xrightarrow{\Delta} 2NaBO_2 + B_2O_3$$

  When this mixture is fused with metallic oxide, it forms characteristic coloured bead, this is known as borax bead test.
- ***Carbon group elements :*** The elements carbon (C), silicon (Si), germanium (Ge), tin (Sn) and lead (Pb) belong to 14th group of the periodic table and are known as carbon group elements.
- ***Allotropes of carbon :*** Diamond, graphite and amorphous carbon, are the allotropes of carbon.
- ***Fullerenes :*** A new allotrope of carbon with 60 atoms and 32 sides. (20 hexagons and 12 pentagons). The group of spherical carbon molecules is called fullerenes.
- ***Characteristics of group 14 elements (carbon family) :***
  (i) ***Metallic character :*** The metallic character decreases down the group.
  (ii) ***Hydrides :*** The hydrides of these elements are covalent. The case of formation decreases from carbon to lead.

Textual Questions

A. Choose the best answer:

1. The elements of group 13 to 18 of the periodic table are known as ..... .
   (a) s - block elements (b) p - block elements
   (c) d - block elements (d) f - block elements *[Ans. (b)]*
2. The general electronic configuration of group 18 elements is ..... .
   (a) ns^2 (b) $ns^2 np^1$ (c) $ns^2 np^{1-5}$ (d) ns^2np^6 *[Ans. (d)]*
3. The basic oxide among the following ..... . *[Govt. Model Question Paper 2017]*
   (a) Bi_2O_3 (b) SnO_2 (c) HNO_3 (d) SO_3 *[Ans. (a)]*
4. The most stable hydride of the following ..... .
   (a) NH_3 (b) PH_3 (c) AsH_3 (d) BiH_3 *[Ans. (a)]*
5. The formula of Borax is ..... .
   (a) $NaBO_2$ (b) $Na_2B_4O_7$ (c) H_3BO_3 (d) None of the above
   [Ans. (b)]
6. The general electronic configuration of carbon group elements is ..... .
   (a) ns^2np^6 (b) ns^2 (c) ns^2np^1 (d) ns^2np^2 *[Ans. (d)]*
7. The process used for the manufacture of ammonia is ..... .
   (a) Contact process (b) Ostwald process (c) Haber's process (d) Linde's process
   [Ans. (c)]
8. The oxides of non-metals are usually ..... .
   (a) ionic (b) coordinate (c) covalent (d) none of the above
   [Ans. (c)]
9. Metallic oxides are generally ..... .
   (a) acidic (b) basic (c) amphoteric (d) neutral *[Ans. (b)]*
10. Fixation of nitrogen is a source for ..... .
    (a) various oxygen compounds (b) various phosphorus compounds
    (c) various nitrogen compounds (d) various sulphur compounds *[Ans. (c)]*
11. The oxyacid of nitrogen which is used in the manufacture of azo dyes ..... .
    (a) Nitrous acid (b) Nitric acid (c) Hyponitrous acid (d) Pernitric acid
    [Ans. (a)]
12. The hydride of V group element which is used in the manufacture of artificial silk ..... .
    (a) ammonia (b) stibine (c) phosphine (d) bismuthine
    [Ans. (a)]
13. Anaesthetic used for minor operation dentistry ..... .
    (a) nitrous oxide (b) nitric oxide
    (c) nitrous oxide + oxygen (d) nitrogen dioxide *[Ans. (c)]*
14. An allotrope of carbon discovered by Richard Smalley *et al* ..... .
    (a) graphite (b) diamond (c) fullerene (d) carbon black
    [Ans. (c)]

Additional One Mark Questions and Answers

1. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I	LIST II
A Diamond	1 Bucky ball
B Graphite	2 Hard
C Amorphous Carbon	3 Soft
D Fullerenes	4 Coke

	A	B	C	D
(a)	2	3	4	1
(b)	4	1	2	3
(c)	3	4	1	2
(d)	1	2	3	4

[Ans. (b)]

2. Statement I : Compounds of carbon with less electronegative elements are called carbides
Statement II : Carbon belongs to group 16.
(a) Statement I and II are correct individually
(b) Statement I and II are correct individually and statement II explains statement I
(c) Statement II is correct and statement I is incorrect
(d) Statement I is correct and statement II is incorrect. *[Ans. (d)]*

3. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I	LIST II
A $Hb + O_2$	1 Beryllium carbide
B $4NO_2 + 2H_2O + O_2$	2 Ammonia
C $Be + C$	3 Nitric Acid
D $N_2 + 3H_2$	4 Oxyhaemoglobin.

	A	B	C	D
(a)	1	4	3	2
(b)	2	3	1	4
(c)	3	4	2	1
(d)	4	2	3	1

[Ans. (c)]

4. (A) : NH_3 and HNO_3 may be converted into ammonium salts and nitrates which aresuitable as fertilizers
(B) : Nitrogen fixation are of vital importance to the agriculturists.
(a) (A) explains (B) (b) (B) explains (A)
(c) Only (A) is correct (d) Both (A) and (B) are wrong. *[Ans. (a)]*

(b)

LIST I	LIST II
A. Inert pair effect	1. Nitric acid
B. Oxyacid	2. Cell fuel
C. Liquid nitrogen	3. Stabilisation of lower oxidation state
D. Ostwald process	4. Platinum gauze
E. Molecular oxygen	5. Refrigerant

	A	B	C	D	E
(a)	5	5	4	2	1
(b)	2	5	1	4	3
(c)	3	5	2	1	4
(d)	4	5	3	2	1

[Ans. (b)]

(c) *Borax bead test*

LIST I	LIST II
A. Copper	1. Blue
B. Iron	2. Grey
C. Manganese	3. Red
D. Cobalt	4. Colorless
E. Chromium	5. Green

	A	B	C	D	E
(a)	4	5	3	2	1
(b)	2	1	5	4	3
(c)	4	2	1	3	5
(d)	3	5	1	5	4

[Ans. (c)]

D. Very Short Answers : ***Textual Questions*** **2 Marks**

1. Mention the reasons for the stabilisation of lower oxidation state of p-block element.

In the case of *p* block elements the valence electrons increase from 3 to 7. They show a variety of oxidation states both positive and negative.

	B	C	N	O	F	Ne
Oxidation state	+3	+4 –4	+5 –3	–2	–1	–
	Al	**Si**	**P**	**S**	**Cl**	**Ar**
Oxidation states	+3	+4 –4	+5 –3	+6 –2	+7 –1	–

It is seen that while + ve oxidation state increases, the – ve oxidation state decreases as we move from left to right across the period. The tendency decreases as metallic character increases. The heavier members show inert pair effect.

13. Molecular oxygen acts as a cell fuel. Give reason.

Dioxygen is also called as molecular oxygen. The molecular oxygen is essential for respiration (for the release of energy in the body) by both animals and plants. It is therefore essential for life. Hence molecular oxygen acts as a cell fuel.

E. Short Answer : Textual Questions — 3 Marks

1. Why diamond is hard compared with graphite?

Structure of diamond : In diamond every atom is bonded with the other by covalent links resulting in the formation of a giant molecule. Each carbon atom is linked with four neighbouring carbon atoms held at the comers of a regular tetrahedron by covalent bonds. The C-C bonds are very strong. A tetrahedral arrangement of carbon atoms is repeated to give the structure of diamond. Hence, the crystal of diamond is very hard.

Structure of graphite : It consists of separate layers. The carbon atoms are arranged in regular hexagons in flat parallel layers. There is no strong bonding between different layers, which are, therefore, easily separable from each other. Since there are no covalent linkages between the adjacent planes, graphite can be easily cleaved along the lines of the planes. This accounts for the softness and lubrication power of graphite.

Hence, diamond is hard when compared to graphite.

2. Why Boron family has a tendency to form hydrides?

Boron has small size and high electronegativity. The difference in electronegativity between boron and hydrogen is less. So they form many covalent hydrides. Especially in diborane, boron and hydrogen bond is of two types. One is regular covalent bond and the second is bridged hydrogen bond (2 electron 3 centre bond). The bridged bond is longer than the ordinary covalent bond.

3. Which is considered to be "earth's protective umbrella"?

The ozone in the upper atmosphere is important in shielding us from the intense ultraviolet radiation coming from the sun. The so-called ozone shield is a shell about 30 km altitude which contains enough ozone to absorb short wavelength UV radiation (less than 300 nm). Hence ozone is considered to be 'earth's protective umbrella'.

4. Mention any 3 uses of ozone.

Uses of ozone :

(i) It is used as germicide and disinfectant.

(ii) It is used for bleaching oils, ivory, flour, starch, etc.

(iii) Used in the manufacture of artificial silk and synthetic camphor,

5. What are CFC's? Mention its environmental action.

Chlorofluorocarbons react with ozone and cause a hole in the ozone layer. CFCs are used as refrigerants and as propellants in some "aerosol sprays". The lifetime of CFCs are so long that in another decade, the extent of ozone depletion in the upper atmosphere will be tremendous. It is reported that the holes caused in the ozone layer over the Antarctic and Arctic ocean are due to the use of CFCs in aerosols and refrigerators. It is feared that this will allow an excessive amount of UV radiation to reach the earth which will cause skin cancer (melanoma) in humans.

Questions are given under 2 marks or 3 marks categories based on the points of Answers. It is only for guidance. However, in the exams, the questions may be asked either in 2 marks or 3 marks.

oxygen combine to give nitric oxide which gets further oxidised to nitrogen dioxide. This reacts with rain water in the presence of excess of oxygen to produce nitric acid and is washed down to earth. Here it reacts with bases of the soil to give nitrates.

In addition to this, certain bacteria living in the nodules on roots of leguminous plants e.g., pea, beans, etc., convert nitrogen into nitrogenous compounds which can be directly assimilated by the plant.

8. How molecular oxygen is important for all oxygenated animals?

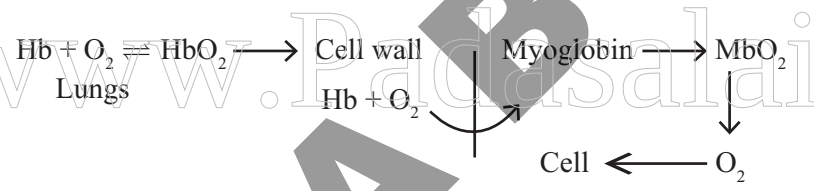
Haemoglobin is an iron containing coordination compound present in red blood cells responsible for the transport of oxygen from the lungs to various parts of the body. Myoglobin is a similiar substance in muscle tissue, acting as a reservoir for the storage of oxygen and as a transport of oxygen within muscle cells.

Haemoglobin consists of heme, a complex of Fe(II) bonded to a porphyrin ligand and globin protein. The sixth position is vacant in free haemoglobin but is occupied by oxygen in oxyhaemoglobin. Haemoglobin (Hb) and O_2 are in equilibrium with oxyhaemoglobin.

$$Hb + O_2 \rightleftharpoons \underset{\text{Oxyhemoglobin}}{HbO_2}$$

Oxyhaemoglobin is formed in the lungs and carried to the cells, where it gives up its oxygen.

Haemoglobin then binds with HCO_3^- which is formed by the reaction of CO_2 (released by the cell) with water. After reaching the lungs, due to hydrolysis CO_2 is released.



9. How ozone reacts with the following? (a) PbS (b) $KMnO_4$ *[Govt. Model Question Paper 2017]*

(i) Ozone reacts with lead sulphide oxidises it into lead sulphate.

$$PbS + 4O_3 \rightarrow PbSO_4 + 4O_2$$

(ii) Ozone oxidises potassium manganate into potassium permanganate.

$$2K_2MnO_4 + H_2O + O_3 \rightarrow 2KMnO_4 + 2KOH + O_2$$

Additional Long Answer Questions

5 Marks

1. Write short notes on oxides of p-block elements.

Oxides of p-block elements may be basic (in case of metallic elements), amphoteric (in case of metalloids) or acidic (in case of non-metals). Non-metals also form a number of oxyacids. In all the groups, the acidic character of the oxide decreases as we move down the group while it increases in the same period from left to right.

For example :

Basic oxide - Bi_2O_3

Amphoteric oxide - SnO, SnO_2, PbO, Pb_2O_3

(i) Boron reacts with CO_2 to form boric oxide.

$$3CO_2 + 4B \longrightarrow \underset{\text{Blue}}{2B_2O_3} + 3C$$

∴ The compound A is B_2O_3 (Boron trioxide)

(ii) B_2O_3 reacts with $CuSO_4$ to form Cu $(BO_2)_2$

$$CuSO_4 + B_2O_3 \longrightarrow Cu(BO_2)_2^{(Blue)} + SO_3$$

∴ The compound B is copper bead. Cu $(BO_2)_2$

Problems for practice - Textual Questions

1. BF_3 reacts with LiH and forms a compound A. The compound A reacts with water to give the compound B. A reacts with ammonia at 390 K and form C. Identify (A), (B) and (C).

Solution:

BF_3 reacts with LiH ⟶ A

Compound A + H_2O → Compound B

$$8BF_3 + 6\,LiH \longrightarrow \underset{\text{A (diborane)}}{B_2H_6} + 6\,LiBF_4$$

∴ Compound A is diborane.

$$B_2H_6 + 6\,H_2O \longrightarrow \underset{\text{B (boric acid)}}{2\,H_3BO_3} + 6H_2$$

∴ Compound B is boric acid.

$$B_2H_6 + 2\,NH_3 \xrightarrow{390\,K} \underset{\text{C (Diamoniate of diborane)}}{B_2H_6\,2NH_3}$$

A - Diborane, B - Boric acid, C - Diammoniate of diborane.

2. An element occupies group number 15 and period number 2 reacts with hydrogen under high pessure and in the presence of a catalyst it forms a hydride (A). In presence of excess of air and in the presence of platinum it forms an oxyacid (B). Identify the element, A and B.

Solution : As per position in the periodic table, the element which occupies group number 15 and period number 2 is Nitrogen.

$$N_2 + 3H_2 \overset{Fe}{\rightleftharpoons} \underset{\text{Ammonia (A)}}{2NH_3}$$

$$NH_3 + \text{air} \longrightarrow \text{oxyacid (B)}$$

$$4NH_3 + 5\,O_2 \xrightarrow{Pt} 4NO + 6H_2O$$

$$2NO + O_2 \longrightarrow 2NO_2$$

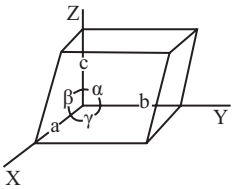
$$4NO_2 + 2\,H_2O + O_2 \longrightarrow \underset{\substack{\text{(B) oxyacid of } N_2 \\ \text{(Nitric acid)}}}{4\,HNO_3}$$

Element is nitrogen. Compound A - Ammonia (NH_3).
Compound B - Nitric acid (HNO_3).

8 THE SOLID STATE – I

Important Terms and Definitions

- ***Solids*** are characterised by incompressibility, rigidity and mechanical strength. In solids, the constituent particles (atoms, molecules, or ions) are held together by strong forces of attraction which account for the properties of solids.
- ***Crystalline solid :*** A crystalline solid consists of orderly arrangement of constituent particles in a three dimensional space. They have sharp melting point. They are anisotropic i.e., their physical properties are different in all directions.
- ***Amorphous solids :*** Amorphous solids do not have any pattern of arrangement of constituent particles and do not have any definite shape or geometry. They are isotropic as they exhibit same physical properties in all directions.
- ***Micro crystalline :*** Such solids, in which the crystals are so small that can be recognised only under a powerful microscope are said to be micro crystalline.
- ***Characteristic features of a crystal :***
  - **(i) Faces :** The definite planes which bind the crystals are known as faces.
  - **(ii Forms :** All the faces corresponding to a crystal constitute a form.
  - **(iii) Edges :** The intersection of two adjacent faces give rise to the formation of an edge.
- ***Crystallography :*** The study of crystals, their geometry and interfacial angles is known as crystallography.
- ***Space lattice :*** An infinite three dimensional array of points, representing the constituent particles in a crystal is known as space lattice and the points are known as lattice points.
- ***Unit cell :*** The smallest structure of which the crystalline solid is built by its repetition in three dimensions is called as unit cell.
- ***Crystallographic axes :*** The lines drawn parallel to the lines of intersection of any three faces of the unit cell, which do not lie in the same plane are called crystallographic axes.
- ***Interfacial angles :*** The angle between the three crystallographic axes are known as interfacial angles.
- ***Primitives :*** The three sides 'a', 'b' and 'c' of a unit cell are known as primitives.



- ***Types of unit cells :*** There are three types of unit cells : (i) simple cubic, (ii) body centred cubic, (iii) face centred cubic.

- ***Characteristics of cubic lattices :***

	Simple	Body-Centered	Face-Centered
Unit cell volume	a^3	a^3	a^3
Lattice points per cell	1	2	4
Nearest neighbour distance	a	$\frac{a\sqrt{3}}{2}$	$\frac{a}{\sqrt{2}}$
Number of nearest neighbours	6	8	12
Second nearest neighbour distance	$a\sqrt{2}$	6	6

Textual Questions

A. Choose the best answer - Textual Questions.

1. The structure of sodium chloride crystal is ..... .
   (a) body centred cubic lattice (b) face centred cubic lattice
   (c) octahedral (d) square planar *[Ans. (b)]*
2. The number of atoms in a face centred cubic unit cell is ..... .
   (a) 4 (b) 3 (c) 2 (d) 1 *[Ans. (a)]*
3. The 8:8 type of packing is present in ..... .
   (a) CsCl (b) KCl (c) NaCl (d) MgF_2 *[Ans. (a)]*
4. In a simple cubic cell, each point on a corner is shared by ..... .
   (a) 2 unit cells (b) 1 unit cells (c) 8 unit cells (d) 4 unit cells
   [Ans. (c)]
5. An amorphous solid is ..... .
   (a) NaCl (b) CaF_2 (c) glass (d) CsCl *[Ans. (c)]*
6. Each unit cell of NaCl consists of 4 chlorine ions and ..... .
   (a) 13 Na atoms (b) 4 Na ions (c) 6 Na atoms (d) 8 Na atoms
   [Ans. (b)]
7. In a body centred cubic cell, an atom at the body of centre is shared by ..... .
   (a) 1 unit cell (b) 2 unit cells (c) 3 unit cells (d) 4 unit cells
   [Ans. (a)]
8. In the sodium chloride structure, formula per unit cell is equal to ..... .
   (a) 2 (b) 8 (c) 3 (d) 4 *[Ans. (d)]*
9. In a face centred cubic cell, an atom at the face centre is shared by ..... .
   (a) 4 unit cell (b) 2 unit cells (c) 1 unit cells (d) 6 unit cells
   [Ans. (b)]

Additional One Mark Questions and Answers

1. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I	LIST II
A Crystalline Solid	1 Glass
B Amorphous Solid	2 Long range order
C Co-ordination no. 6	3 Anisotropic
D Double Refraction	4 NaCl

	A	B	C	D
(a)	2	1	4	3
(b)	3	2	1	4
(c)	1	3	2	4
(d)	2	4	3	1

[Ans. (a)]

2. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I	LIST II
A Body	1 Shared by 2 unit cells
B Face	2 Shared by 8 unit cells
C Edge	3 No sharing
D Corner	4 Shared by 4 unit cells

	A	B	C	D
(a)	1	2	3	4
(b)	2	4	1	3
(c)	4	3	2	1
(d)	3	1	4	2

[Ans. (b)]

3. Calculate the Miller indices of crystal planes which cut through the crystal axes at (6a, 3b, 3c)
(a) (326) (b) (111) (c) (122) (d) (211) *[Ans. (c)]*

4.

Crystalline Solid	Structure	Co-ordination number
NaCl	FCC	X
CsCl	Y	8

The X and Y are _____.
(a) SC, 6 (b) 6, BCC (c) 4. FCC (d) 4, BCC *[Ans. (b)]*

5. Pick out the odd statement(s) among the following.
(a) Miller Indices is obtained by taking reciprocal of weiss indices
(b) Unit cell is a smallest structure.
(c) Unit cell is built by its repetition in three dimension.
(d) The angles between the crystallographic axes is called interfacial angle. *[Ans. (a)]*

6. ..... is an example of crystalline solid.
(a) Glass (b) Rubber (c) Sugar (d) both (a) and (b)
[Ans. (c)]

5. The three types of cubic unit cells are ....., ... and ..... .
   (a) sc, bcc, fcc (b) cubic, triclinic, mono clinic
   (c) circle, triangular, rectangular
   (d) primitives, crystallographic axes, interfacial angels *[Ans. (a)]*
6. A crystal may have a number of planes or axes of symmetry but it possesses only one ..... of symmetry.
   (a) corner (b) edge (c) centre (d) wall *[Ans. (c)]*
7. Amorphous solids that exhibit same physical properties in all the directions are called ..... .
   (a) super cooled liquid (b) anisotropic
   (c) true solid (d) isotropic *[Ans. (d)]*
8. Crystalline solids that exhibit different physical properties in all directions are called ..... .
   (a) super cooled liquid (b) anisotropic
   (c) true solid (d) isotropic *[Ans. (b)]*
9. The number of atoms in a single unit cell of cubic close packed sphere is ..... .
   (a) 1 (b) 2 (c) 4 (d) 8 *[Ans. (c)]*
10. In a bcc, an atom of the body centre is shared by ..... unit cell.
   (a) 1 (b) 2 (c) 3 (d) 8 *[Ans. (a)]*
11. The Weiss indices of a plane are 1/2, 1/2, 1/2. Its miller indices will be .....and the plane is designated as ..... .
   (a) (111) (b) (222) (c) (333) (d) (000) *[Ans. (b)]*
12. A plane is parallel to X & Z axes and makes unit intercepts along Y-axis. Its Weiss indices are ..... Its Miller indices are ..... The plane is designated as ..... .
   (a) ∞, 1, 1; 011; (011) plane (b) ∞, ∞, 1; 001; (001) plane
   (c) ∞, 1, ∞; 010; (010) plane (d) None of the above *[Ans. (c)]*

C. *Very Short Answers :* **Textual Questions** **2 Marks**

1. What is meant by 'unit cell' in crystallography?

The smallest structure of which the crystalline solid (or crystal) is built by its repetition in three dimensions is called as unit cell.

