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CHEMISTRY

11th Standard

VOLUME - I & II

Based on the updated new textbook for the year 2019 - 20

Salient Features

- Prepared as per the updated new textbook for the year 2019 - 20
- Exhaustive Additional MCQs, VSA, SA, LA questions with answers are given in each chapter.
- All the objective type (1 Mark) questions, are given with 4 options.
    - (i) Choosing the correct option
    - (ii) Matching
    - (iii) Filling the blanks
    - (iv) Assertion & Reason
    - (v) Choosing the correct Statement
    - (vi) Choosing the Incorrect Statement
- Govt. Model Question Paper-2018 ***[Govt. MQP-2018]***, First Mid-Term Test (2018) ***[First Mid-2018]***, Quarterly Exam - 2018 **[QY-2018]**, Half Yearly Exam - 2018 ***[HY-2018]*** are incorporated at appropriate sections.
- Govt. Model Question Paper - 1 (2018) & 2 (2019) with Answer Key.
- Sura's Model Question Paper - 1 & 2 with Answer Key.
- Public Exam Question Paper March 2019 with Answer Key

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It gives me great pride and pleasure in bringing to you **Sura's Chemistry Guide** Vol. I & II for **11th Standard**. A deep understanding of the text and exercises is rudimentary to have an insight into the subject. The students have to carefully understand the topics and exercises.

Sura's Chemistry 11th Standard Guide encompasses all the requirements of the students to comprehend the text and the evaluation of the textbook.

It will be a teaching companion to teachers and a learning companion to students.

As the guide has been framed based on the **'New 100 Marks Pattern'** and the public exam question paper is for 70 Marks, it provides a precise and clear understanding of text and exercises from the examination perspective.

- Chapter Snapshot, Concept Map, Formulae to Remember, Must know Definitions are given in almost each chapter.
- Exhaustive Additional MCQs, SA, LA questions with Answers are given in each chapter. Solved numerical problems are given wherever necessary.
- These features will help students practice and learn effectively all the sections of the textbook.

In order to learn effectively, I advise students to learn the subject sectionwise and practice the exercises given.

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I pray the almighty to bless the students for consummate success in their examinations.

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