2. How many types of cubic unit cell exits?

Three types of cubic unit cell exists. They are (i) Simple cubic (ii) Body-centred cubic and (iii) Face-centred cubic.

3. What are Miller Indices?

The reciprocals of Weiss indices and multiplying throughout by the smallest number in order to make all reciprocals as integers obtain the Miller indices of a plane.

4. Mention the number of sodium and chloride ions in each unit cell of NaCl.

No. of Sodium ions $= 12 \text{ (At edge centres)} \times \left(\frac{1}{4}\right) + 1 \text{ (At body centre)} \times 1$

$= (12 \times \frac{1}{4}) + (1 \times 1) = 3 + 1 = 4$

Questions are given under 2 marks or 3 marks categories based on the points of Answers. It is only for guidance. However, in the exams, the questions may be asked either in 2 marks or 3 marks.

E. Short Answer : Textual Questions 3 Marks

1. What governs the packing of particles in crystals?

(i) Faces : Crystals are bound by plane faces. The surfaces usually planar and arranged on a definite plane (as a result of internal geometry), which bind crystals are called faces.

(ii) Form : All the faces corresponding to a crystal are said to constitute a form.

(iii) Edge : The intersection of two adjacent faces gives rise to the formation of edge.

(iv) Interfacial angle : The angle between the normals to the two intersecting faces is called interfacial angle.

Additional Short Answer Question

3 Marks

1. How many types of unit cell exist?

There are seven classes of unit cells.

(i) Cubic

(ii) Triclinic

(iii) Monoclinic

(iv) Orthorhombic

(v) Tetragonal

(vi) Hexagonal and

(vii) Rhombohedral.

2. What are the characteristics features of a crystal?

Crystal possess the following characteristic feature:

i) Faces: Crystals are bound by plane faces. The surfaces usually planar and arranged on a definite plane (as a result of internal geometry), which bind crystals are called faces.

Faces are of two types:

Like : A crystal having all faces alike e.g. Fluorspar.

Unlike : A crystal having all faces not alike e.g. Galena.

ii) Form : All the faces corresponding to a crystal are said to constitute a form.

iii) Edges : The intersection of two adjacent faces gives rise to the formation of edge.

iv) Interfacial Angle : The angle between the normals to the two intersecting faces is called interfacial angle.

3. What are the characteristic parameters of unit cell?

Characteristic parameters of unit cell

(i) Crystallographic axes: The lines drawn parallel to the lines of intersection of any three faces of the unit cell which do not lie in the same plane are called crystallographic axes.

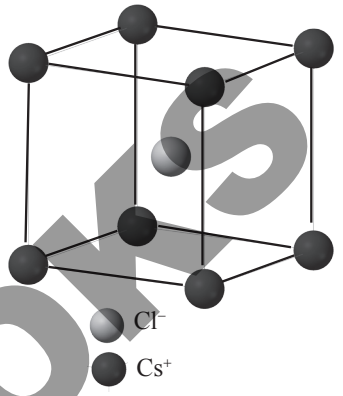
(ii) Each Cs^+ ion is connected to eight Cl^- ions and each Cl^- ion is connected to eight Cs^+ ions i.e., 8:8 coordination. Thus each atom is at the center of a cube of atoms of the opposite kind, so that the coordination number is eight. The unit cell of cesium chloride has one Cs^+ ion and one Cl^- ion as shown below.

No. of Cl^- ions = 8 (At corners) × $(\frac{1}{8})$ (common to eight unit cell)

= $8 \times \frac{1}{8} = 1$

No. of Cs^+ ion = 1 (At the body center) × 1

$1 \times 1 = 1$



Thus, number of CsCl units per unit cell is 1.

Representative crystals having the CsCl arrangements include : CsBr, CsI, TlBr, TlI, NH_4Cl etc.

Problems - Textual Examples

1. Calculate the Miller indices of crystal planes which cut through the crystal axes at (i) (2a, 3b, c), (ii) (a, b, c), (iii) (6a, 3b, 3c), and (iv) (2a, –3b, –3c) .

Solution : We prepare the tables as per the procedure :

(i) (2a, 3b, c).

a	b	c	
2	3	1	intercepts
½	1/3	1	reciprocals
3	2	6	clear fractions

Hence, the Miller indices are (326).

(ii) (a, b, c).

a	b	c	
1	1	1	intercepts
1	1	1	reciprocals
1	1	1	clear fractions

Hence, the Miller indices are (111).

(iii) (6a, 3b, 3c).

a	b	c	
6	3	3	intercepts
1/6	1/3	1/3	reciprocals
1	2	2	clear fractions

Hence, the Miller indices are (122).

5. At room temperature, pollonium crystallizes in a primitive cubic unit cell. If a = 3.36Å, calculate the theoretical density of pollonium; its atomic mass is 209 g mol^{-1}.

Solution : A primitive cubic unit cell contains atoms only at the 8 corners with each corner contributing 1/8th of an atom. Hence n = 8 × (1/8) = 1.

Volume V = a^3 = (3.36Å)^3

$$\rho = \frac{nMm}{N_0 V}$$

$$= \frac{(1)\,209\,g\,mol^{-1}}{(6.022\times10^{23}\,mol^{-1})(3.36\times10^{-8}\,cm)^3}$$

$$= 9.15\ g\ cm^{-3}$$

Problems - Textual Questions

1. How many atoms are there per unit cell in (i) simple cubic arrangement of atoms, (ii) body centred cubic arrangement of atoms, and (iii) face-centred cubic arrangement of atoms?

Solution :

(i) The primitive unit cell consists of one atom at each of the 8 corners, each atom is thus shared by 8 unit cells. Hence n = 8 × $\frac{1}{8}$ = 1.

(ii) The body centred cubic unit cell, consists of 8 atoms at the 8 corners and one atom at the centre. At each corner only $\frac{1}{8}$ th of the atom is within the unit cell. Thus the contribution of the 8 corners is 8 × $\frac{1}{8}$ = 1 while that of the body centred atom is 1. Hence n = 1 + 1 = 2.

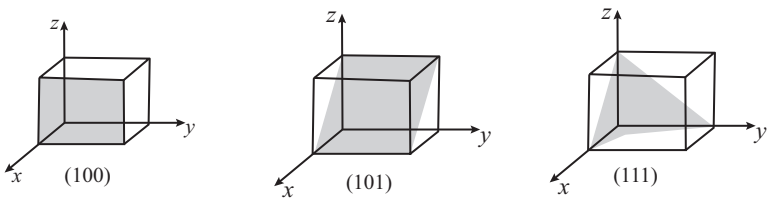
(iii) In face centred cubic unit cell, the 8 atoms at the corners contribute 8 × $\frac{1}{8}$ = 1 atom. There is 1 atom for each of the six faces, which is shared by 2 unit cells each. Hence the contribution face centred atoms = 6 × $\left(\frac{1}{2}\right)$ = 3. Hence n = 1 + 3 = 4.

2. How do the spacings of the three planes (100), (101) and (111) of simple cubic lattice vary?

Solution :

Simple Cubic Lattice

100, 101, 111



9 GASEOUS STATE - I

Important Terms and Definitions

- ***Matter :*** Any object which occupies space and volume.
- ***State of matter :*** Matter exists in three states. i.e., solid, liquid and gas.
- ***Gaseous state :*** It is characterised by the dynamic motion of the molecules and the attraction between these molecules are the least.
- ***Kinetic theory of gases :*** The basic theory which explains the behaviour of gases is known as kinetic theory of gases.
- ***Properties of gases :*** Pressure (P), Volume (V), Temperature (T) and the amount of gas expressed in number of moles (n) are the properties. These can be measured and hence known as measurable properties of gases.
- ***Pressure*** is due to the collision of the molecules on the walls of the container. ie. the number of molecules that collide per unit area of the walls of the container in one second.

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

- ***Temperature :*** It is a measure of hotness or coldness of a body. It is related to the velocity of the molecules and kinetic energy of the molecules.

  Higher the velocity of the gas molecules, lighter is the temperature of the gas. When the molecular motion ceases, at a point, the temperature is said to be 'absolute zero'.
- ***Volume :*** The space available for the gas molecules to move, is known as the volume of the gas.
- ***Number of mole of the gas :*** $\dfrac{\text{Weight of the gas in g.}}{\text{g. molecular weight}}$
- ***Dependence on the measurable properties on each other :*** All the measurable properties are dependent on each other. Increasing the pressure of the gas, increases the temperature, if the volume is kept constant. Similarly, increasing the pressure of the gas decreases the volume of the gas if the temperature is kept constant. Thus, the volume of a gas has to be specified at a pressure and temperature, it has been measured.
- ***Boyle's law :*** At constant temperature, the pressure of given mass of a gas is inversely proportional to its volume. ie., $P \propto \dfrac{1}{V}$ at constant temperature.

$$PV = \text{constant or } P_1V_1 = P_2V_2$$

- ***Vander Waal's*** constants in terms of critical constants.

(i) $P_c = \frac{a}{27b^2}$

(ii) $T_c = \frac{8a}{27Rb}$

(iii) $V_c = 3b$

- ***Joule-Thomson effect :*** The phenomenon of producing lowering of temperature when a gas is made to expand adiabatically from a region of high pressure into a region of low pressure is known as Joule-Thomson effect.
- ***Inversion temperature :*** The temperature below which a gas expands adiabatically into a region of low pressure through a porous plug with a fall in temperature is called as inversion temperature (T_i).

$$T_i = \frac{2a}{Rb}$$

- ***Linde's method :*** It is a method of liquefaction of gas using the principle of Joule-Thomson effect.
- ***Claude's process :*** In this method, compressed air is allowed to do mechanical work of expansion, which is done at the expense of kinetic energy of the gas. Hence a fall in temperature is observed. This principle is combined with Joule-Thomson effect and used in the liquefaction of air.
- ***Adiabatic demagnetisation :*** When a magnetic substance is suddenly demagnetised under adiabatic conditions, a fall in temperature is noticed. By this technique, the temperature as low as zero kelvin can be reached.

Textual Questions

A. Choose the best answer - Textual Questions.

1. A curve drawn at constant temperature is called an isotherm. This shows relationship between ..... .

(a) P and $\frac{1}{V}$ (b) PV and V (c) P and V (d) V and $\frac{1}{P}$ ***[Ans. (c)]***

2. A gas deviates from ideal behavior at ..... .

(a) high T (b) low T (c) high T & low P (d) low T & high P ***[Ans. (d)]***

3. The critical temperature of a gas is that temperature ..... .

(a) above which it can no longer remain in the gaseous state

(b) above which it can not be liquefied by pressure

(c) at which it solidifies

(d) at which volume of gas becomes zero ***[Ans. (b)]***

4. If a gas expands at constant temperature ..... .
   (a) Number of molecules of the gas decreases
   (b) The kinetic energy of the molecules decreases
   (c) The kinetic energy of the molecules remains the same.
   (d) The kinetic energy of the molecules increases *[Ans. (c)]*
5. The molecules of a gas A travel four times faster than the molecules of gas B at the same temperature. The ratio of molecular weight (M_A/M_B) will be ..... .
   (a) $\frac{1}{16}$ (b) 4 (c) $\frac{1}{4}$ (d) 16 *[Ans. (d)]*

Additional One Mark Questions and Answers

1. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I	LIST II
A. $\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$	1. Boyle's law
B. PV = constant	2. Graham's law
C. $\frac{V}{T}$ = constant	3. Ideal gas
D. PV = nRT	4. Charle's law

	A	B	C	D
(a)	1	2	3	4
(b)	4	3	2	1
(c)	2	1	4	3
(d)	1	3	4	2

[Ans. (c)]

2. If a gas diffuses at the rate of one-half as fast as O_2, find the molecular mass of the gas.
   (a) 128 (b) 8 (c) 11.31 (d) 2.83 *[Ans. (a)]*
3. 50ml of gas A effuse through a pin-hole in 146 seconds. The same volume of CO_2 under identical conditions effuse in 115 sec. Calculate the molecular mass of A.
   (a) 17 (b) 71 (c) 170 (d) 710 *[Ans. (b)]*
4. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I	LIST II
A. Permanent Gas	1. 2a/Rb
B. Temporary Gas	2. N_2
C. T_i	3. Low T_c
D. Joule Thomson effect	4. NH_3

4. The adiabatic expansion of a real gas results in ..... .
(a) heating (b) cooling (c) reduction (d) oxidation
[Ans. (b)]

5. The rate of diffusion of gas is ..... to square root of their molecular mass.
(a) inversely proportional (b) directly proportional
(c) equal (d) square *[Ans. (a)]*

C. *Match the following - Textual Questions have been converted into MCQs with relevant options.*

LIST I	LIST II
A. Ideal gas behaviour	1. Critical temperature
B. Adiabatic demagnetization	2. Liquid oxygen
C. CO_2 at 31.1°C	3. Mole fraction of the gas
D. Joule Thomson Experiment	4. Low pressure and high temperature
E. Ratio of the partial pressure to the total pressure	5. Liquid Helium

	A	B	C	D	E
(a)	2	3	5	4	1
(b)	5	4	3	2	1
(c)	3	4	5	1	2
(d)	4	5	1	3	2

[Ans. (c)]

D. *Very Short Answers :* **Textual Questions** **2 Marks**

1. Write the mathematical expression for Boyle's law.

Boyle's law states that for given mass of a gas at constant temperature, the pressure (P) is inversely proportional to its volume (V).

$P \propto \frac{1}{V}$ (at constant temperature) (or) PV = constant

Thus if V_1 is the volume occupied by a given mass of a gas at pressure P_1 and V_2 is the volume when pressure changes to P_2, then as the temperature remains constant, according to Boyle's law.

$$P_1V_1 = P_2V_2 = \text{Constant}$$

2. Compare the partial pressures of gases A and B when 3 moles of A and 5 moles of B mixed in constant volume, and 25°C and 1 atm pressure.

Partial Pressure of A = Mole fraction of A × Total pressure

Mole fraction of A $= \frac{n_A}{n_A + n_B} = \frac{3}{3+5} = \frac{3}{8}$

Mole fraction of B $= \frac{n_B}{n_A + n_B} = \frac{5}{8}$

Partial Pressure of A $= \frac{3}{8} \times 1 = 0.375\,\text{atm}$

9. Give the values of R-gas constant in calories and Joules.

$R = 8.314$ Joule K^{-1} mol^{-1}

$R = 1.987$ cals deg^{-1} mol^{-1}

10. What are the units of Vanderwaals constants 'a' and 'b' ?

Unit of a = atm. dm^6 mol^{-2} (1 litre = 1 dm^3)

[or] $litre^2$ atm. mol^{-2}

Unit of b = dm^3 mol^{-1} (or) litre mol^{-1}

11. Define Joule-Thomson effect.

The phenomenon of producing lowering of temperature when a gas is made to expand adiabatically from a region of high pressure into a region of low pressure, is known as Joule-Thomson effect.

12. What is meant by inversion temperature ?

The characteristic temperature below which a gas expands adiabatically into a region of low pressure through a porous plug with a fall in temperature is called as inversion temperature (Ti).

$$T_i = \frac{2a}{Rb}$$

Additional Very Short Answer Questions

2 Marks

1. What are the measurable properties that describe the gaseous state?

A gaseous state can be described in terms of four parameters which are known as measurable properties such as the volume, V; Pressure, P; Temperature, T and Number of moles, n of the gas in the container.

2. Define Pressure.

Pressure is defined as force per unit area.

3. Define STP.

The conditions of a gas system present at standard temperature and standard pressure are its temperature at 273K and its pressure being at normal atmospheric pressure namely 1.013×10^5 Nm^{-2} (1 atm). Value of R (Gas constant) depends on the different units of pressure and volume.

E. Short Answer : Textual Questions — 3 Marks

1. What is the change in temperature when a compressed real gas is allowed to expand adiabatically through a porous plug?

When a compressed real gas is allowed to expand adiabatically through a porous plug into a region of low pressure, there is appreciable cooling.

When the gas is allowed to escape into a region of low pressure, the molecules move apart rapidly against the intermolecular attractive forces. In this case, work is done by the gas

Questions are given under 2 marks or 3 marks categories based on the points of Answers. It is only for guidance. However, in the exams, the questions may be asked either in 2 marks or 3 marks.

molecules at the expense of internal energy of the gas. Therefore, cooling occurs as the gas expands. This reduction in temperature is referred as Joule-Thomson effect.

2. Write the significance of Vanderwaal's constants. *[Govt. Model Question Paper 2017]*

(i) The term a/V^2 is the measure of the attractive forces of the molecules. It is also called as the cohesion pressure (or) internal pressure.

(ii) The inversion temperature of a gas can be expressed in terms of 'a' and 'b'

$$T_i = \frac{2a}{Rb}$$

(iii) The Vanderwaal's constants 'a' and 'b' enable the calculation of critical constants of a gas.

3. Write the limitations of Vanderwaal equation of state.

(i) It could not explain the quantitative aspect of deviation satisfactorily as it could explain the qualitative aspects of P and V deviations.

(ii) The values of 'a' and 'b' are also found to vary with P and T, and such variations are not considered in the derivation of Vanderwaal's equation.

(iii) Critical constants calculated from Vanderwaal's equation deviate from the original values determined by other experiments.

Additional Short Answer Question

3 Marks

1. Define Dalton's law of partial pressure.

Dalton's law of partial pressure states that at constant temperature, the total pressure exerted by the gaseous mixture is equal to the sum of the individual pressures which each gas would exert if it occupies the same volume of mixture fully by itself. Partial pressure is the measure of the pressure of an individual gas in a mixture of same volume and temperature.

The total pressure P of the gaseous mixture is given by

$P = p_1 + p_2 + p_3$ ..., provided the volume and temperature of mixture and that of the individual gases are the same.

F. Explain briefly on the following: Textual Questions 5 Marks

1. At 27°C, H_2 is leaked through a tiny hole into a vessel for 20 minutes. Another unknown gas at the same T and P as that of H_2 is leaked through the same hole for 20 minutes. After effusion of the gas, the mixture exerts a pressure of 6 atm. The H_2 content of the mixture is 0.7 moles. If volume of the container is 3 litres what is the molecular weight of unknown gas ?

Given :-

Number of moles of H_2 ie. n = 0.7

T = 27 + 273 = 300 K,

R = 0.0821 dm^3 atm deg^{-1}. mol^{-1}

V = 3 litres

Additional Long Answer Questions

5 Marks

1. Explain the measurable properties of gases in detail.

A gaseous state can be described in terms of four parameters which are known as **measurable properties** such as the volume, V; Pressure, P; Temperature, T and Number of moles, n of the gas in the container.

Pressure effect

A gas may be considered to consist of a large number of molecules moving haphazardly all around in a vessel. Due to their constant motion, the molecules may not collide against one another very frequently, but can strike against the walls of the containing vessel. The molecular collisions are regarded as ideal (ie) perfectly elastic, so that there is no loss of energy in these collisions. **Pressure is defined as force per unit area.** This depends upon the number of molecules that strike per unit area of the walls of the container in one second. The greater the number of molecules striking per unit area of the walls in one second, the greater would be the pressure exerted by the gas. Thus for example, when we pump air into a bicycle tube, the number of molecules within the tube increases and hence the number of collisions of the molecules with the walls per second increases and the pressure goes up.

Temperature effect

The kinetic energy of molecules is given by $1/2\ mv^2$ where m is the mass of the molecule and v is the velocity of its motion. When a gas is heated, its temperature increases. Although the mass of the molecule remains constant, its velocity increases. This causes an increase in kinetic energy. Therefore the molecules strike the wall of the containing vessel more frequently. In this case there is no change in the number of molecules, but the number of collisions against the walls of the container in a given time increases. Therefore the pressure of the gas increases with rise in temperature when the amount and its volume remain constant.

Volume effect

The volume of the container is considered as the volume of the gas sample. This is considered from the postulates of kinetic theory of gases. That is, the volume of gas molecules themselves are negligible compared to the container volume. Volume of gas is determined by its pressure, temperature and number of moles at any instant.

Number of moles (n) effect

Effects of pressure and volume of a gas bear a direct proportionality with number of moles. When `n' increases the number of molecules colliding against the wall of container increases. This effect increases the pressure of the gas. When the amount of gas increases the volume occupied by themselves also, increases.

2. Derive equation of state for an ideal gas.

Gases which obey Boyle's law and Charle's law are known as ideal gases. By combining these two laws, an equation of state of an ideal gas can be derived.

According to Boyle's law at constant temperature,

$$P \alpha \frac{1}{V}$$

$$\frac{T_c}{P_c} = \frac{8a}{27Rb} \times \frac{27b^2}{a} = \frac{8b}{R} \quad \text{..... (iii)}$$

Given T_c = 33.2°C = 33.2 + 273 = 306.2K and P_c = 12.4 atm; R = 0.082 atm. litre $K^{-1}mol^{-1}$. Substituting the values in equation (iii), we get

$$\frac{306.2}{12.4} = \frac{8 \times b}{0.082}$$

$$b = \frac{306.2 \times 0.082}{12.4 \times 8} = 0.253 \text{ litre mol}^{-1}.$$

Now, substituting the value of `b' in equation (i) we have

$$T_c = \frac{8a}{27Rb} \text{ (or) } 306.2$$

$$= \frac{8 \times a}{27 \times 0.082 \times 0.253}$$

(or) a = 21.439 atm $litre^2$ mol^{-1}

Problems - Self Test - Textual Questions

1. Calculate the partial pressures of O_2 and H_2 in a mixture of 3 moles of O_2 and 1 mole of H_2 at S.T.P.

$$p_{O_2} = \frac{\text{Number of moles of } O_2}{V} \times RT$$

$$p_{H_2} = \frac{\text{Number of moles of } H_2}{V} \times RT$$

$$\text{Mole fraction of } O_2 = X_{O_2} = \frac{3}{4} = 0.75$$

$$\text{Mole fraction of } H_2 = X_{H_2} = \frac{1}{4} = 0.25 \qquad (X_2 + X_1 = 1.0)$$

$$\text{But } P = \frac{RT}{V} \text{ and } V = 22.4 \text{ lit at S.T.P.}$$

For 4 moles V = 22.4 × 4 lit ; R = 0.0821 ; T = 278K

$$P = \frac{0.0821 \times 278}{22.4 \times 4} = 0.2501 \text{ atm}$$

$$p_{O_2} = 0.75 \times 0.2501 = 0.1876 \text{ atm}$$

$$p_{H_2} = 0.25 \times 0.2501 = 0.0625 \text{ atm}$$

10 CHEMICAL BONDING

Important Terms and Definitions

- ***Chemical bonding :*** It is the force of attraction that exists between two atoms (or more atoms) in a molecule. There are various types of bonds (i) ionic bond (ii) covalent bond (iii) co-ordinate covalent bond.
- ***Kossel-Lewis approach to chemical bonding :*** The formation of a bond that results from the transfer of one or more electrons from an atom to another amongst themselves to attain the nearest inert gas configuration is known as ionic bond.

  The approach does not explain the formation of homonuclear diatomic molecules like H_2, O_2 etc.
- ***G.N.Lewis approach to chemical bonding*** where one or more pairs of electrons may be shared by the bonded atoms to attain the stable nearest inert gas configuration. Subsequently, with our understanding of the structure of atom, existence of atomic orbitals, the formation of covalent bond is overlapping of atomic orbitals with suitable energy each containing one unpaired electron.
- ***A covalent bond*** is further classified into (i) a non polar covalent bond and (ii) a polar covalent bond. A non polar covalent bond is formed between elements having the same value of electronegativity while a polar covalent bond is formed between the atoms having different electronegativities. H_2 is a non polar molecule and HCl is a polar molecule (i.e., a molecule with a non polar covalent bond and a polar covalent bond respectively).
- ***The major difference between an ionic bond and a covalent bond*** is that while an ionic bond has no directional characteristics, covalent bond has directional characteristics. This explains why covalent compounds have a definite shape and geometry. The shape and geometry of the covalent bond is explained by

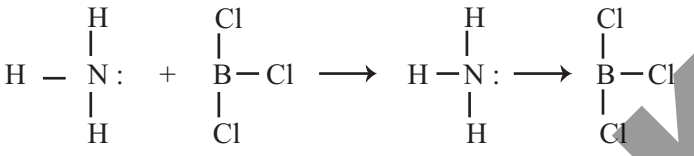
  (i) Valence Shell Electron Pair Repulsion Theory (VSEPR Theory) and

  (ii) Valence Bond Theory
- ***According to valence shell electron pair repulsion theory,*** in any molecule, there will be a central atom, which are bonded to other atoms. The pair of electrons which are bonded to other atoms is known as "bond pair of electrons". There will be pair of electrons in the bonded atoms which do not take part in bond formation. These are known as "lone pair of electrons". These atoms position themselves in space in such a way that repulsions between bond pair-bond pair of electrons, bond pair-lone pair of electrons and lone pair-lone pair of electrons are

the nearest minimum. This gives a specified geometry for the moleucle. Using this theory, the shapes of many molecules like $BeCl_2$, BF_3, CH_4, PCl_5 etc. can be explained.

Another type of bonding is ***coordinate covalent bond.*** In this type of bond, an atom in a compound (donor atom) has a lone pair of electrons and another atom in another compound has a deficient octet (acceptor atom).

The donor atom donates the electron pair to the acceptor atom and both the donor and acceptor atom shares the pair of electrons e.g.,



donor atom acceptor atom coordinate covalent bond

- ***In terms of orbital overlap concept,*** the filled orbital of the nitrogen (sp^3 hybrid orbitals) overlaps with the valence orbital of boron (sp^3 hybrid orbitals) and form a co-ordinate covalent bond (dative bond). It must be known that co-ordinate covalent bond differs from the covalent bond, only in its method of formation. Once the co-ordinate covalent bond is formed, practically there is no difference from the covalent bond with respect to its characteristics.

Textual Questions

A. Choose the correct answer :

1. The crystal lattice of electrovalent compounds is composed of _____.
   (a) Atoms (b) Molecules
   (c) Oppositely charged ions (d) Both molecules and ions *[Ans. (c)]*
2. The compound which contains both ionic and covalent is _____.
   (a) CH_4 (b) H_2 (c) KCN (d) KCl *[Ans. (c)]*

Additional One Mark Questions and Answers

I. Choose the best answer :

1. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I	LIST II
A. $BeCl_2$	1. Tetrahedral
B. NH_4^+	2. Octahedral
C. PCl_5	3. Linear
D. SF_6	4. Trigonal Bipyramidal

	A	B	C	D
(a)	3	2	4	1
(b)	2	4	1	3
(c)	4	1	3	2
(d)	4	3	2	1

[Ans. (b)]

4. Two atoms of similar electronegativity are expected to form _____ compounds.
   (a) co-orolinate (b) ionic (c) complex (d) covalent *[Ans. (d)]*
5. Repulsion between bond pair-bond pair is _____than in between lone pair-lone pair.
   (a) higher (b) lesser (c) superior (d) greater
   [Ans. (b)]

C. *Match the following - Textual Questions have been converted into MCQ's with relevant options.*

LIST I	LIST II
A. Electrovalent bonding	1. Benzene
B. Covalent Bonding	2. Heitler and London
C. Valence Bond theory	3. Electron transfer
D. Polarised Bond	4. Electron sharing
E. Resonance	5. Fajan's theory

	A	B	C	D	E
(a)	2	4	5	1	3
(b)	3	5	2	4	1
(c)	5	3	1	2	4
(d)	4	5	3	1	2

[Ans. (c)]

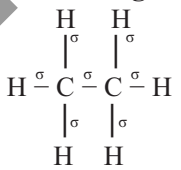
D. *Very Short Answers :* Textual Questions — 2 Marks

1. Arrange NaCl, $MgCl_2$ and $AlCl_3$ in the increasing order of covalent character.

$AlCl_3 > MgCl_2 > NaCl$. Al^{3+} ion has a higher polarising power. The polarising power of the cation decrease in the order $Al^{3+} > Mg^{2+} > Na^{+}$. Greater the charge of the cation, more is the polarization.

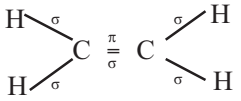
2. Find σ and π bonds in the following : CH_3-CH_3, $CH_2 = CH_2$, $CH \equiv CH$

$CH_3 - CH_3 \longrightarrow$



7 sigma bonds

$CH_2 = CH_2 \longrightarrow$



1 π bond 5 σ bonds

$CH \equiv CH \longrightarrow$

2 π bonds 3 σ bonds

3. Among Na^{+}, Ca^{+2}, Mg^{+2}, Al^{+3} which has high polarising power?

Al^{+3}. Greater the charge on the cation, greater is its polarising power.

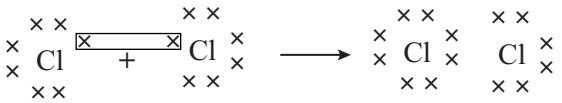
Questions are given under 2 marks or 3 marks categories based on the points of Answers. It is only for guidance. However, in the exams, the questions may be asked either in 2 marks or 3 marks.

10. What is covalent bond?

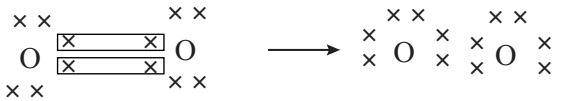
A covalent bond is a chemical bond formed when two atoms mutually share a pair of electron.

11. Give the Lewis dot structure of (i) Cl_2 (ii) O_2

(i)



(ii)



E. Short Answer : Textual Questions 3 Marks

1. sp^3 hybridisation is involved in CH_4, H_2O and NH_3. Why are the bond angles different in three cases?

In CH_4 there are four bond pairs of electrons. In H_2O, there are two bond pair and two lone pair of electrons. In NH_3, there are three bond pair and one lone pair of electrons. As lone pair - lone pair repulsion increases, there is decrease in tetrahedral bond angle as we move from CH_4 to NH_3 to H_2O.

2. What is meant by electrovalent bond? Explain the bond formation in $AlBr_3$ and CaO.

The electrostatic attraction force existing between the cation and the anion produced by the electron transfer from one atom to the other is known as the ionic (or) electrovalent bond.

Bond Formation $AlBr_3$:

$$Al \rightarrow Al^{3+} + 3e^-$$
$$2p^6\ 3s^2\ 3p^1 \qquad (2s^2, 2p^6)$$
$$3\ Br + 3e^- \rightarrow 3\ Br^-$$
$$(4s^2\ 4p^5) \qquad (4s^2\ 4p^6)$$
$$Al^{3+} + 3Br^- \rightarrow AlBr_3 \text{ (ionic bond)}$$

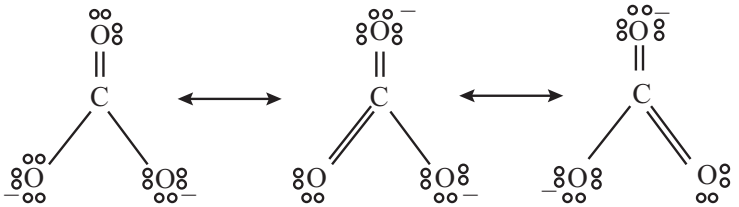
CaO : In CaO, which is an ionic compound, the formation of the ionic bond involves two electron transfers from Ca to O atoms. Thus, doubly charged positive and negative ions are formed.

$$\underset{3p^6\,4s^2}{Ca} \xrightarrow{\text{ionisation}} Ca^{2+} + 2e^- \text{ (Calcium cation)}$$

$$\underset{2s^2\,2p^4}{O_2} + 2e^- \xrightarrow[\text{affinity}]{\text{electron}} \underset{2s^2\,2p^6}{O^{2-}} \text{ (Oxide anion)}$$

$$Ca^{2+} + O^{2-} \xrightarrow[\text{attraction}]{\text{electrostatic}} \underset{\text{ionic compound}}{CaO}$$

Resonance structure of CO_3^{2-} ion



F. *Explain briefly on the following:* Textual Questions 5 Marks

1. Discuss the important properties of electrovalent compounds.

The important characteristics of an electrovalent or ionic compound are :

(i) They have high melting and boiling points.

(ii) They are poor conductors in the solid state but their aqueous solutions conduct electricity.

(iii)They exist only as ions packed in a definite three dimensional manner.

(iv) They are soluble in polar solvents like H_2O and insoluble in non polar solvents like benzene.

(v) Electrovalent compounds having the same electronic configuration exhibit isomorphism.

2. Calculate the lattice energy of NaCl using Born-Haber cycle.

The lattice enthalpy of NaCl is the sum of the enthalpy changes shown below.

$Na(s) \longrightarrow Na(g)$ ΔH°_1 = Atomisation = +108.70 (kJ mol^{-1})

$Na(g) \longrightarrow Na^+(g) + e$ ΔH°_3 = Ionisation energy = +495.00

$\frac{1}{2}Cl_2(g) \longrightarrow Cl(g)$ ΔH°_2 = Dissociation energy = +122.00

$Cl(g) + e \longrightarrow Cl^-(g)$ ΔH°_4 = Electron affinity = –349.00

$Na^+(g) + Cl^-(g) \longrightarrow NaCl(s)$ ΔH°_5 = Lattice energy = LE

$$\Delta H^\circ_f = \Delta H^\circ_1 + \Delta H^\circ_2 + \Delta H^\circ_3 + \Delta H^\circ_4 + \Delta H^\circ_5$$

$$-411.3 = 108.7 + 122.0 + 495 - 349 + LE$$

$$LE = -788.0 \text{ kJ mol}^{-1}$$

Lattice enthalpy value is written with reversed sign.

$\therefore$ Lattice energy of $NaCl(s) \longrightarrow Na^+(s) + Cl^-(s)$, is +788.0 kJ mol^{-1}

3. Explain the important properties of covalent compounds.

The important properties of covalent compounds are -

(i) These compounds exist as neutral molecules and not as ions.

(ii) They do not conduct electricity in fused or molten state.

(iii) They possess low melting and boiling points.

(iv) Because of their directional nature, they possess definite geometry.

(v) They are soluble in non polar solvents and insoluble in polar solvents.

4. Discuss the partial covalent character in ionic compounds using Fajan's rule.

The phenomenon of deformation of anion by a cation is known as polarisation. Greater, the extent of polarisation of the anion by the cation, greater is the covalent character. Generally,

(iv) Electron gain for Cl to Cl^- is –355 kJ mol^{-1}

(v) $\Delta H_f^{(o)}$ overall is –795 kJ mol^{-1}

ΔH^0_1 for Sublimation $Ca(s) \longrightarrow Ca(g) = 121.0$ kJ mol^{-1}

ΔH^0_2 for Ionisation $Ca(g) \longrightarrow Ca^{2+}(g) + x = 2422.0$ kJ mol^{-1}

ΔH^0_3 for Dissociation $Cl_2(g) \longrightarrow 2Cl(g) = 242.8$ kJ mol^{-1}

ΔH^0_4 for Electron gain enthalpy (g) $2Cl(g) + 2e^- \longrightarrow 2Cl^-(g) = 2 \times 355$ kJ mol^{-1}

ΔH^0_5 for $2Cl^-(g) + Ca^{2+}(g) \longrightarrow CaCl_2(s)$ LE

ΔH°_f of $CaCl_2$ = – 795 kJ mol^{-1}

$\therefore$ – 795 = 121 + 2422 + 242.8 – (2 × 355) + LE

= 2785.8 – 710 + LE

= 2075.8 + LE

$\therefore$ LE = – 795 – 2075.8 = –2870.8 kJ mol^{-1}

(for lattice enthalpy sign has to be reversed).

This is the energy released for the reaction for the reaction

$Ca^{2+} + 2Cl^- \longrightarrow CaCl_2$ for the reaction

Lattice enthalpy of $CaCl_2$ is = + 2870.8 kJ mol^{-1}

Additional Long Answer Questions

5 Marks

1. Explain the formation of NaCl.

Formation of NaCl molecule from sodium and chlorine atoms can be considered to take place according to Kossel's theory by an electron transfer as:

(i) $Na \xrightarrow{\text{loss of e}} Na^+ + e^-$

$[Ne]3s^1$ [Ne]

where [Ne] = electronic configuration of Neon

= $2s^2\,2p^6$

(ii) $Cl + e^- \xrightarrow{\text{gain of } e^-} Cl^-$

$[Ne]3s^2\,3p^5$ [Ar]

[Ar] = electronic configuration of Argon

(iii) $Na^+ + Cl^- \xrightarrow[\text{attraction}]{\text{electrostatic}} NaCl$ (or) Na^+Cl^-

NaCl is an electrovalent or ionic compound made up of sodium ions and chloride ions. The bonding in NaCl is termed as electrovalent or ionic bonding. Sodium atom loses an electron to attain Neon configuration and also attains a positive charge. Chlorine atom receives the electron to attain the Argon configuration and also becomes a negatively charged ion. The coulombic or electrostatic attraction between Na^+ and Cl^- ions result in NaCl formation.

11 COLLIGATIVE PROPERTIES

Important Terms and Definitions

- ***Solution :*** A homogeneous mixture of two or more substances.
- ***Colligative Property :*** The characteristic properties of a dilute solution which depend only on the number of solute particles and not on their chemical nature.
- ***Vapour pressure of a liquid :*** The pressure exerted by the vapour, when it is in equilibrium with its own liquid.
- ***Raoult's Law :*** The vapour pressure of a solution (p) is directly proportional to the mole fraction of the solvent (X_1) present in solution, at constant temperature.
- ***Lowering of vapour pressure :*** The difference between the vapour pressure of the pure solvent (p) and that of the solution (p^0) is known as lowering of vapour pressure.
- ***Relative lowering of vapour pressure :*** The ratio between the lowering of vapour pressure to that of the vapour pressure of pure solvent is known as the relative lowering of vapour pressure.
- ***Freezing point of a solvent (T^0) :*** The temperature at which vapour pressure of the solid solvent is equal to the vapour pressure of the liquid.
- ***Freezing point of a solution (T) :*** The temperature at which the vapour pressure of the solution is equal to the vapour pressure of the solid solvent.
- ***Depression in freezing point (ΔT_f) :*** The difference between the freezing point of solvent to that of the solution ($T - T^0 = \Delta T_f$).
- ***Cryoscopic or molal depression constant :*** It is the depression in freezing point produced when one mole of a solute is dissolved in one kg of the solvent.
- ***Boiling point of a liquid :*** The temperature at which the vapour pressure of a liquid becomes equal to the atmospheric pressure.
- ***Elevation of boiling point :*** The difference between the boiling point of pure solvent (T^0) and the boiling point of the solution (T).
- ***Ebullioscopic constant (or) molal elevation constant :*** It is the elevation of boiling point produced when one mole of the solute is dissolved in 1 kg of the solvent.
- ***Osmosis :*** The spontaneous movement of the solvent particles to the solution side when the solvent and the solution are separated by a semipermeable membrane.
- ***Osmotic pressure :*** It is the excess hydrostatic pressure that must be applied to the solution side to prevent osmosis.

- ***Hypotonic solution :*** A solution having lower osmotic pressure with respect to another solution.
- ***Hypertonic solution :*** A solution having higher osmotic pressure with respect to another solution.
- ***Isotonic solutions :*** Two solutions of different substances having the same osmotic pressure at the same temperature.
- ***Abnormal colligative properties :*** Experimental values of colligative properties, which differ from those obtained theoretically.
- ***Vant Hoff factor 'i' :*** The extent to which solutes which undergo dissociation or association in a given solvent.

$$i = \frac{\text{Experimental colligative property}}{\text{Normal (or) theoretical colligative property}}$$

- **Degree of dissociation** $\alpha_{dissociation} = \frac{i-1}{n-1}$

  where 'i' is *Vant Hoff factor*; *n* is the total number of particles furnished by one molecule of the solute.

- **Degree of association** $\alpha_{association} = \frac{(1-i)n}{n-1}$

  where 'i' is *Vant Hoff factor*; and '*n*' is the number of small molecules that associate into a single larger new molecule.

Textual Questions

A. Choose the best answer - Textual Questions.

1. Properties which depend only on number of particles present in solution are called _____.
   (a) Additive (b) Consecutive (c) Colligative (d) None ***[Ans. (c)]***
2. Which solution would possess the lowest boiling point _____.
   (a) 1% NaCl solution (b) 1% Urea solution
   (c) 1% glucose solution (d) 1% sucrose solution ***[Ans. (a)]***
3. In cold countries, ethylene glycol is added to water in the radiators of cars during winters. It results in _____.
   (a) Lowering boiling point (b) Reducing viscosity
   (c) Reducing specific heat (d) Lowering freezing point ***[Ans. (d)]***
4. Which of the following 0.1 M aqueous solutions will have the lowest freezing point?
   (a) Potassium Sulphate (b) Sodium Chloride
   (c) Urea (d) Glucose ***[Ans. (a)]***
5. The Van't Hoff factor of 0.005M aqueous solution of KCl is 1.95. The degree of ionisation of KCl is _____.
   (a) 0.94 (b) 0.95 (c) 0.96 (d) 0.59 ***[Ans. (b)]***

Additional One Mark Questions and Answers

I. Choose the best answer :

1. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I		LIST II	
A	Relative lowering of vapour pressure	1	Berkley-Hartley method
B	Depression in freezing point	2	Cottrell's Method
C	Elevation of boiling point	3	Beckmann method
D	Osmotic Pressure	4	Ostwald-Walker method

	A	B	C	D
(a)	4	3	2	1
(b)	3	4	1	2
(c)	2	1	3	4
(d)	3	1	4	2

[Ans. (a)]

2. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I		LIST II	
A	Raoult's law	1	$\pi \propto C$
B	Boiling point elevation	2	$\pi \propto CT$
C	Boyle's - Vant Hoff law	3	$p = p^{\circ}X_1$
D	Charle's - Vant Hoff law	4	$\Delta T_b = K_b\, m$

	A	B	C	D
(a)	4	3	2	1
(b)	3	4	1	2
(c)	2	1	3	4
(d)	3	1	4	2

[Ans. (b)]

4. How will you calculate the molecular weight of solute by measuring the osmotic pressure value?

(a) $M_2 = \frac{\pi V}{RT}$ (b) $M_2 = \frac{RT}{\pi V}$ (c) $M_2 = \frac{W_2RT}{\pi V}$ (d) $M_2 = \frac{\pi V}{W_2RT}$

[Ans. (c)]

5. Calculate the vapour pressure of the solution. The mole fraction of the solute is 0.3. The vapour pressure of the pure solvent is 0.9atm.

(a) 0.6 atm (b) 0.63 atm (c) 0.67 atm (d) 6 atm *[Ans. (b)]*

6. Statement I : Beckmann thermometer is used to measure small temperature changes.

Statement II : Temperature differences of even 0.01K can be measured using Beckmann thermometer.

(a) Statement II explains statement I (b) Statement II does not explain statement I

(c) Only statement I is correct (d) Both the statements are wrong. *[Ans. (a)]*

2. A liquid having high vapour pressure has _____ boiling point.
   (a) high (b) effective (c) low (d) negative *[Ans. (c)]*
3. The least count of Beckmann's thermometer is _____.
   (a) 0.01 k (b) 0.01 k (c) 0.001 k (d) 1 k *[Ans. (a)]*
4. Molal elevation constant is a characteristic constant for given _____.
   (a) solute (b) solution (c) substance (d) solvent *[Ans. (d)]*
5. Semipermeable membrane allows the passage of _____through it.
   (a) solvent (b) solute (c) substance (d) solution *[Ans. (a)]*
6. For a deliquescence to occur, the vapour pressure of water in the air must be _____ than that of the saturated solution.
   (a) greater (b) much greater (c) higher (d) lesser *[Ans. (d)]*
7. Depression in freezing point is _____ pronounced if camphor is used as a solvent in place of water for same amount of solute and solvent.
   (a) less (b) more (c) not at all (d) most *[Ans. (b)]*
8. Every solution behaves as ideal solution _____.
   (a) at concentrate stage (b) at moderate concentration stage
   (c) at concentrate stage (d) at super saturated stage *[Ans. (c)]*
9. The osmotic pressures of 0.1M glucose and 0.1M NaCl solutions are _____.
   (a) different (b) same (c) identical (d) isotonic *[Ans. (a)]*
10. Solutions that have same osmotic pressure are called _____ solutions.
   (a) Isomeric (b) Identical (c) Isotonic (d) Isomorphic
   [Ans. (c)]

C. *Very Short Answers :* Textual Questions — 2 Marks

1. What are colligative properties?

Colligative properties are the properties of dilute solutions which depend only on the number of solute particles and not on their chemical nature.

2. Define relative lowering of vapour pressure.

The ratio between the lowering of vapour pressure (p° – p) to the vapour pressure of the pure solvent (p°) is known as the relative lowering of vapour pressure.

3. What do you understand by molal elevation of boiling point? What are abnormal solutes?

The elevation in boiling point produced by a one molal solution of a non-volatile, non-electrolyte solute in a given solvent is known as molal elevation of boiling point.

Abnormal solutes, are those which undergo dissociation or association in a given solvent.

4. Volatile hydrocarbons are not used in the brakes of automobile as lubricant, but non-volatile hydrocarbon are used as lubricants. Why?

If volatile hydrocarbons are used, they volatilise and the lubricant properties are lost.

5. Prove that the depression in freezing point is a colligative property.

A 1 molar solution of glucose and a 1 molar solution of urea, produce the same depression in freezing point. A 1M solution of glucose and a 1M solution of urea have the same number of solute particles. Hence the depression in freezing point is a colligative property.

Problems - Textual Questions

1. The vapour pressure of pure benzene at a certain temperature is 640 mm of Hg. A non-volatile non-electrolyte solid weighing 2.175 g is added to 39 g of benzene. The vapour pressure of the solution is 600 mm of Hg. What is molecular weight of solid substance?

Solution :

Vapour pressure of benzene (p°) = 640 mm Hg

Vapour pressure of the solution (p) = 600 mm Hg

Weight of the solute (W_2) = 2.175 g

Weight of the solvent (W_1) = 39.0 g

Molecular weight of solvent (M_1) = 78 g mol^{-1}

Molecular wt. of solvent : Benzene C_6H_6
$= (1\times6) + (12\times6)$
$= 6 + 72 = 78$

According to Raoult's law,

$$\frac{p^o - p}{p^o} = \frac{W_2}{M_2}\times\frac{M_1}{W_1}$$

$$\frac{640-600}{640} = \frac{2.175}{M_2}\times\frac{78}{39}$$

$$M_2 = \left(\frac{2.175\times78}{39}\times\frac{640}{40}\right) = 69.6 \text{ g mol}^{-1}$$

2. Calculate the freezing point of an aqueous solution of a non-electrolyte having an osmotic pressure 2.0 atm at 300 K. K_f = 1.86 k.kg.mol^{-1}. R = 0.0821 lit.atm.k^{-1} mol^{-1}

Solution :

π = 2.0 atm, R = 0.0821 lit.atm.k^{-1} mol^{-1}, T = 300 K, V = 1 litre, K_f = 1.86 k.kg.mol^{-1}

Applying the formula,

$$\boxed{\pi = CRT}$$

$$C = \frac{\pi}{RT} = \frac{2.0}{0.0821\times300}$$

$$C = 0.0812$$

$$\frac{n_2}{V} = 0.0812 \qquad \boxed{\because\ C = \frac{n_2}{V}}$$

$$n_2 = 0.0812$$

Assuming the density of the solution = 1,

Molality of the solution, m = 0.0812

$$\Delta T_f = K_f \times m$$

$$= 1.86\text{K Kg mol}^{-1} \times 0.0812$$

$$\Delta T_f = 0.151$$

$$\boxed{\Delta T_f = T^0 - T}$$

$$0.151 = 0 - T$$

$$T = 0 - 0.151$$

$$T = -0.151°C$$

Observed molecular mass, $M_2 = \frac{1.86 \times 0.5 \times 1000}{100 \times 0.24} = 38.75\ g.mol^{-1}$

The colligative property is inversely related to the molar mass.

$\therefore$ Van't Hoff factor, $i = \frac{\text{Observed colligative property}}{\text{Normal colligative property}}$

$= \frac{\text{Theoretical molar mass}}{\text{Observed molar mass}}$

Vant Hoff factor, $i = \frac{74.5}{38.75} = 1.92$

Degree of dissociation, $\alpha = \frac{i-1}{n-1}$

n = 2 for KCl

$\therefore \alpha = \frac{1.92-1}{2-1} = 0.92$

$\therefore$ Degree of dissociation = 0.92.

10. The depression in the freezing point of a benzene solution containing 0.784g of Acetic acid dissolved in 100ml of benzene is 0.35k. Calculate the van't Hoff factor and the degree of association of the solute at this concentration

(k_f for benzene = 5.10 k.kg.mol^{-1}, molar mass of acetic acid is 60.01).

$\Delta T_f = 0.35k$

$M_2 = \frac{k_f . W_2}{\Delta T_f . W_1}$

$= \frac{5.10 \times 0.784 \times 1000}{100 \times 0.35} = 114.24$

The colligative property is inversely related to molar mass.

$\therefore$ Van't Hoff factor, $i = \frac{\text{Observed colligative property}}{\text{Normal colligative property}} = \frac{\text{Theoretical molar mass}}{\text{Observed molar mass}}$

Van't Hoff factor, $i = \frac{60}{114.24} = 0.525$

Degree of association, $\alpha = \frac{n(1-i)}{n-1}$

n = 2 for dimerisation

Acetic acid exist as dimers in benzene

$\alpha = 2\frac{(1-0.525)}{2-1} = 0.95$

$\therefore$ Degree of association = 0.95.

12 THERMODYNAMICS – I

Important Terms and Definitions

- ***Thermodynamics*** deals with the relationship between heat and work. It is derived from Greek word 'Thermos' meaning heat and 'dynamics' meaning flow.
- ***Energy :*** It is the capacity to do work.
- ***Forms of energy :*** There are various forms of energy viz. thermal or heat, mechanical, potential, kinetic, electrical energy etc.
- ***Transformation of energy :*** One form of energy can be transformed into another form of energy.
- ***System :*** Thermodynamically a system is defined as any portion of matter under consideration which is separated from the rest of the universe by real or imaginary boundaries.
- ***Surroundings :*** Everything in the universe that is not the part of system and can interact with it is called as surroundings.
- ***Boundary :*** Anything (fixed or moving) which separates the system from its surroundings is called boundary.
- ***Isolated system :*** A system which can exchange neither energy nor matter with its surroundings is called as isolated system.
- ***Closed system :*** A system which permits the exchange of energy but not mass, across the boundary with its surroundings is called a closed system.
- ***Open system :*** A system is said to be open if it can exchange both energy and matter with its surroundings.
- ***Homogeneous system :*** If the physical states of all the matter is uniform throughout the system, it is known as homogeneous system.
- ***Heterogeneous system :*** If the physical state of all the matter is not uniform throughout the system, it is known as heterogeneous system.
- ***Macroscopic properties of a system :*** The properties associated with the bulk of the system are referred to as macroscopic properties of a system. eg. Pressure, volume, temperature, density, viscosity, refractive index etc.
- ***Intensive properties :*** The properties that are independent of the mass or size of the system are known as intensive properties. eg. refractive index, surface tension, density, temperature, boiling point, freezing point etc.
- ***Extensive properties :*** The properties that depend on the mass or size of the system are known as extensive properties. eg., Volume, number of moles, mass, energy, internal energy etc.
- ***State of a system :*** The state of a system is defined by specifying values for the macroscopic properties of the system.

3. Which of the following is an exothermic reaction?
   (a) melting of ice (b) combustion reactions
   (c) hydrolysis (d) boiling of water *[Ans. (b)]*
4. Which of the following is reversible process?
   (a) Diffusion (b) melting (c) neutralization (d) combustion
   [Ans. (b)]
5. In which process, work is maximum?
   (a) reversible (b) irreversible (c) exothermic (d) cyclic *[Ans. (a)]*

Additional One Mark Questions and Answers

I. Choose the correct answer :

1. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I	LIST II
A Extensive property	1 Freezing of liquid
B Intensive Property	2 Melting of solid
C Exothermic	3 Mass
D Endothermic	4 Density

	A	B	C	D
(a)	1	2	3	4
(b)	3	4	1	2
(c)	2	3	4	1
(d)	4	1	2	3

[Ans. (b)]

2. When no work is done by one portion over another portion, it implies _____ equilibrium.
   (a) Mechanical (b) Chemical (c) Thermodynamic (d) None of these
   [Ans. (a)]
3. Statement I : Enthalpy is a state function.
   Statement II : Enthalpy depends on U, P, V
   (a) Statement II explains statement I (b) Statement I explains statement II
   (c) Statement I is false (d) Statements II is false *[Ans. (a)]*
4. From the following data at constant volume for combustion of benzene, calculate the heat (ΔH) of this reaction at constant pressure condition. $C_6H_{6(l)} + 7\frac{1}{2}O_{2(g)} \rightarrow 6CO_{2(g)} + 13H_2O_{(l)}$
   $\Delta E_{25°C} = -781.1$ k cal
   (a) –782 k cal (b) 78.2 K cal (c) 7.82 k cal (d) +728 k cal
   [Ans. (a)]
5. Pick out the odd one among the following.
   (a) Pressure – Volume work is referred as mechanical work
   (b) Work = F.s
   (c) Work is an algebraic quantity
   (d) Heat is a path function *[Ans. (d)]*

B. *Fill in the blanks-Textual questions have been converted into MCQs with relevant options.*

1. Translational energy of molecules is a part of _____ energy of the system.
   (a) external energy (b) solar energy (c) chemical energy (d) internal energy *[Ans. (d)]*
2. Specific heat of a liquid system is _____ property.
   (a) extensive (b) intensive (c) thermal (d) chemical *[Ans. (b)]*
3. Work done in the reversible expansion is _____ *[Govt. Model Question Paper 2017]*
   (a) maximum (b) minimum (c) slow (d) very slow *[Ans. (a)]*
4. Combustion is an _____ process.
   (a) reversible (b) cyclic (c) exothermic (d) endothermic *[Ans. (c)]*
5. Heat of neutralisation of a strong acid is _____ than that of a weak acid.
   (a) lesser (b) greater (c) equal (d) very less *[Ans. (b)]*

C. *Very Short Answers :* **Textual Questions** **2 Marks**

1. Name the equipment using which heat of combustion of compounds are determined.
The equipment used for determining heat of combustion is known as bomb calorimeter.

2. Energy can be created and be destroyed. State whether this is true or false.
The statement is false. According to first law of thermodynamics, energy can neither be created nor destroyed.

3. Define zeroth law of thermodynamics. *[Govt. Model Question Paper 2017]*
If two systems at different temperatures are separately in thermal equilibrium with a third one, then they tend to be in thermal equilibrium with themselves.

4. Give the relation between ΔU and ΔH.
$\Delta H = \Delta U + P\Delta V$. For gaseous reaction $\Delta H = \Delta U + \Delta n_g RT$.

5. Define an adiabatic process.
Adiabatic process is defined as that one which does not exchange heat with its surroundings during the change from initial to final states of the system.

6. What are intensive and extensive properties?
Intensive properties : The properties that are independent of the mass or size of the system are known as intensive properties. eg. refractive index, surface tension, density, temperature, boiling point, freezing point etc.
Extensive properties : The properties that depend on the mass or size of the system are known as extensive properties. eg., Volume, number of moles, mass, energy, internal energy etc.

7. Define first law of thermodynamics.
"Energy may be converted from one form to another, but cannot be created or be destroyed".

Questions are given under 2 marks or 3 marks categories based on the points of Answers. It is only for guidance. However, in the exams, the questions may be asked either in 2 marks or 3 marks.

Additional Very Short Answer Questions

2 Marks

1. Define thermodynamics.

'Thermos' meaning heat and 'dynamics' meaning flow. Thermodynamics deals with the inter-relationship between heat and work. It is concerned with the interconversions of one kind of energy into another without actually creating or destroying the energy.

2. Define System.

Thermodynamically a system is defined as any portion of matter under consideration which is separated from the rest of the universe by real or imaginary boundaries.

3. Define Surroundings.

Everything in the universe that is not the part of system and can interact with it is called as surroundings.

4. Define Boundary.

Anything (fixed or moving) which separates the system from its surroundings is called boundary.

5. Define Isolated system.

A system which can exchange neither energy nor matter with its surroundings is called as isolated system. For example, a sample in a sealed thermos flask with walls made of insulating materials represents an isolated system.

6. Define Closed system.

A system which permits the exchange of energy but not mass, across the boundary with its surroundings is called a closed system.

For example: A liquid in equilibrium with its vapours in a sealed tube represents a closed system since the sealed container may be heated or cooled to add or remove energy from its contents while no matter (liquid or vapour) can be added or removed.

7. Define Open system.

A system is said to be open if it can exchange both energy and matter with its surroundings.

For example: An open beaker containing an aqueous salt solution represents open system. Here, matter and heat can be added or removed simultaneously or separately from the system to its surroundings.

8. What are Macroscopic properties of system?

The properties which are associated with bulk or macroscopic state of the system such as pressure, volume, temperature, concentration, density, viscosity, surface tension, refractive index, colour, etc. are called as macroscopic properties.

9. Define state of a system.

State of a system is defined by specific measurable macroscopic properties of the system.

10. What does initial and final state of the system refer to?

The **initial state** of system refers to the starting state of the system before any kind of interaction with its surroundings.

The **final state** of system refers to the state after the interaction of system with its surroundings.

(ii) heat is a path function and is not a state function.

(iii) heat changes are generally considered as temperature changes of the system.

2. What are the Characteristics of free energy?

Characteristics of energy (U) are:

(i) U is a state function. Its value depend on the initial and final states of the system.

(ii) U is an extensive property. Its magnitude depend on the quantity of material in the system.

(iii) U is not a path function. Its value remains constant for fixed initial and final states and does not vary even though the initial and final states are connected by different paths.

In S.I. system the unit of energy is Joules `J' or kJ.

3. Define Enthalpy of combustion.

Enthalpy change of combustion $\Delta_c H$, of a substance at a given temperature is defined as the enthalpy change of the reaction accompanying the complete combustion of one mole of the substance in presence of excess oxygen at that temperature.

4. Define enthalpy of neutralisation.

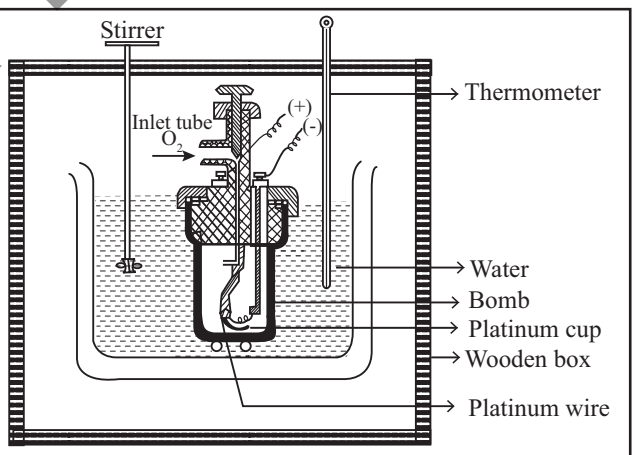
The enthalpy change of neutralisation is defined as the enthalpy change accompanied by the complete neutralisation of one gram - equivalent amount of a strong acid by a gram-equivalent amount of strong base under fully ionised state in dilute conditions.

E. *Explain briefly on the following:* Textual Questions 5 Marks

1. Describe a bomb calorimeter and explain how heat of formation of an organic compound is determined.

Enthalpy changes of combustion of chemical substances are experimentally determined using a bomb calorimeter.

The bomb calorimeter apparatus is shown in Figure. The inner vessel or the bomb and its cover are made of strong steel. The cover is fitted tightly to the vessel by means of metal lid and screws. A weighed amount of the substance is taken in a platinum cup or boat connected with electrical wires for striking an arc instantly to kindle combustion. The bomb is then tightly closed and pressurised with excess oxygen. The bomb is lowered in water which is placed inside the calorimeter.



Bomb Calorimeter

A stirrer is placed in the space between the wall of the calorimeter and the bomb, so that water can be stirred uniformly. The reaction is started in the bomb by heating the substance through electrical heating. During burning, the exothermic heat generated inside the bomb raises the temperature of the surrounding water bath. The enthalpy measurements in this case corresponds to the heat of reaction at constant volume. Although the temperature rise is small (only by few degrees), the temperature change can be measured accurately using Beckmann thermometer.

$$P(V_p - V_r) = RT(n_p - n_r)$$

$$\therefore \; P\Delta V = \Delta n_g RT \quad \text{where,}$$

Δn_g refers to the difference in the number of moles product and reactant gases. But, we already know that, $\Delta H = \Delta U + P\Delta V$.

$$\therefore \; \boxed{\Delta H = \Delta U + \Delta n_g RT}$$

In certain processes internal energy change $\Delta U = \Delta E$ also.

6. Write the conventions used in a thermochemical equation.

The following conventions are necessarily adopted in a thermochemical equation :

(i) The coefficients in a balanced thermochemical equation refers to number of moles of reactants and products involved in the reaction.

(ii) The enthalpy change of the reaction $\Delta_r H$ has unit KJ mol^{-1} and will remain as it is, even if more than one mole of the reactant or product are involved but with only the magnitude changing.

(iii) When a chemical equation is reversed the value of ΔH is reversed in sign with the magnitude remaining the same.

(iv) Physical states of all species is important and must be specified in a thermochemical equation since ΔH depends on the phases of reactants and products.

(v) If the thermochemical equation is multiplied throughout by a number, the enthalpy change is also be multiplied by the same number value.

(vi) The negative sign of $\Delta_r H°$ indicates the reaction to be an exothermic reaction and positive sigh of $\Delta_r H°$ indicates an endothermic type of reaction.

Problems - Textual questions

1. Calculate the enthalpy of combustion of acetic acid (*l*) when burnt in excess of O_2 in a bomb calorimeter. Given that $\Delta H_f°$, $H_2O_{(l)}$ = –285.84 kJ mol^{-1} and $\Delta_f H°$, $CO_2(g)$ = –393.52 kJ mol^{-1}; $\Delta_f H° CH_3COOH_{(l)}$ = –463 kJ mol^{-1}.

Solution :

$\Delta_f H°$, $CO_{2(g)}$ = –393.52 kJ mol^{-1}; $\Delta_f H° CH_3COOH_{(1)}$ = – 463 kJ mol^{-1}

$$CH_3COOH_{(l)} + 2O_{2(g)} \longrightarrow 2CO_{2(g)} + 2H_2O_{(l)}$$

$$\begin{aligned}
\Delta H° &= \Sigma H°_{f\,(products)} - \Sigma H°_{(reactants)} \\
&= \Sigma \Delta H°_{f\,(products)} - \Sigma \Delta H°_{f\,(reactants)} \\
&= \{2\Delta H°_f(CO_2) + 2\Delta H°_f(H_2O)\} - \{\Delta H°_f(CH_3COOH) + 0\} \\
&= \{2 \times (-393.52) + 2(-285.84)\} - \{(-463)\} \\
&= (-787.04 - 571.68) + 463 \\
&= -1358.72 + 463 \\
\Delta H° &= -895.72 \text{ kJ mol}^{-1}
\end{aligned}$$

2. Heat of neutralisation of a weak acid HA by NaOH is –12.13 kJ mol^{-1}. Calculate the enthalpy of ionization of HA.

Solution :

$$\Delta H_{heat} = \Delta H_{ion} + \Delta H \text{ of SA + SB}$$
$$-12.13 = \Delta H_{ion} + (-57.32)$$
$$\Delta H_{ionisation} = -12.13 + 57.32 = 45.19 \text{ kJ mol}^{-1}$$

3. ΔH for the reaction at 298 K, $CO_{(g)} + \frac{1}{2}O_{2(g)} \rightarrow CO_{2(g)}$ is 282.85 kJ mol^{-1}. Calculate ΔU of the reaction.

Solution :

$$\Delta H = \Delta U + RT(\Delta n_g)$$
$$\Delta H = 282.85 \text{ kJ mol}^{-1}$$
$$\Delta n_g = 1 - \frac{1}{2} = \frac{1}{2}$$
$$282.85 = \Delta U + 8.314 \times 10^{-3} \times 298 \times (-\frac{1}{2})$$
$$282.85 = \Delta U - 1.239 \times 10^{-3}$$
$$282.85 = \Delta U - 1.239$$
$$\Delta U = 282.85 + 1.239 = 284.09 \text{ kJ mol}^{-1}$$

Problems - Textual Examples

1. From the following data at constant volume for combustion of benzene, calculate the heat of this reaction at constant pressure condition.

$$C_6H_{6(l)} + 7\tfrac{1}{2}O_{2(g)} \rightarrow 6CO_{2(g)} + 13H_2O_{(l)}$$

$$\Delta E_{25°C} = -781.1 \text{ kcal}$$
$$\Delta H = \Delta E + \Delta n_g RT$$
$$\Delta E = -781.1 \text{ k.cal}$$
$$\Delta n_g = 6 - 7\tfrac{1}{2} = -1.5$$
$$\Delta H = -781.1 + \frac{(-1.5)\times 1.987 \times 298}{1000}$$
$$= -781.1 - 0.888$$
$$\therefore \Delta H = -782 \text{ k.cal}$$

2. Calculate the enthalpy of combustion of ethylene at 300K at constant pressure if its enthalpy of combustion at constant volume is -1406 kJ mol^{-1}.

Solution :

The complete ethylene combustion reaction can be written as,

$$C_2H_{4(g)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 2H_2O_{(l)}$$

$\Delta H = \Delta E + RT\ \Delta n_{(g)}$, where $\Delta n_{(g)} = n_{p(g)} - n_{r(g)}$.

$\therefore \Delta_{n(g)} = 2 - (3 + 1) = -2.$

13 CHEMICAL EQUILIBRIUM – I

Important Terms and Definitions

- ***Irreversible reactions :*** Reactions which go to completion and never proceed in the reverse direction are called irreversible reactions. An irreversible reaction can take place only in one direction i.e., forward reaction.
- ***Equilibrium reaction :*** Reactions which never proceed to completion in both forward and backward directions.
- ***Reversible reaction :*** A reaction which can take place both in the forward and backward direction simultaneously under the given experimental conditions is known as reversible reaction.
- ***Chemical equilibrium :*** It is a state of a reversible reaction, where the two opposing reactions occur at the same rate and the concentration of the reactants and products do not change with time.
- ***Dynamic equilibrium :*** A chemical equilibrium is said to be dynamic when both the forward and reverse reaction take place at equal rates. Once equilibrium is attained the properties such as the concentration of the reactants, products, temperature, pressure etc, **remain constant** and do not change with time. This state is said to be a 'dynamic equilibrium'.
- ***Homogeneous equilibrium :*** In an equilibrium, if the reactants and products are in **same** phases, it is said to be a homogeneous equilibrium.
- ***Heterogeneous equilibrium :*** In an equilibrium, if the reactants and products are in **different** phases, it is said to be a heterogeneous equilibrium.
- ***Law of mass action :*** The rate of a chemical reaction is directly proportional to the product of active masses of the reactants.
- ***Active mass :*** It is the molar concentration i.e., number of mole per litre.
- ***Equilibrium constant :*** It is the ratio of the product of equilibrium concentrations of the products to the product of equilibrium concentrations of the reactants, with each concentration term raised to a power equal to the coefficient of the substance in the balanced equation.
- ***Relationship between K_p & K_c :*** $K_p = K_c (RT)^{\Delta n}$ where Δn is the difference between the number of moles of gaseous products to that of the gaseous reactants.
- ***Degree of dissociation (α) :*** It is fraction of one mole of the reactant that undergoes dissociation.

Textual Questions

A. Choose the best answer - Textual Questions.

1. In which equilibrium pressure has no effect

(a) $PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$ (b) $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI(g)$

(c) $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$ (d) $NH_4Cl_{(g)} \rightleftharpoons NH_{3(g)} + HCl_{(g)}$

[Ans. (b)]

2. For the equilibrium $N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$, the K_p and K_c values are related as ,

(a) $K_p = K_c(RT)$ (b) $K_p = K_c(RT)^2$ (c) $K_p = K_c(RT)^{-1}$ (d) $K_p = K_c (RT)^{-2}$

[Ans. (a)]

3. For endothermic equilibrium, increase in temperature changes the K_{eq} value as,

(a) No change (b) Increases (c) Decreases (d) None

[Ans. (b)]

4. In the heterogenous equilibrium $CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$ the K_{eq} value is given by,

(a) partial pressure of CO_2 (b) activity CaO

(c) activities of $CaCO_3$ (d) [CaO] / [$CaCO_3$]

[Ans. (a)]

5. For the equilibrium reaction $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$

(a) $K_p = K_c$ (b) $K_p > K_c$ (c) $K_p < K_c$ (d) $K_p = 1/K_c$

[Ans. (a)]

Additional One Mark Questions and Answers

1. In the equilibrium reaction $CO_{2(g)} + C_{(s)} \rightleftharpoons 2CO_{(g)}$ the partial pressure of CO_2 and CO are 0.78 atm and 1.22 atm respectively at equilibrium. Calculate the equilibrium constant.

(a) 1.9 atm (b) 1.56 atm (c) 0.64 atm (d) 0.548 atm

[Ans. (a)]

2. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I	LIST II
A. Homogeneous	1. $Na + Cl \rightarrow NaCl$
B. Heterogeneous	2. $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$
C. Reversible	3. $CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$
D. Irreversible	4. $H_2 + I_2 \rightleftharpoons 2HI$

D. Very Short Answers : Textual Questions — 2 Marks

1. Define law of mass action.

The rate of a chemical reaction is directly proportional to the product of active masses of the reactants.

2. Write the K_p expression for $PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$.

$$K_p = \frac{P_{PCl_3} \times P_{Cl_2}}{P_{PCl_5}} = \frac{x^2 P}{1 - x^2}$$

3. Relate k_p and k_c when $\Delta n = 0$, $\Delta n = 1$; $\Delta n = 2.0$

For $\Delta n = 0$; $K_p = K_c \times (RT)^0 = K_p = K_c$

$\Delta n = 1$; $K_p = K_c \times (RT)^1 = K_p = K_c \times RT$

$\Delta n = 2$; $K_p = K_c \times (RT)^2 = K_p = K_c \times (RT)^2$

4. Give an example of irreversible reaction.

$$C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)}$$

5. Reason out why equilibrium concentrations remain constant.

The rate of forward and backward reactions are equal at equilibrium. Since the rates are proportional to the concentration, the equilibrium concentration remain constant.

6. Differentiate irreversible and reversible reactions.

	Irreversible reactions	Reversible reactions
(i)	Proceed only in one direction i.e., forward direction.	Proceed both in the forward and backward directions.
(ii)	Proceed till the reaction is complete.	Proceed till equilibrium is obtained.

Additional Very Short Answer Questions

2 Marks

1. What are equilibrium reactions?

Reactions which never proceed to completion in both forward and backward direction are called as **Equilibrium reactions.**

2. Discuss the scope of Chemical Equilibrium.

The knowledge on whether the equilibrium lies in favour of reactants or products under certain experimental conditions is useful to increase yields in industrial processes.

This study is also useful or certain acids, bases and salts in water exist in ionic equilibria which control their use as buffers, color indicators etc.

3. Give an example of irreversible reaction.

$$NaCl_{(aq)} + AgNO_{3(aq)} \rightarrow NaNO_{3(aq)} + AgCl\downarrow$$

Questions are given under 2 marks or 3 marks categories based on the points of Answers. It is only for guidance. However, in the exams, the questions may be asked either in 2 marks or 3 marks.

Problems - Textual Examples

1. Equivalent amounts of hydrogen and iodine are allowed to reach equilibrium at a given temperature. $H_{2(g)} + I_{2(g)} \rightarrow 2HI_{(g)}$. If 80% of the hydrogen can be converted to hydrogen iodide, what is the value of K_c and K_p at this temperature?

	H_2	I_2	HI
Initial concentration mol dm^{-3}	1	1	0
Equilibrium concentration	1–0.8 = 0.2	1–0.8 = 0.2	1.6 1.6

$$K_c = \frac{[HI]^2}{[H_2][I_2]} = \frac{1.6 \times 1.6}{0.2 \times 0.2} = 64$$

$$K_p = K_c (RT)^{\Delta n}$$

In this reaction $\Delta n = 0$ $\therefore K_p = K_c$ $K_c = 64$

2. At 100°C and 1 atm pressure, the degree of dissociation of N_2O_4 is 0.9114. Calculate its equilibrium constant. What will be the degree of dissociation if temperature remains constant and pressure is doubled?

$$N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$$

(1–x) 2x

x = degree of dissociation

1–x = fraction undissociated

P = total pressure

Total no. of molecules in equilibrium

= 1 – x + 2x = (1 + x)

$$K_p = \frac{4x^2P}{1-x^2}$$

P = 1 atm and x = 0.9114 (given)

$$\therefore K_p = \frac{1 \times 4 \times 0.9114^2}{1-0.9114^2} = 19.63$$

Let y be the degree of dissociation at P = 2 atm

Then $K_p = 19.63 = \frac{4y^2P}{1-y^2} = \frac{4y^2 \times 2}{1-y^2}$

Solving for y, y = 0.8428

i.e., degree of dissociation at P = 2 atm is 0.8428.

In this case, increase in pressure lowers the degree of dissociation.

14 CHEMICAL KINETICS – I

Important Terms and Definitions

- ***Chemical kinetics :*** Chemical kinetics is the study of the rates and the mechanism of chemical reactions. It helps us to understand how a chemical reaction (i.e., mechanism of a reaction) occurs.
- ***Mechanism of a reaction :*** The probable steps by which a reaction occurs is known as the mechanism of a reaction.
- ***Rate of a chemical reaction :*** The change in concentration of any reactant or product per unit time is known as the rate of a chemical reaction. It tells, how fast or how slow a reaction could be.
- ***Expression of rate of reaction :*** (i) For a reaction $A + B \rightarrow C + D$

$$\text{Rate} = \frac{\text{change in concentration}}{\text{time taken}} = \frac{-\Delta[A]}{\Delta t}$$

This is known as the 'average rate' of the reaction. The - *ve* sign indicates that the concentration of the reactant A, i.e., [A] decreases with time.

Unit of rate : $\text{Rate} = \frac{\text{concentration}}{\text{time}} = \frac{\text{mol}}{\text{dm}^3\text{s}} = \text{mol dm}^{-3}\text{s}^{-1}$

If time is in seconds, it will be, mol dm^{-3} s^{-1},

if it is in minutes, the unit will be, mol dm^{-3} m^{-1}.

- ***Law of mass action :*** The rate of a reaction is directly proportional to the product of the active mass (molar concentration) of reactants.
- ***Rate constant :*** It is the rate of the reaction, when the product of the molar concentration of the reactants is unity.
- ***Rate law :*** Rate of the reaction is proportional to the product of the initial concentration of all the reactants with each concentration raised to certain exponential powers.
- ***Order of a reaction :*** It is the sum of the powers to which the concentration of the reactants have to be raised in order to express the rate of the reaction.
- ***First order reaction :*** The rate of the reaction is dependent as the change in concentration of only one reactant during the reaction.
- ***Half-life period or time for half change ($t_{1/2}$) :*** It is the time required to reduce the concentration of the reactant to half its initial value. (or) It is the time required for 50% of the reaction to go for completion.

- ***Molecularity of a reaction :*** It is the number of species (atoms, molecule, or ions) that are present in the slow step or rate determining step of the reaction.
- ***Rate determining or slow step of the reaction :*** In a multistep reaction, the rate of a particular step is slower than the rest. i.e., the rate constant for this step will be lower than that of the rest of the steps. Such a step is known as slow step or rate determining step of the reaction.
- ***Pseudo first order reaction :*** A second order reaction, following the first order kinetics, if the concentration of one of the reactants is taken in large excess compared to the other.
- ***Zero order reaction :*** If the rate of the reaction is independent of the concentration of the reactants, it is known as the zero order reaction.
- ***Second order reaction :*** If the rate of the reaction is dependent on the change in concentration of two reactants or square of the concentration of a single reactant, it is known as the second order reaction.
- ***Third order reaction :*** A reaction is said to be third order if the rate of the reaction is dependent on the change in concentration of three reactants.

Textual Questions

A. Choose the best answer - Textual Questions.

1. $mol.dm^{-3} sec^{-1}$ is the unit of _____

   (a) rate (b) rate constant (c) order (d) active mass

   [Ans. (a)]

2. The elementary step with slow rate represents _____

   (a) rate determining step (b) maximum rate step

   (c) third order rate (d) overall order ***[Ans. (a)]***

3. Molecularity is determined for _____

   (a) an elementary reaction (b) an overall reaction

   (c) an over all stoichiometric reaction (d) a fractional order reaction ***[Ans. (a)]***

Additional One Mark Questions and Answers

1. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I		LIST II	
A	Rate	1	Theoretical concept
B	Rate constant	2	Rate = $k[A]^p [B]^q$
C	Rate Law	3	Concentration change / Time
D	Molecularity	4	Experimental value

D. Very Short Answers : Textual Questions — 2 Marks

1. Define half life period. *[Govt. Model Question Paper 2017]*

It is the time required to reduce the concentration of the reactant to half its initial value.

2. What is molecularity?

Molecularity is defined as the number of atoms or molecules taking part in an elementary step leading to a chemical reaction.

3. What is a rate determining step?

In a multistep reaction, the rate of a particular step is slower than the rest, i.e., the rate constant for this step will be lower than that of the rest of the steps. Such a step is known as slow step or rate determining step of the reaction.

4. Write the rate law of $pA + qB \rightarrow lC + mD$ reaction.

The rate law can be expressed as the decrease in concentration of the reactant or increase in concentration of the product.

$$\text{rate} = -\frac{d(A)}{dt}\times\frac{1}{p} = -\frac{d(B)}{dt}\times\frac{1}{q} \quad \text{(or)} \quad \frac{d(C)}{dt}\times\frac{1}{l} = \frac{d(D)}{dt}\times\frac{1}{m}$$

5. Define the rate of a reaction.

The rate of the reaction is defined as the change in the concentration of any reactant or product in the reaction per unit time. It tells, how fast or how slow a reaction could be.

Additional Very Short Answer Questions — 2 Marks

1. What is chemical kinetics?

Chemical kinetics is the study of the rates and the mechanism of chemical reactions.

2. Explain the scope of chemical kinetics.

The study of chemical kinetics has been highly useful in determining the factors that influence the rate, maximum yield and conversion in industrial processes.

3. Write the mathematical expression for the rate of a reaction.

Let us consider a simple reaction : $A + B \rightarrow C + D$

$$\therefore \text{Rate} = \frac{\text{concentration change}}{\text{time taken}} = \frac{-\Delta[A]}{\Delta t} = \frac{-d[A]}{dt} = \frac{-d[B]}{dt} = \frac{+d[C]}{dt} = \frac{+d[D]}{dt}$$

4. Give the units of Rate of a reaction.

Reaction rate has units of concentration divided by time. Since concentration is expressed in mol lit^{-1} or mol dm^{-3} the unit of the reaction rate is mol lit^{-1} s^{-1} or mol dm^{-3} s^{-1}.

$$\text{Rate} = \frac{\text{concentration change}}{\text{time}} = \frac{\text{mol dm}^{-3}}{\text{s}}$$

Questions are given under 2 marks or 3 marks categories based on the points of Answers. It is only for guidance. However, in the exams, the questions may be asked either in 2 marks or 3 marks.

F. Explain briefly on the following: Textual Questions 5 Marks

1. Compare and contrast the terms, order and molecularity of a reaction.

[Govt. Model Question Paper 2017]

S.No	Order of a reaction	Molecularity of a reaction
(i)	It is the sum of powers raised on concentration terms in the rate expression.	It is the number of molecules of reactants taking part in elementary step of a reaction.
(ii)	Order of a reaction is an experimental value, dervied from rate expression.	It is a theoretical concept.
(iii)	Order of a reaction can be zero, fractional or integer.	Molecularity can neither be zero nor fractional.
(iv)	Order of a reaction may have negative value.	Molecularity can never be negative.
(v)	It is assigned for overall reaction.	It is assigned for each elementary step of mechanism.
(vi)	It depends upon pressure, temperature and concentration (for pseudo order)	It is independent of pressure and temperature.

2. Describe the factors on which the rate of a reaction depends.

The factors which influence the rate of reaction are –

(i) **Effect of nature of reactant and product :** The reaction depends on the nature of the reactants. For example, reactions involving iodine are slower than the reactions involving chlorine. In reversible reactions for eg., the overall rate depend on the reactivity of the products.

(ii) **Effect of concentration :** Increasing the concentration of the reactant increases the rate of reaction.

(iii) **Effect of temperature :** Increasing the temperature, increases the rate of reaction.

(iv) **Effect of a catalyst :** A catalyst alters the rate of reaction. A positive catalyst increases the rate of reaction and a negative catalyst decreases the rate of reaction.

(v) **Effect of surface area of the reactant :** Greater the surface area of the reactants, greater is the rate of reaction. Thus the reactants in a powdered form reacts fastly than present as larger particles. eg., Powdered zinc reacts with dil. H_2SO_4 faster than a zinc rod.

(vi) **Effect of radiation :** Photochemical reactions are influenced by light radiation. The rate of photochemical reactions depend on the intensity of incident radiation.

15 BASIC CONCEPTS OF ORGANIC CHEMISTRY

Important Terms and Definitions

- ***Organic Chemistry :*** Chemistry of carbon compounds or the chemistry of hydrocorbons and their derivatives.
- ***Catenation :*** The tendency of an atom to combine with each other to form a large number of open chain and closed chain compounds is known as catenation.
- ***Open chain or acylic or aliphatic compounds :*** In these compounds, the carbon atoms are bonded to each other, and are arranged in a linear or branched fashion.
- ***Closed chain or cyclic compounds :*** In these compounds, three or more carbon atoms are arranged in such a way they form closed chain or ring compounds.
- ***Homocyclic compounds*** **:** In these compounds, the ring arrangement is made up of only carbon atoms.
- ***Aromatic (or benzenoid) compounds :*** These compounds contain six carbon atoms arranged as a hexagonal ring. They may contain one or more benzene rings fused together.
- ***Alicyclic compounds :*** Cyclic compounds with ring structure containing only carbon atoms are known as alicyclic or carbocyclic (non benzenoid) compounds.
- ***Heterocyclic (non benzenoid) compounds :*** Cyclic compounds which contain atoms like nitrogen, oxygen, and sulphur in the ring in addition to carbon are known as heterocyclic compounds.
- ***Homologous series :*** A group of organic compounds which are characterised by a general molecular formula and having identical physical or chemical properties is known as homologous series.
- ***Functional group :*** A characteristic group which is present in an organic compound which explains all the properties of the compound is known as the functional group.
- ***IUPAC :*** International Union of Pure and Applied Chemistry. This organisation framed the rules for naming organic compounds.
- ***Root Word :*** Derived from Greek / Latin indicating the number of carbon atom.
- ***Suffix :*** A primary suffix is added to the root word to indicate whether the parent carbon chain is saturated or unsaturated. A secondary suffix is used to indicate the functional group present in the organic compound.
- ***Prefix :*** A part of the name which appears before the root word. A primary prefix is used to distinguish alicyclic from cyclic compound. The name of the substituents are indicated by secondary prefixes.

- ***Free radical addition :*** Addition by a free radical across a C = C bond is known as free radical addition. *eg.,*

$$CH_3CH=CH_2 \xrightarrow{HBr} CH_2CH_2CH_2Br$$

- ***Elimination reactions :*** The reaction in which, atleast two atoms or groups are removed with the formation of a double bond or triple bond is known as elimination reactions. They can be further classified as unimolecular elimination (E_1) or bimolecular elimination (E_2).
- ***Polymerisation reactions :*** The reaction in which several simple molecules combine together to form giant molecule is known as polymerisation.

  e.g., $n\,CH_2 = CH_2 \rightarrow (-CH_2-CH_2-)_n$
- ***Condensation reactions :*** When two or more molecules, combine with or with out the elimination of simple molecules like H_2O, NH_3, HCl, CO_2 etc., the reaction is known as condensation reaction.
- ***Hydrolysis :*** Reactions in which H_2O is one of the reactant are known as hydrolysis. Hydrolysis is usually carried out in the presence of acid (acid hydrolysis) or in the presence of a base (basic hydrolysis).
- ***Reduction and oxidation reactions :*** A reaction which proceeds by the addition of hydrogen is termed reduction and that one involves addition of oxygen is called oxidation.

Additional One Mark Questions and Answers

➤ ***Choose the correct answer :***

1. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I		LIST II	
A	Open chain compounds	1	Anthracene
B	Homocyclic compounds	2	Cyclobutane
C	Heterocyclic compounds	3	2-methylbutane
D	Alicyclic compounds	4	Pyridine

	A	B	C	D
(a)	3	2	4	1
(b)	2	4	1	3
(c)	2	1	3	4
(d)	1	2	4	3

[Ans. (b)]

2. Match the list I with list II and select the correct answer using the code given below the lists.

ORDER		UNIT OF K	
A	$CH_2 = CH - CH_2 - Cl$	1	But - 1 - ene
B	$CH_3 - C = CH$	2	Ethoxyethane
C	$CH_3 - CH_2 - CH \equiv CH_2$	3	Propyne
D	$CH_3 - CH_2 - O - CH_2 - CH_3$	4	3-chloro-1-propene

(i) $CH_3OCH_2CH_2CH_3$ *[Ans. Methoxy propane]*

(j) $CH_3-O-\underset{\underset{CH_3}{|}}{CH}-CH_3$ *[Ans. 2-methoxy propane]*

(k) $CH_3CH_2CH_2CH_2NH_2$ *[Ans. 1-amino butane]*

D. Very Short Answers : Textual Questions 2 Marks

1. Substitution reaction.

A reaction in which an atom or group of atoms are replaced by some other atom or group of atoms without any change in the structure is known as substitution reaction.

e.g., $CH_3CH_2OH \xrightarrow{HBr} CH_3CH_2Br + H_2O$

2. Addition reaction.

When a molecule is added across a double bond or a triple bond to form a single product, the reaction is known as addition reaction.

$$\begin{array}{c} CH_2 \\ \| \\ CH_2 \end{array} + Cl-Cl \rightarrow \begin{array}{c} CH_2Cl \\ | \\ CH_2Cl \end{array}$$

3. Elimination reaction.

The reaction in which, atleast two atoms or groups are removed with the formation of a double bond or triple bond is known as elimination reactions. They can be further classified as unimolecular elimination (E_1) or bimolecular elimination (E_2).

4. Resonance effect.

The transfer of electrons from one part of configurated pi bond to the other due to the phenomenon of resonance is called resonance or mesomeric effect.

Additional Very Short Answer Questions

2 Marks

1. What is catenation ?

Catenation : The tendency of atoms of an element to unite with each other forming a chain of covalent bond is known as catenation.

2. What are heterocyclic compounds? Give 2 examples.

Heterocyclic compounds (Non - benzenoid aromatic) : Cyclic compounds in which the ring atoms are made up of hetero atoms like nitrogen, oxygen and sulphur in addition to carbon atoms are called heterocyclic compounds.

Questions are given under 2 marks or 3 marks categories based on the points of Answers. It is only for guidance. However, in the exams, the questions may be asked either in 2 marks or 3 marks.

16 PURIFICATION OF ORGANIC COMPOUNDS

Important Terms and Definitions

- ***Purification of organic compounds :*** The removal of a large number of other compounds which are present as impurities is known as purification.
- ***Crystallisation :*** The separation of solid organic compound from the impurities is known as crystallisation.
- ***Fractional crystallisation :*** When the solubility of two substances in a given solvent is not very much different from each other, the slightly less soluble substance crystallize out, while the other substance remain in mother liquor. This process is known as fractional crystallisation.
- ***Sublimation :*** Separation of a volatile solid from a non-volatile solid is effected by sublimation. When the mixture is heated, the volatile solid sublimes over and the non-volatile solid remains.
- ***Distillation :*** It is a process by which the constituents of a liquid mixture are separated, depending upon the difference in the boiling points of the constituents.
- ***Simple distillation :*** It is a process which involves conversion of a liquid to its vapour and condensing the vapour back to the liquid.
- ***Fractional distillation :*** The process of separation of the components in a liquid mixture at their respective boiling points in the form of vapours and subsequent condensation of those vapours is called fractional distillation.
- ***Steam distillation :*** If the substance to be purified is insoluble in water and the impurities present are non-volatile, distillation in a current of steam, results in the condensate which contains water and the organic compound to be purified. This process is known as steam distillation.
- ***Distillation under reduced pressure :*** The process of purifying or separating thermally unstable liquid compounds which decompose at their normal boiling points is known as distillation under reduced pressure.
- ***Solvent Extraction :*** The separation of an organic compound from an aqueous solution by extracting it by another solvent in which the substance is more soluble in water is known as solvent extraction.
- ***Chromatography :*** It is a technique of separation based on the differential movement of individual compounds through a porous medium under the influence of a moving solvent.
- ***Column chromatography :*** In this process the different components of the mixture (A, B, C) get absorbed to different extent by the absorbent present in the column and get eluded by a suitable solvent. This acts as moving phase.

- ***Thin Layer Chromatography :*** (TLC) This is a method of separation of the components of a mixture over a thin layer of an adsorbent.
- ***Retention factor (R_f) value :*** The relative adsorption of each component of the mixture is expressed in terms of Retention factor or R_f value.

$$R_f = \frac{\text{Distance moved by the substance from base line } (x)}{\text{Distance moved by the solvent from base line } (y)}$$

- ***Paper chromatography :*** In this technique, the stationary phase is the cellulose network of the specially made paper in which the water molecules are bound to the cellulose network. The mobile phase is a solvent or a mixture of solvents.
- ***Ascending paper chromatography :*** The mobile phase moves upwards on the paper strip (stationary phase) in this case.
- ***Descending paper chromatography :*** The mobile phase moves downwards on the paper strip (stationary phase).
- ***Circular or radial paper chromatography :*** The mobile phase moves horizontally along a circular sheet of paper (stationary phase) in this case.
- ***Chromatogram :*** The components separated by chromatographic techniques are resolved by duration and these components gets separated into different zones in the stationary phase. This is known as chromatogram.

Textual Questions

A. Choose the best answer - Textual Questions.

1. Organic compounds are soluble in _____ .
   a) Non-polar Solvents b) Polar solvents
   c) Water d) HCl ***[Ans. (a)]***
2. Decolourisation of coloured compounds can be effected by using _____ .
   a) Animal charcoal b) Carbon c) Coke d) Infra-red rays
   [Ans. (a)]
3. Compounds having boiling points widely apart 40K and above can be purified by _____ .
   a) Crystallisation b) Simple distillation
   c) Fractional distillation d) Sublimation ***[Ans. (b)]***
4. Nitrobenzene and benzene can be separated by the method of _____ .
   a) Steam distillation b) Crystallisation
   c) Fractional crystallisation d) Chromatography ***[Ans. (a)]***
5. Purification of two miscible liquids possessing very close boiling points can be separated using _____ .
   a) Fractional distillation b) Sublimation
   c) Simple distillation d) Steam distillation ***[Ans. (a)]***

6. Purification of mixture of compounds can be done by steam distillation only if the impurities are _____ .
   a) non-volatile b) volatile c) insoluble in water d) both a & c
   [Ans. (d)]
7. When the stationary phase is solid, then the compounds can be separated on the basis of _____ .
   a) adsorption b) partition
   c) both partition and adsorption d) either *[Ans. (a)]*
8. Column Chromatography is based on the principle of _____ .
   a) adsorption b) partition c) absorption d) distribution
   [Ans. (a)]
9. In Ascending Paper Chromatography, the solvent moves _____ .
   a) upwards b) downwards c) horizontally d) none *[Ans. (a)]*
10. The existence of wide range of organic compounds is due to their property of _____ .
   a) extensive catenation b) lower boiling points
   c) polymerisation d) isomerism *[Ans. (a)]*

Additional One Mark Questions and Answers

1. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I	LIST II
A. Sublimation	1. 484 K
B. Nitrobenzene	2. Manometer
C. $p_1 + p_2$	3. Camphor
D. Pressure	4. Atmospheric Pressure

	A	B	C	D
(a)	1	2	3	4
(b)	2	4	1	3
(c)	4	3	2	1
(d)	4	1	3	2

[Ans. (b)]

2. The X and Y are _____

	TYPE OF CHROMATO GRAPHY	STATIONARY PHASE	MOBILE PHASE
1.	Thin layer chromatography	Solid	_____X_____
2.	Paper chromatography	_____Y_____	Liquid

(a) liquid, liquid (b) solid, liquid (c) liquid, solid (d) gas, gas *[Ans. (a)]*

3. What type of chromatography takes place if the mobile phase moves upwards on the paper strip ?
   (a) Column Chromatography (b) Thin layer Chromatography
   (c) Ascending Paper Chromatography (d) None of these *[Ans. (c)]*

2. Define steam distillation.

Steam distillation : If the substance to be purified is insoluble in water and the impurities present are non-volatile, then the distillation is carried out in a current of steam. This method is applicable to solids as well as liquids.

3. What are different types of distillation?

(i) simple distillation, (ii) fractional distillation,
(iii) steam distillation (iv) distillation under reduced pressure.

4. Give the advantages of distillation under reduced pressure.

(i) The compounds which decompose on heating to their boiling points, can be purified by the method. This is because at a reduced pressure, a liquid would boil at temperature much below its normal boiling point.
(ii) Since the liquid boils at a temperature below the normal boiling point, this method is fuel-economical.

5. What are the types of paper chromatography?

(i) Ascending paper chromatography.
(ii) Descending paper chromatography.
(iii) Circular or Radial paper chromatography.

Additional Very Short Answer Questions

2 Marks

1. What are the different methods used for purification of organic compounds?

Various methods used for purification and separation of organic compounds are:

i) Crystallisation ii) Fractional Crystallisation
iii) Sublimation iv) Distillation
v) Extraction with solvents
vi) Chromatography

2. What is fractional distillation?

The process of separation of the components in a liquid mixture at their respective boiling points in the form of vapours and the subsequent condensation of those vapours is called fractional distillation.

3. For purification by steam distillation, what are the conditions that the impure compound must satisfy?

i) It should not decompose at the steam temperature.
ii) It should have a fairly high vapour pressure at 373 K.
iii) It should be insoluble in water.
iv) The impurities present should be non-volatile.

Questions are given under 2 marks or 3 marks categories based on the points of Answers. It is only for guidance. However, in the exams, the questions may be asked either in 2 marks or 3 marks.

column. The components which are adsorbed very strongly are retained at the top while others are retained at lower levels. In this way different zones or bands are formed in the column which contain different components of a mixture. As soon as the last portion of the substances enter the column, a selected solvent, known as eluent, is added to the column. This acts as moving phase. The elements dissolve out the different components from the various zones selectively and thus 'take out' the different bands in the form of fractions which are collected separately.

7. Describe the procedure involved in paper chromatography. *[Govt. Model Question Paper 2017]*

Paper Chromatography : It is partition chromatography. The stationary phase is water molecules bound to the cellulose network (inert support) of the paper. The mobile phase, known as the developing solvent consists of either one solvent or a mixture of different solvents. The mobile phase travels by capillary action through the paper. Depending upon the way the solvent travels on the paper, there are three types of paper chromatography.

i) Ascending Paper Chromatography : The mobile phase moves upwards on the paper strip in this case.

ii) Descending Paper Chromatography : The mobile phase in this case moves downward on the paper strip.

iii) Circular or radial paper chromatography: The mobile phase moves horizontally along a circular sheet of paper in this case.

$$R_f = \frac{\text{Distance travelled by the compound}}{\text{Distance travelled by solvent}}$$

17 DETECTION AND ESTIMATION OF ELEMENTS

Important Terms and Definitions

- ***Detection of nitrogen, sulphur and halogens :*** All these elements are detected by Lassaigne's test.
- ***Quantitative analysis :*** It involves the estimation of percentage composition of various elments present by suitable methods.

Percentage of carbon : $\frac{12}{44} \times \frac{\text{Wt. of } CO_2 \text{ formed}}{\text{Wt. of organic compound taken}} \times 100$

Percentage of hydrogen : $\frac{2}{18} \times \frac{\text{Wt. of } H_2O \text{ formed}}{\text{Wt. of organic compound taken}} \times 100$

Percentage of nitrogen by Kjeldahl method : $\frac{14 N_1 V_1}{1000} \times \frac{100}{W}$

N_1 = Normality of NH_3; V_1 = Volume of NH_3, W = Wt. of the organic compound

Percentage of sulphur : $\frac{32}{233} \times \frac{\text{Wt. of } BaSO_4 \text{ formed}}{\text{Wt. of organic compound}} \times 100$

Percentage of chlorine : $\frac{35.5}{143.5} \times \frac{\text{Wt. of AgCl formed}}{\text{Wt. of organic compound}} \times 100$

Percentage of bromine : $\frac{80}{188} \times \frac{\text{Wt. of AgBr formed}}{\text{Wt. of organic compound}} \times 100$

Percentage of iodine : $\frac{127}{235} \times \frac{\text{Wt. of AgI formed}}{\text{Wt. of organic compound}} \times 100$

Percentage of oxygen : 100 – (Sum of percentage of all elements present in the organic compound.)

2. How is sulphur defected?

Sulphur : Organic compounds containing sulphur give sulphide on fusion with sodium.

$$2Na + S \rightarrow Na_2S$$

Test : To the Lassaigne's filtrate, sodium nitroprusside is added. Purple colour is developed.

$$Na_2S + Na_2\,[Fe(CN)_5NO] \rightarrow Na_4[Fe(CN)_5\,NOS]$$

sodium nitroprusside purple

Additional Short Answer Question

3 Marks

1. How will you defect the presence of oxygen in an organic compound?

Detection of Oxygen : There is no direct method for the detection of oxygen in organic compounds. It is detected indirectly. For example,

(i) If any organic compound on heating in a dry test tube, gives out water vapour, then the presence of oxygen in the organic compound is indicated.

(ii) If any organic compound is found to contain any oxygen containing functional groups such as - OH, -CHO, -COOH, $-NO_2$ etc., then the compound contains oxygen.

(iii) If the sum of the percentages of various elements present in the compound is less than 100, then the compound contains oxygen.

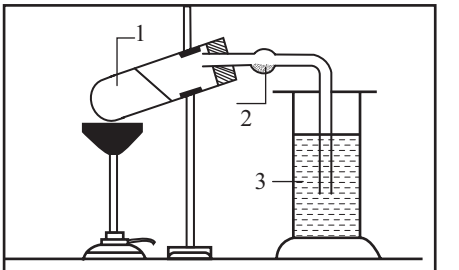
Additional Long Answer Questions

5 Marks

1. How will you detect the presence of carbon and hydrogen in an organic compound?

Detection of carbon and hydrogen : The detection of carbon and hydrogen in an organic compound is done by a single experiment.

A small quantity of pure and dry compound is mixed with about ten times its weight of copper oxide (CuO). The mixture is taken in a hard glass test tube fitted with a delivery tube having a small bulb. The other end of the tube is immersed in freshly prepared lime water. In the bulb of delivery tube, a small amount of anhydrous copper sulphate (white) is placed. The mixture is heated strongly when carbon and hydrogen present are oxidised to carbon dioxide and water respectively.



1. Organic Compound + Copper (II) oxide
2. Anhydrous copper sulphate
3. Lime water

$$C + 2CuO \rightarrow CO_2 + Cu$$
$$2H + CuO \rightarrow H_2O + Cu$$

w_1 g of AgCl contains : $\frac{35.5 \times w_1}{143.5}$ g of Cl_2

Percentage of chlorine $= \frac{35.5 \times w_1 \times 100}{143.5 \times w}$

similarly, Percentage of bromine $= \frac{80}{188} \times \frac{w_1}{w} \times 100$

Percentage of iodine $= \frac{127}{235} \times \frac{w_1}{w} \times 100$

Problems - Textual Questions

Estimation of carbon and hydrogen :

1. 0.12 g of an organic compound gave on combustion 0.18 g of water and 0.11g of CO_2. Calculate the percentage of C and H in the organic compound.

Solution :

Weight of the organic compound = 0.12g *[Govt. Model Question Paper 2017]*

Percentage of carbon $= \frac{12}{44} \times \frac{\text{Wt. of } CO_2 \text{ formed}}{\text{Wt. of organic compound}} \times 100$

$= \frac{12}{44} \times \frac{0.11}{0.12} \times 100 = 25$

Percentage of carbon = 25%

Percentage of hydrogen $= \frac{2}{18} \times \frac{\text{Wt. of } H_2O \text{ formed}}{\text{Wt. of organic compound}} \times 100$

$= \frac{2}{18} \times \frac{0.18}{0.12} \times 100 = 16.66$

Percentage of hydrogen = 16.66%.

2. An organic compound contains C, H and O. 0.2475 g of the organic compound yielded on combustion 0.4950 g of CO_2 and 0.2025 g of H_2O. Find the percentage composition of the organic compound.

Solution : Percentage of carbon $= \frac{12}{44} \times \frac{\text{Wt. of } CO_2 \text{ formed}}{\text{Wt. of organic compound}} \times 100$

$= \frac{12}{44} \times \frac{0.4950}{0.2475} \times 100 = 54.54\%$

18 HYDROCARBONS

Important Terms and Definitions

- ***Hydrocarbons:*** Organic compounds containing carbon and hydrogen are known as hydrocarbons.
- ***Alkanes :*** They are saturated hydrocarbons with general molecular formula C_nH_{2n+2}.
- ***Alkenes :*** They are unsaturated hydrocarbons with general molecular formula C_nH_{2n}.
- ***Alkynes :*** They are unsaturated hydrocarbons with general molecular formula C_nH_{2n-2}.
- ***Pyrolysis :*** Heating an organic compound to high temperature to break it into simpler fragments is known as pyrolysis.
- ***Vicinal dihalides :*** The dihalogen derivatives of alkanes, in which the halogen atoms are present in adjacent carbon atoms are known as vicinal dihalides.

  eg:

  $$\begin{array}{ccc} R-CH & - & CH_2 \\ | & & | \\ Br & & Br \end{array}$$

- ***Markovnikov's Rule :*** The negative part of the addendum attaches itself to the carbon atom carrying lesser number of hydrogen atoms.
- ***Anti Markovnikov's Rule (Khaush effect) :*** Addition of H to a double bond, in the presence of organic peroxides, result in the formation of the product on contrary to the Markovnikov's rule. This is knowns an as Anti Markovnikov's addition or Khaush effect.
- ***Alkadienes :*** Unsaturated compounds containing two double bonds are known as alkadienes.

  Isolated double bonds : In alkadienes, of the double bonds are present at the ened of the carbon chain, they are known as isolated double bonds. eg: $CH_2 = CH - CH_2 - CH = CH_2$

  Cumulated double bonds : In alkadienes, the two double bonds are present with the same carbon atom, they are known as cumulated double bonds. eg: $CH_2 = C = CH_2$

  Conjugated double bonds : If the two double bonds are present alternating in an alkadiene, they are known as conjugated double bonds. eg: $CH_2 = CH - CH = CH_2 - CH = CH_2$
- ***Acidic hydrogen atoms :*** In alkynes, the hydrogen atom attached to an 'sp' carbon atom in an acidic hydrogen atom. They are also known as terminal hydrogen atom.

  $CH_3C \equiv CH$ acidic hydrogen atom

  $HC \equiv CH$

Textual Questions

A. Choose the best answer :

1. Alkanes can be represented by the formula _____.
   a) C_nH_{2n+2} b) C_nH_{2n} c) C_nH_{2n-2} d) C_nH_{2n-3} *[Ans. (a)]*
2. Alkenes are represented by the formula _____.
   a) C_nH_{2n+2} b) C_nH_{2n} c) C_nH_{2n-2} d) C_nH_{2n-3} *[Ans. (b)]*
3. Alkynes are represented by the formula _____.
   a) C_nH_{2n+2} b) C_nH_{2n} c) C_nH_{2n-2} d) C_nH_{2n-3} *[Ans. (c)]*
4. The type of substitution reaction that takes place when methane is treated with Cl_2 in presence of light _____.
   a) ionic b) electrophilic c) nucleophilic d) radical *[Ans. (d)]*
5. When n-hexane is passed over hot alumina supported chromium, vanadium or molybdenum oxide the compound formed is _____.
   a) cyclopentane b) cyclohexane c) toluene d) benzene *[Ans. (d)]*
6. When the identical groups are on the same or opposite sides of the bonds in alkenes the isomerism is called as _____.
   a) chain isomerism b) geometrical isomerism
   c) position isomerism d) optical isomerism *[Ans. (b)]*
7. Diels-Alder reaction is the reaction between _____. *[Govt. Model Question Paper 2017]*
   a) diene and dienophile b) electrophile and nucleophile
   c) oxidant and reductant d) none *[Ans. (a)]*
8. Unsaturated compounds with two double bonds are called as _____.
   a) diene b) alkadiene c) olefins d) paraffins *[Ans. (b)]*
9. The hybridization of carbons in ethylene is _____.
   a) sp^2 b) sp c) sp^3 d) dsp^2 *[Ans. (a)]*
10. Alcohols can be dehydrated to olefins using _____.
    a) H_2SO_4 b) $SOCl_2$ c) Pd d) Zn/Hg *[Ans. (a)]*
11. When alkyl halides are treated with alcoholic KOH, the products are _____.
    a) olefins b) alkanes c) alcohols d) aldehydes
    [Ans. (a)]
12. Wurtz reaction is used to prepare _____.
    a) an alkene b) an alkyne c) an alkane d) none of the above
    [Ans. (c)]
13. Electrolysis of potassium succinate gives _____.
    a) ethylene b) ethane c) acetylene d) none of the above
    [Ans. (a)]

Additional One Mark Questions and Answers

1. Match the list I with list II and select the correct answer using the code given below the lists.

LIST I	LIST II
A. Ethylene	1. Thiokol
B. Acetylene	2. Westron
C. Ethylene dichloride	3. Ripening of fruits
D. Diene + Dienophile	4. Diel's-Alder reaction

	A	B	C	D
(a)	3	2	1	4
(b)	4	3	2	1
(c)	2	1	4	3
(d)	1	2	3	4

[Ans. (a)]

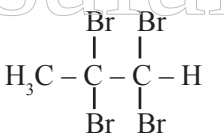
2. Butadiene is used in the manufacture of _____

(a) Plastic (b) Polythene (c) Buna rubber (d) Phenolpthalein

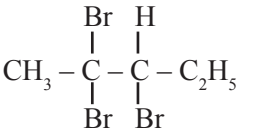
[Ans. (c)]

3. Give the structure for 1, 1, 2, 2 - tetrabromo propane.

(a) 

(b) 

(c) 

(d) 

[Ans. (b)]

4. Predict the products formed during the ozonolysis of ethylene.

(a) $H_2O_2 + HCHO$ (b) $CH_3 - \underset{\underset{O}{\|}}{C} - CH_3 + HCHO + H_2O_2$

(c) $CH_3COOH + HCOOH$ (d) $HCOOH$

[Ans. (a)]

5. $CH_2 = CH_2 \xrightarrow[KMnO_4]{\text{Cold alkaline}}$

(a) epoxide (b) polythene (c) formaldehyde (d) ethylene glycol

[Ans. (d)]

6. Aliphatic saturated hydrocarbons are otherwise called _____.

(a) alkenes (b) alkanes (c) alkynes (d) cyclic compounds

[Ans. (b)]

B. *Fill in the blanks-Textual questions have been converted into MCQs with relevant options.*

1. In alkanes, the carbon atoms are connected by _____ bonds.
   (a) σ (b) π (c) hydrogen (d) co-ordinate
   [Ans. (a)]
2. Treatment of 1, 2 dibromopropane with zinc and ethanol gives _____.
   (a) prepane (b) propene (c) propanol (d) propanal
   [Ans. (b)]
3. Cis But-2-ene is an _____ isomer.
   (a) optical (b) functional (c) geometrical (d) positional
   [Ans. (c)]
4. Addition of HCl to an olefin follows _____ rule.
   (a) n+l (b) Hund's
   (c) Huckel's (d) Markovinkov's *[Ans. (d)]*
5. An alkene reacts with ozone to form _____.
   (a) oxgen (b) nascent oxygen (c) ozonide (d) amide *[Ans. (c)]*
6. CaC_2 on hydrolysis gives _____.
   (a) acetylene (b) ethylene (c) ethane (d) methane
   [Ans. (a)]
7. Ethylenedibromide on treatment with KOH gives _____.
   (a) acetylene (b) ethylene (c) ethane (d) methane
   [Ans. (b)]
8. Electrolysis of sodium maleate gives _____.
   (a) ethylene (b) propylene (c) acetylene (d) acetone
   [Ans. (c)]

C. *Very Short Answers :* **Textual Questions** **2 Marks**

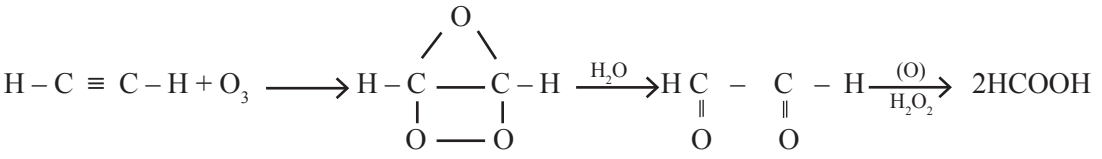
1. What is polymerisation?

It is a process by which, simple molecules (known as monomers) combine under suitable experimental conditions and form a huge or gaint molecule (known as polymers).

eg: $\underset{\text{ethylene}}{nCH_2=CH_2} \xrightarrow[\text{under pressure}]{O_2.\Delta} \underset{\text{polythene}}{-(CH_2-CH_2)_n}$

2. What is the action of ozone on acetylene?

Ozone reacts with acetylenes to form ozonides. These ozonides get decomposed with water to yield diketones. Diketones are oxidised to acids by hydrogen peroxide, produced in the reaction.



F. Explain briefly on the following: Textual Questions 5 Marks

1. Mention any five chemical properties of alkanes.

(i) Alkanes undergo chlorination or bromination when treated with Cl_2 or Br_2 in the presence of sunlight.

(ii) They undergo vapour phase nitration to form nitro alkanes.

(iii) They readily burn in excess of air to form CO_2 and H_2O.

(iv) They undergo isomerisation, when heated with anhydrous $AlCl_3$, HCl at 300°C.

(v) They undergo aromatisation, when alkanes with six or more carbon atoms are passed over hot Alumina supplied by Cr, Vd or Mo oxide.

2. Discuss the general methods of preparing alkanes.

Preparation of Alkanes :

(i) By catalytic reduction of alkenes :

Reducing agent : $H_2(g)$ + finely divided nickel, supported by Kieselguhr at 200° – 300°C.

$$\underset{\text{Ethene}}{CH_2 = CH_2} + H_2 \xrightarrow[H_2]{Ni/300°C} \underset{\text{Ethane}}{CH_3CH_3}$$

(ii) Wurtz reaction :

An ethereal solution of an alkyl halide is treated with sodium to obtain an alkane.

$$CH_3CH_2Br + 2Na + Br - CH_2CH_3 \rightarrow CH_3(CH_2)_2CH_3 + 2NaBr$$

The reaction can be applied to mixed alkyl halides. The products are mixed alkanes.

$$CH_3CH_2Br + 2Na + BrCH_2CH_2CH_3 \rightarrow CH_3CH_2CH_2CH_3 + CH_3CH_2CH_2CH_2CH_2CH_3 + CH_3CH_2CH_2CH_2CH_3$$

$$CH_3Br + 2Na + BrCH_3 \xrightarrow{ether} 2NaBr + \underset{\text{Ethane}}{CH_3 - CH_3}$$

$$CH_3CH_2Br + 2Na + BrCH_2CH_2CH_3 \xrightarrow{ether} \underset{n-\text{pentane}}{CH_3CH_2CH_2CH_2CH_3}.$$

(iii) From Grignard reagents :

Alkyl magnesium halides (RMgX, X = halogen) are known as Grignard reagents. Alkyl halides (chloride, bromide or iodide) react with magnesium in dry ether to give Grignard reagents. Grignard reagents react with water or dilute acids to give alkanes.

$$CH_3CH_2Br + Mg \xrightarrow{Ether} CH_3CH_2MgBr$$

$$CH_3CH_2MgBr + H_2O \longrightarrow CH_3CH_3 + MgBr(OH)$$

(iv) Decarboxylation of Sodium salt of carboxylic acids :

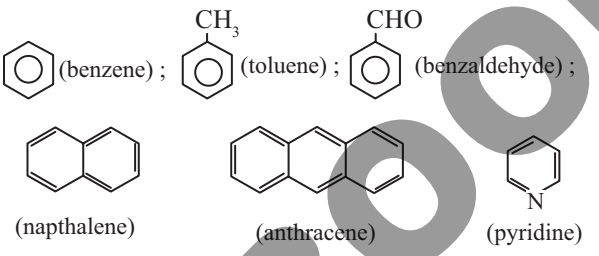
When sodium salts of carboxylic acids are heated with soda lime, alkanes are obtained.

$$CH_3CH_2COONa + NaOH \xrightarrow{CaO/350°C} CH_3CH_3 + Na_2CO_3$$

19 AROMATIC HYDROCARBONS

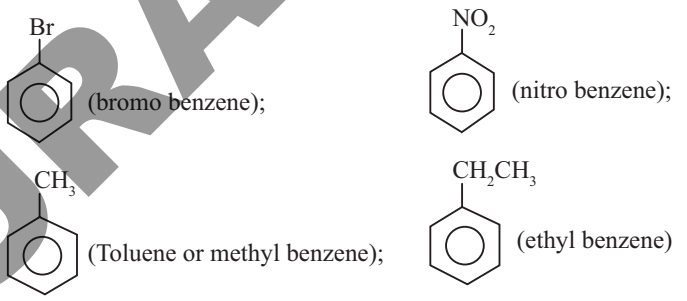
Important Terms and Definitions

- ***Aromatic compounds (Benzenoid compounds) :*** Organic compounds, with pleasant odour, were arbitrarily known as aromatic compounds. Since they produce benzene or derivatives of benzene by several chemical reactions they are also known as benzenoid compounds. Aromatic compounds refer to benzene and its structural homologues.
- ***Examples of aromatic compounds :***

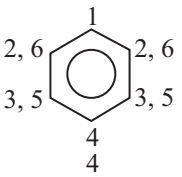


- ***Coal tar :*** The distillate obtained when coal is heated to 1000°C in the absence of air is known as coal tar. It is a source of many organic compounds.
- ***Monosubstituted benzenes :*** If a hydrogen atom in the benzene is replaced by means of a substituent, the derivative is known as monosubstituted benzene.

  eg:



  Benzene forms only one monosubstituted derivative.
- ***Disubstituted derivatives :*** When two hydrogen atoms in the benzene are replaced by two substituents disubstituted benzenes and formed. The disubstituted benzenes are known as ortho, meta, para disubstituted benzenes.



(i) position 2, 6 are known as ortho positions.
(ii) position 3, 5 are known as meta positions.
(iii) position 4, with respect to 1 is known as para position.

- ***Halogenation :*** Replacement of a hydrogen atom in the benzene ring by a halogen is known as halogenation. If the halogen is chlorine, the reaction is known as chlorination; If it is bromine, it is known as bromination.
- ***Sulphonation :*** Replacement of a hydrogen atom by means of a sulphuric acid group ($-SO_2OH$) is known as sulphonation. It is brought about by a neutral electrophile SO_3.
- ***Friedel-Crafts alkylation :*** Replacement of a hydrogen atom by means of an alkyl group (R) is known as alkylation. Since the reaction is carried out in the presence of anhydrous aluminium chloride by Friedel-Crafts, this reaction is known as Friedel-Crafts alkylation.
- ***Resonance :*** The phenomenon in which, when a single structure does not explain all the properties of a compound, a series of structures are written, each will explain some or a few properties of the compound. The actual structure is a combination of all these structures which cannot be written on the plane of paper. (or)

  The phenomenon in which two or more structures, the combination which will explain all the properties of the compound is known as resonance.
- ***Localised chemical bonding :*** It may be defined in which the electrons are shared by two nuclei only.
- ***Delocalised chemical bond :*** The delocalised chemical bonding is one in which electrons are shared by more than two nuclei.
- ***Polynuclear hydrocarbons :*** These are aromatic hydrocarbons containing two or more of benzene rings fused together.

  eg:

Naphthalene Phenanthrene Anthracene

Textual Questions

A. Choose the best answer :

1. Aromatic compounds are _____.
   a) benzenoid compounds b) non-benzenoid compounds
   c) aliphatic compounds d) alicyclic compounds ***[Ans. (a)]***
2. Benzene was first isolated by _____.
   a) Huckel b) Faraday c) Hofmann d) Barthelot ***[Ans. (b)]***
3. Benzene undergoes _____.
   a) addition reactions b) oxidation reactions
   c) polymerisation reactions d) electrophilic substitution reactions
   [Ans. (d)]
4. The modern theory of aromaticity was introduced by _____.
   a) Faraday b) Huckel c) Hofmann d) Berthelot ***[Ans. (b)]***

9. _____ reacts vigorously with aromatic hydrocarbons even in the absence of catalyst.
(a) I (b) Br (c) Cl (d) F *[Ans. (d)]*

10. In the presence of _____ benzene reacts with hydrogen to give cyclohexane. *[Ans. platinum]*
(a) F (b) Pt (c) P (d) Pd
[Ans. (b)]

Additional Very Short Answer Questions

2 Marks

1. What are benzenoid compounds?

Benzene and its homologous are called as benzenoid compounds.

2. How was benzene first synthesised in the lab?

Benzene was first synthesised by Berthelot (1870) by passing acetylene through a red-hot tube.

$$3C_2H_2 \rightarrow C_6H_6 + \text{Other products.}$$

3. What are ortho para directing groups? Give examples.

If a substituent directs the incoming group to ortho and para positions, it is called ortho, para - directing.

R, OH, OR, NH_2, NHR, $NHCOCH_3$, Cl, Br, I, F, SH etc.

4. What are meta-directing groups? Give examples.

If the substituent directs the incoming group to the meta-position. They are called meta-directing groups.

NO_2, CHO, COOH, COOR, SO_3H, CN, NH_3^+ etc.

5. What are activating and deactivating groups?

The substituents that increase the rate of substitution compared to benzene are called activating group and those decreasing the rate are called deactivating group. The activating groups increase the rate by increasing the electron density of ring, but the deactivating groups decrease the rate by decreasing the electron density of the ring.

6. Write notes on Wurtz-Fittig reaction.

Wurtz-Fittig reaction : The derivatives of benzene can be prepared by a reaction known as Wurtz-Fittig reaction. When a mixture of aryl halide and an alkyl halide is treated with metallic sodium the derivatives of benzene are formed.

Example :

$$\underset{\text{Bromobenzene}}{C_6H_5Br} + 2Na + \underset{\text{Methyl bromide}}{BrCH_3} \rightarrow \underset{\text{Toluene}}{C_6H_5CH_3} + 2NaBr$$

7. Explain Friedel-Crafts reaction. *[Govt. Model Question Paper 2017]*

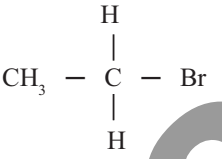
Friedel-Crafts reaction : Benzene reacts with alkyl halides in presence of anhydrous aluminium chloride as catalyst to form alkyl benzenes.

Questions are given under 2 marks or 3 marks categories based on the points of Answers. It is only for guidance. However, in the exams, the questions may be asked either in 2 marks or 3 marks.

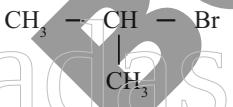
20 ORGANIC HALOGEN COMPOUNDS

Important Terms and Definitions

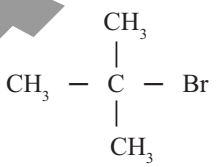
- ***Alkyl halides :*** Contain a halogen atom (F, Cl, Br, I) attached to an sp^3 hybridised carbon atom. (These are considered to be the derivatives of alkanes, where a hydrogen atom is replaced by a halogen atom).
- ***Primary alkyl halides :*** The alkyl halide in which the halogen atom is attached to a primary carbon atom e.g.,



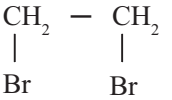
- ***Secondary alkyl halides :*** The alkyl halide in which the halogen atom is attached to a secondary carbon atom. e.g.,



- ***Tertiary alkyl halides :*** The alkyl halide in which the halogen atom is attached to a teriary carbon atom e.g.,



- ***Dihalide :*** Those halides, which contain two halogen atoms. If two halogen atoms are bonded to the same carbon atom, they are known as alkylidene halides eg., $CH_3\ CH\ Br_2$. If two halogen atoms are bonded to two different carbon atoms they are known as dihalides of alkenes. e.g.,



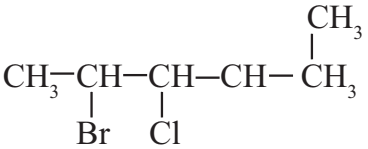
- ***Markovnikov's Rule :*** Addition of a hydrogen halide to an unsymmetrical alkene, takes place according to this rule. The rule states that the negative part of the hydrogen halide will go to the carbon atom containing lesser number of hydrogen atoms.
- ***Hunsdiecker or Borodine-Hunsdiecker reaction :*** Formation of an alkyl bromide or chloride from silver salt of carboxylic acid with Cl_2 or Br_2.

$$R\ COO\ Ag + Br_2 \rightarrow R\ Br + CO_2 + AgBr$$

Textual Questions

A. Choose the correct answer - Textual Questions.

1. The IUPAC name of



is _____.

(a) 2-Bromo-3-chloro-4-methylpentane
(b) 2-Methyl-3-chloro-4-bromopentane
(c) 2-Bromo-3-chloro-3-isopropyl propane
(d) 2,4-Dimethyl-4-Bromo-3-chloro butane. *[Ans. (a)]*

2. For reacting with HCl, the alcohol which does not require $ZnCl_2$ is _____.

(a) $CH_3\ CH_2\ OH$ (b) $CH_3 - CH_2\ CH_2\ OH$
(c) $CH_3 - CH(CH_3)\ OH$ (d) $(CH_3)_3\ C - OH$ *[Ans. (d)]*

3. For converting alcohols into alkyl halides, the best reagent is _____.

(a) PCl_3 (b) PCl_5 (c) $SOCl_2$ (d) None of the above

[Ans. (c)]

4. The olefin, which is not important for Markovni Koff's addition of HCl, is _____.

(a) Propene (b) But-1-ene
(c) 2-Methyl-propene (d) Ethylene *[Ans. (d)]*

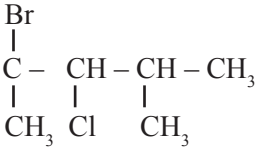
5. The S_N^1 reaction of alkyl halides is not affected by the nature of the _____.

(a) alkyl group (b) the halogen (c) medium (d) nucleophile

[Ans. (d)]

Additional One Mark Questions and Answers

1. The IUPAC name for



(a) 2-Bromo-3-chloro-2,4-dimethyl pentane
(b) 3-Bromo-2-chloro-2,4-methyl pentane
(c) 2-Bromo-3-chloro-2,4-dimethyl propane
(d) None of the above. *[Ans. (a)]*

31. Benzyl chloride reduced to toluene in the presence of _____ alloy.
(a) Ni - Al (b) Zn-Mg (c) Cu-Ni (d) Zn-Cu
[Ans. (d)]

32. Mild oxidation of benzyl chloride with $Cu(NO_3)_2$ gives _____.
(a) Benzoic acid (b) Benzene (c) benzaldehyde (d) Benzyl alcohol
[Ans. (c)]

33. Grignard reagents are discovered by the french chemist, _____.
(a) Victor Grignard (b) Faraday (c) Hofmann (d) Huckel *[Ans. (a)]*

34. Oxidation of $C_6H_5CH_2Cl$ with alk. $KMnO_4$ gives _____ .
(a) C_6H_5CHO (b) C_6H_5COOH (c) $C_6H_5CH_2OH$ (d) $C_6H_5CH_3$ *[Ans. (b)]*

B. *Fill in the blanks-Textual questions have been converted into MCQs with relevant options.*

1. Markovnikov's rule is followed for the addition of HCl to_____.
(a) symmetrical alkene (b) unsymmetrical alkene
(c) symmetrical alkane (d) unsymmetrical alkane *[Ans. (b)]*

2. In Swarts reaction metallic fluorides are added to_____. *[Ans. alkyl chloride]*
(a) alkyl chloride (b) aryl chloride (c) allyl alcohol (d) ethanol *[Ans. (a)]*

3. Chloropicrin is prepared by adding nitric acid to_____. *[Ans. chloroform]*
(a) CCl_4 (b) CH_3Cl (c) $CHCl_3$ (d) None *[Ans. (c)]*

C. *Very Short Answers :* Textual Questions — 2 Marks

1. What are Lewis acids?

Electron pair acceptors are Lewis acids.

eg., BCl_3, $AlCl_3$.

2. What is an electrophilic addition?

When an electrophile adds to an electron rich carbon atom (when an electrophile adds an C = C or C ≡ C) of a polarised double or triple bond, the reaction is known as electrophilic addition.

3. What is Hunsdiecker reaction?

Hunsdiecker reaction : Formation of an alkyl bromide or chloride from silver salt of carboxylic acid with Cl_2 or Br_2.

$$R\,COO\,Ag + Br_2 \rightarrow R\,Br + CO_2 + AgBr$$

Questions are given under 2 marks or 3 marks categories based on the points of Answers. It is only for guidance. However, in the exams, the questions may be asked either in 2 marks or 3 marks.

2. Explain the following reactions: (i) Wurtz-Fittig (ii) Fittig.

(i) Wurtz-Fittig reaction : Aryl halides react with alkyl halides when heated with sodium in ether solution to form alkylbenzene.

$$C_6H_5Br + 2Na + C_2H_5Br \xrightarrow{\text{ether}} \underset{\text{ethyl benzene}}{C_6H_5 - C_2H_5} + 2NaBr$$

(ii) Fittig reaction : In the absence of alkyl halides, aryl halides in ether solution react with sodium to give biaryl compounds in which two benzene rings are bonded together.

$$C_6H_5Br + 2Na + BrC_6H_5 \rightarrow \underset{\text{Biphenyl}}{C_6H_5 - C_6H_5}$$

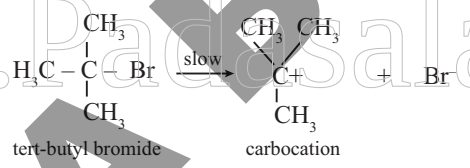
F. *Explain briefly on the following:* **Textual Questions** **5 Marks**

1. Discuss S_N1 mechanism.

S_N1 stands for unimolecular nucleophilic substitution. When the rate of nucleophilic substitution reaction depends only on the concentration of the substrate (alkyl halide), the reaction is first order and is represented as S_N1.

Consider the hydrolysis of tertiary butyl bromide. The reaction consists of two steps.

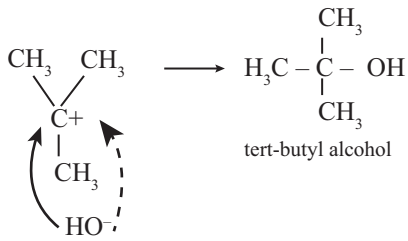
Step 1: The alkyl halide ionises to give the carbocation (carbonium ion). This step is the slow rate determining step.



tert-butyl bromide carbocation

The carbocation is planar. This is because the central positively charged carbon atom is sp^2 hybridised.

Step 2 : The nucleophile can attack the planar carbocation from either side to give tertiary butyl alcohol.



tert-butyl alcohol

Primary alkyl halides undergo hydrolysis by S_N2 mechanism. The tertiary alkyl halides undergo hydrolysis by S_N1 mechanism. Secondary alkyl halides may undergo hydrolysis by both S_N1 and S_N2 mechanism.

2. Discuss S_N2 mechanism.

S_N2 stands for bimolecular nucleophilic substitution. When the rate of nucleophilic substitution reaction depends on the concentration of both the substrate and the nucleophile, the reaction is of second order and is represented as S_N2.

11th STD. GOVT. MODEL QUESTION PAPER WITH ANSWERS

Time : 2½ Hours **Chemistry** Max. Marks : 70

Part - I

I. Answer all the questions. [15 × 1 = 15]

Choose the most appropriate answer

1. The number of atoms present in 0.5 gram atoms of nitrogen is same as the atoms in
   (a) 12g of C
   (b) 8g of the Oxygen
   (c) 32g of S
   (d) 24g of Magnesium.

2. Froth flotation process is suitable for concentrating ..... ores
   (a) Sulphide (b) Oxide
   (c) Carbonate (d) Halide

3. Consider the following statements
   (1) Transition metals have the ns^{1-2} $(n-1)d^{1-10}$ electronic configuration.
   (2) Cl^- ion is bigger than Cl atom.
   (3) Second ionization potential is lesser than the first ionization potential.
   Which of the following statement(s) given above is/are not correct?
   (a) 1,2and 3 (b) only 2
   (c) only 3 (d) 2 and 3

4. Match the list I with list II and select the correct answer using the code given below the lists.

List I		List II	
A	$Na + O_2$	1.	Sodium Deuteroxide
B	$Na + H_2O$	2.	Sodium Peroxide
C	$Na + NH_3$	3.	Sodium Hydroxide
D	$Na + D_2O$	4.	Sodamide

Code :

	A	B	C	D
(a)	1	2	3	4
(b)	4	3	2	1
(c)	2	3	4	1
(d)	1	3	4	2

5. The basic oxide among the following
   (a) Bi_2O_3 (b) SnO_2
   (c) HNO_3 (d) SO_3

6. The Weiss indices of a plane are $\frac{1}{2}, \frac{1}{2}, \frac{1}{2}$ Its miller indices will be ..... .
   (a) (0,1,1) (b) (1,0,1)
   (c) (2,2,2) (d) $\left(\frac{1}{2}, \frac{1}{2}, \frac{1}{2}\right)$

7. Excluded volume per molecule is
   (a) $4V_m$ (b) $2V_m$
   (c) $\frac{Vm}{2}$ (d) $4nV_m$

8. The compound which contains both ionic and covalent is
   (a) CH_4 (b) H_2
   (c) KCN (d) KCl

9. Work done in the reversible expansion is .....
   (a) minimum (b) maximum
   (c) zero
   (d) not predictable

10. The equilibrium constant for the reaction $CO_{2(g)} + C_{(s)} \rightleftharpoons 2CO_{(g)}$. When the partial pressure of CO_2 and CO are 0.04atm and 0.2 atm respectively is
   (a) 1.9 atm (b) 1 atm
   (c) 2 atm (d) 0.04 atm

33. Complete the following Reaction

a) $CH_4 + O_2 \xrightarrow{MoO_3}$

b) $3CH \equiv C - CH_3 \xrightarrow[\text{Under pressure}]{\text{Red hot tube}}$

c) $C_6H_5OH \xrightarrow[\text{Zinc}]{\text{Dry distillation}}$

Part - IV

IV. Answer All the Questions [5 × 5 = 25]

34. (i) Calculate the Equivalent mass of Sulphuric Acid (2)

(ii) How will you determine equivalent mass of an element by oxide method. (3)

(or)

(i) Describe the principle process involved in the purification of the metal by this Zone Refining method. (3)

(ii) Distinguish between ores and minerals with suitable example. (2)

35. (i) Determine the number of electrons in the Ist shell and mention the values of its quantum numbers. (3)

(ii) Write a note on Principal Quantum Number. (2)

(or)

(i) Explain the liquification of gases by Claude's method. (3)

(ii) Classify the following gases NH_3, N_2, H_2, CO_2 as "permanent" and "temporary" gases. (2)

36. Calculate the lattice enthalpy of $CaCl_2$ given that the enthalpy of

(i) sublimation of Ca is 121 $kJmol^{-1}$

(ii) Dissociation of Cl_2 to 2Cl is 242.8 $kJmo^{-1}$

(iii) Ionization of Ca to Ca^{2+} is 2422 $kJmol^{-1}$

(iv) Electron gain for Cl to Cl^- is–355 $kJmol^{-1}$ (v) ΔH^o_f overall is – 795 $kJmol^{-1}$

(or)

Distinguish between Order and Molecularity of a reaction

37. (i) Comment on the constant value of Enthalpy of neutralization between strong acid and strong Base. (3)

(ii) Define Zeroth law of thermodynamics (2)

(or)

(i) Discuss the principle and procedure involved in purification of organic compound by Paper Chromatography. (3)

(ii) Why organic compounds need to be purified (2)

38. a. Give the structural formula for

(i) But -1- ene

(ii) 2 - methyl 2 - propanol

(iii) Methoxy Ethane

(iv) Ethane dioic acid

(v) (N-methyl amino) methane

(or)

b. An organic compound (A) of Molecular formula C_7H_8 on treatment with Cl_2 in the presence of sunlight to give compound (B) of molecular formula C_7H_7Cl. Compound (B) react with Zn-Cu couple to give back compound (A). Compound (B) on mild oxidation with $Cu(NO_3)_2$ gives (C) C_7H_6O. Identify (A), (B), (C). Explain the reactions.

***

Answers

Part - I

1. (b)	2. (a)	3. (c)	4. (c)	5. (a)
6. (c)	7. (a)	8. (c)	9. (b)	10. (b)
11. (b)	12. (b)	13. (a)	14. (a)	15 .(b)

11th STD. SURA'S MODEL QUESTION PAPER - 1

Based on Scheme of Examination as per G.O. (2D) No.50 dated 09-08-2017

Time : 2½ Hours **Chemistry** **Max. Marks : 70**

Part - I

I. Answer all the questions. [15 × 1 = 15]

Choose the most appropriate answer

1. The total number of moles present in 111 g of $CaCl_2$ is ..... .
   (a) One mole (b) Two moles
   (c) Three moles (d) Four moles
2. A mineral from which metal can be profitably extracted is called .....
   (a) roasting (b) ore
   (c) smelting (d) all the above
3. Which of the following has no neutrons in the nucleus?
   (a) Deuterium (b) Helium
   (c) Hydrogen (d) Tritium
   (e) An alpha particle.
4. Which element has the greatest tendency to lose electrons?
   (a) Chlorine (b) Sulphur
   (c) Francium (d) Berylium
5. Deuterium with oxygen gives
   (a) oxydeuterium (b) water
   (c) heavy water (d) all the above
6. Quick lime is ..... .
   (a) Calcium oxide
   (b) Calcium hydroxide
   (c) Calcium nitrate
   (d) Calcium sulphate
7. Metallic oxides are generally ..... .
   (a) acidic (b) basic
   (c) amphoteric (d) neutral
8. Each unit cell of NaCl consists of 4 chlorine ions and ..... .
   (a) 13 Na atoms (b) 4 Na atoms
   (c) 6 Na atoms (d) 8 Na atoms
9. The compound which contains both ionic and covalent is _____.
   (a) CH_4 (b) H_2
   (c) KCN (d) KCl
10. In cold countries, ethylene glycol is added to water in the radiators of cars during winters. It results in _____.
    (a) lowering boiling point
    (b) reducing viscosity
    (c) reducing specific heat
    (d) lowering freezing point
11. Which of the following is reversible process?
    (a) Diffusion (b) melting
    (c) neutralization (d) combustion
12. In the heterogenous equilibrium $CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$ the K_{eq} value is given by,
    (a) partial pressure of CO_2
    (b) activity CaO
    (c) activities of $CaCO_3$
    (d) $[CaO] / [CaCO_3]$
13. The elementary step with slow rate represents _____
    (a) rate determining step
    (b) maximum rate step
    (c) third order rate
    (d) overall order
14. Column Chromatography is based on the principle of _____ .
    a) Adsorption b) Partition
    c) Absorption d) Distribution

11th STD. SURA'S MODEL QUESTION PAPER - 2

Based on Scheme of Examination as per G.O. (2D) No.50 dated 09-08-2017

Time : 2½ Hours **Chemistry** **Max. Marks : 70**

Part - I

I. Answer all the questions. [15 × 1 = 15]

Choose the most appropriate answer

1. Which of the following pair of species have same number of atoms under similar conditions ?
   (a) 1L each of SO_2 and CO_2
   (b) 2L each of O_3 and O_2
   (c) 1L each of NH_3 and Cl_2
   (d) 1L each of NH_3 and 2L of SO_2

2. ..... is used as a foaming agent.
   (a) slag (b) flux
   (c) pine oil (d) matrix

3. The maximum number of electrons that can be accommodated in the nth level is .....
   (a) n^2 (b) n+1
   (c) n–1 (d) $2n^2$
   (e) 2 + n.

4. Which of the following will have lowest first ionization enthalpy ?
   (a) Na (b) Al
   (c) Mg (d) Si

5. If the element can lose an electron readily, they are said to be
   (a) electronegative
   (b) electropositive (c) electronative
   (d) electrovalent

6. The compound used in making moulds for statues is ..... .
   (a) Epsom salt
   (b) Calcium sulphide
   (c) Plaster of paris
   (d) Gypsum

7. Anaesthetic used for minor operation dentistry ..... .
   (a) nitrous oxide
   (b) nitric oxide
   (c) nitrous oxide + oxygen
   (d) nitrogen dioxide

8. In a face centred cubic cell, an atom at the face centre is shared by ..... .
   (a) 4 unit cell
   (b) 2 unit cells
   (c) 1 unit cells
   (d) 6 unit cells

9. The tendency of atoms having eight electrons in the outermost shell is _____ rule.
   (a) Hund's (b) Octet
   (c) Lewis (d) Kossel

10. Properties which depend only on number of particles present in solution are called _____.
   (a) Additive (b) Constitutive
   (c) Colligative (d) None

11. In which process, work is maximum?
   (a) reversible (b) irreversible
   (c) exothermic (d) cyclic

12. For the equilibrium reaction $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$
   (a) $K_p = K_c$ (b) $K_p > K_c$
   (c) $K_p < K_c$ (d) $K_p = 1/K_c$

13. $mol.dm^{-3}\ sec^{-1}$ is the unit of _____
   (a) rate (b) rate constant
   (c) order (d) active mass

11th STD. | QUARTERLY EXAMINATION 2017-18 | Reg. No.
Time : 2.30 hrs | CHEMISTRY | Marks : 70

PART - I

1. Answer all questions

2. Choose and write the correct answer:

[15 × 1 = 15]

1. What is the relationship between molecular weight and vapour density of a gas?
   (*a*) Molecular weight = 2 × Vapour density
   (*b*) 2 × Molecular weight = Vapour density
   (*c*) Molecular weight = $\frac{Vapourdensity}{2}$
   (*d*) Molecular weight = Vapour density
2. Which of the following contains maximum number of atoms?
   (*a*) 2.0g hydrogen (*b*) 2.0g oxygen
   (*c*) 2.0g Nitrogen (*d*) 2.0g methane
3. Identify the formula of tinstone _____
   (*a*) MnO_2 (*b*) SnO_2
   (*c*) $SnCl_2$ (*d*) ZnS
4. Highly pure metals are obtained by _____ process.
   (*a*) Zone refining
   (*b*) Mond's Process
   (*c*) Electrolytic refining
   (*d*) all the above
5. Consider the following statements.
   (i) The positive charge of the nucleus is due to neutrons.
   (ii) The total number of nucleons is termed as mass number (A) of the atom.
   (iii) The number of protons in an atom is called its atomic number (z)
   Which of the following statement(s) given above is/are is correct?
   (*a*) 1, 2 and 3 (*b*) only 1
   (*c*) only 3 (*d*) 2 and 3
6. How many sub-shells are present in M-shell?
   (*a*) 2 (*b*) 4
   (*c*) 3 (*d*) 1
7. Statement I : Crystalline solids are anisotropic
   Statement II: Their physical properties are same in all directions.
   (*a*) Statement I is correct
   (*b*) Statement I is correct but II is not relevant to statement I
   (*c*) Statement I and II are is correct
   (*d*) Statement I is incorrect but statement II is correct
8. The number of CsCl units per unit cell of cscl is _____
   (*a*) one (*b*) four
   (*c*) two (*d*) six
9. Match the list I with List II and select the correct answer using the code given below the lists.

	List I		List I
A.	$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$	1.	Boyle's Law
B.	PV = constant	2.	Graham's law of diffusion
C.	$\frac{V}{T}$	3.	Ideal gas equaltion
D.	PV = nRT	4.	Charles law

   A B C D
   (*a*) 1 2 3 4
   (*b*) 4 3 2 1
   (c) 2 1 4 3
   (d) 1 3 4 2
10. Give unit of Vanderwall's constant 'a'
   (*a*) lit mol^{-1}
   (*b*) lit mol^{-2}
   (*c*) lit mol^{-2}
   (*d*) atm lit2 mol^{-2}

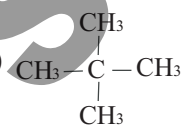
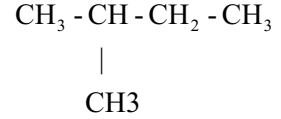
11. Arrange the follwing compounds in their increasing order of covalent character
liCl, NaCl, CaCl, KCl, RbCl
(*a*) RbCl > KCl > CsCl > NaCl > liCl
(*b*) liCl > CsCl > KCl > NaCl > RbCl
(*c*) liCl > NaCl > KCl > RbCl > CsCl
(*d*) CsCl > RbCl > KCl > NaCl > liCl

12. Match the list I with list II and select the correct answer using the code given below the lists.

	List I		List I
A	BF_3	1.	Tetrahedral
B	NH_4	2.	Octahedral
C	$Becl_2$	3.	Triagonal planar
D	SF_6	4.	Linear

A B C D
(*a*) 3 1 4 2
(*b*) 1 2 3 4
(c) 3 4 2 1
(d) 3 4 1 2

13. The correct catenation order among the following:
(*a*) Si ≃ S > c > o > N > P
(*b*) C > Si ≃ S > p > N > o
(*c*) C < Si ≃ S < p N < o
(*d*) P < N < 0 < C< Si ≃ S

14. Select the correct structure of Neopentane
(*a*) CH_3-CH_2-CH_2-CH_2
(*b*) 
(*c*) 
(*d*) polar bond

15.

Type of chromatography	Stationay Phase	Moblie Phase
Thin layer chromatography paper Chromotography	Solid Y	X liquid

The X and Y are .....
(*a*) liquid, liquid (*b*) solid, liquid
(*c*) liquid, solid (*d*) Gas, gas

Part - II

Answer Any Six questions. [6 × 2 = 12]

16. What is the mass in grams of a chlorine atom, Cl?
17. Distinguish between ore and mineral with suitable example?
18. Give the expected and actual configuration for chromium (Cr) and copper (Cu)
19. Calculate the Miller indices of (2a, 3b, c) crystal planes.
20. Define Dalton's law of partial pressure.
21. What is hybridisation?
22. How does ethylene glycol react with terephthalic acid?
23. Give the common and IUPAC name for the following compounds.
(i) CH_3NHCH_3 (ii) CH_3 CHO
24. Explain the method of separating camphor from non-volatile impurities.

Part - III

Note : 1. Answer any six questions
2. Atleast two questions from each section should be answered
[6 × 3 = 18]

Section - A

25. Define oxidation number and calculate the oxidation number of underlined elements in the following compounds (i) $\underline{Cr}_2O$ (ii) $H\underline{N}O_3$
26. Explain the method of concentration of Zinc blend ore.

27. Define Aufbau principle and prove that 4s orbital has less energy than 3d orbital.

28. How many atoms are there per unit cell in

(i) Simple cube (ii) Body centred cube

29. What is known as Joule Thomson effect? Give the conditions for liquefaction of gases.

30. How is σ and π bond formed and explain how is it formed in oxygen molecule? Among these bonds which one is stronger.

31. Explain with reason the reduction of tetrahedral bond angle (109°28¹) in ammonia and water molecules.

32. Give the structural formula of the following compounds.

(i) 2-Butene (ii) Ethyl methyl ether

(iii) Propanic acid

33. Write short notes on extraction with solvents.

Part - IV

Note : Answer question number 70 compulsorily and answer any three questions from the remaining questions. [4 × 10 = 40]

34. (i) Define equivalent mass of an acid.

(ii) How will you determine equivalent mass of an element by chloride method?

(or)

(i) Write short notes on calcination.

(ii) How is copper purified by electrolytic refining?

35. (i) Determine the numbers of electrons in the 1st shell and mention the values of its quantum numbers.

(ii) Discuss the postulates of Bohr's model of an atom.

(or)

(i) How do you the spacings of the three plans (100) (101) and (111) of simple cubic lattice

(ii) Describe the structure of sodium chloride with a neat diagram.

36. Derive the critical constants V_C, P_C and T_C from Vanderwaal's constants.

(or)

(i) Calculate the lattice enthalpy of mg Br_2 given that the enthalpy of

1) Sublimation of Mg is + 148 kJ mol
2) Ionisation of Mg to Mg is + 2187kJ/mol.
3) Vaporisation of Br_2 (l) to Br_2 (g) is 31kJ/mol.
4) Dissociation of Br_2(g) to 2Br is 193kJ/mol.
5) Electron given for Br^- to Br is 331kJ/mol.
6) Standard enthalpy change, ΔH° for the overall reaction is –524 kJmol.

37. (i) Give the electron dot representation for PH_3 and ethane.

(ii) Write the differences between ionic and covalent compounds.

(or)

(i) What are called heterocyclic compounds? Give examples.

(ii) Write the differences between electrophili and nucleophile.

38. (i) Explain differences types of Structural isomerism with example.

(ii) What is inductive effect?

(or)

(i) Why should we need to purify an organic compound?

(ii) Mention the conditions for the compounds to be purified by steam distillation.

(iii) What is known as retention factor (R_f)?

***

Answers

Part - I

1. (a)	2. (a)	3. (b)	4. (a)	5. (b)
6. (c)	7. (b)	8. (a)	9. (c)	10. (d)
11. (c)	12. (a)	13. (b)	14. (b)	15 .(a)

SURA'S

11th Std(New Pattern)

All Subjects Guides

&

Question Papers with Answer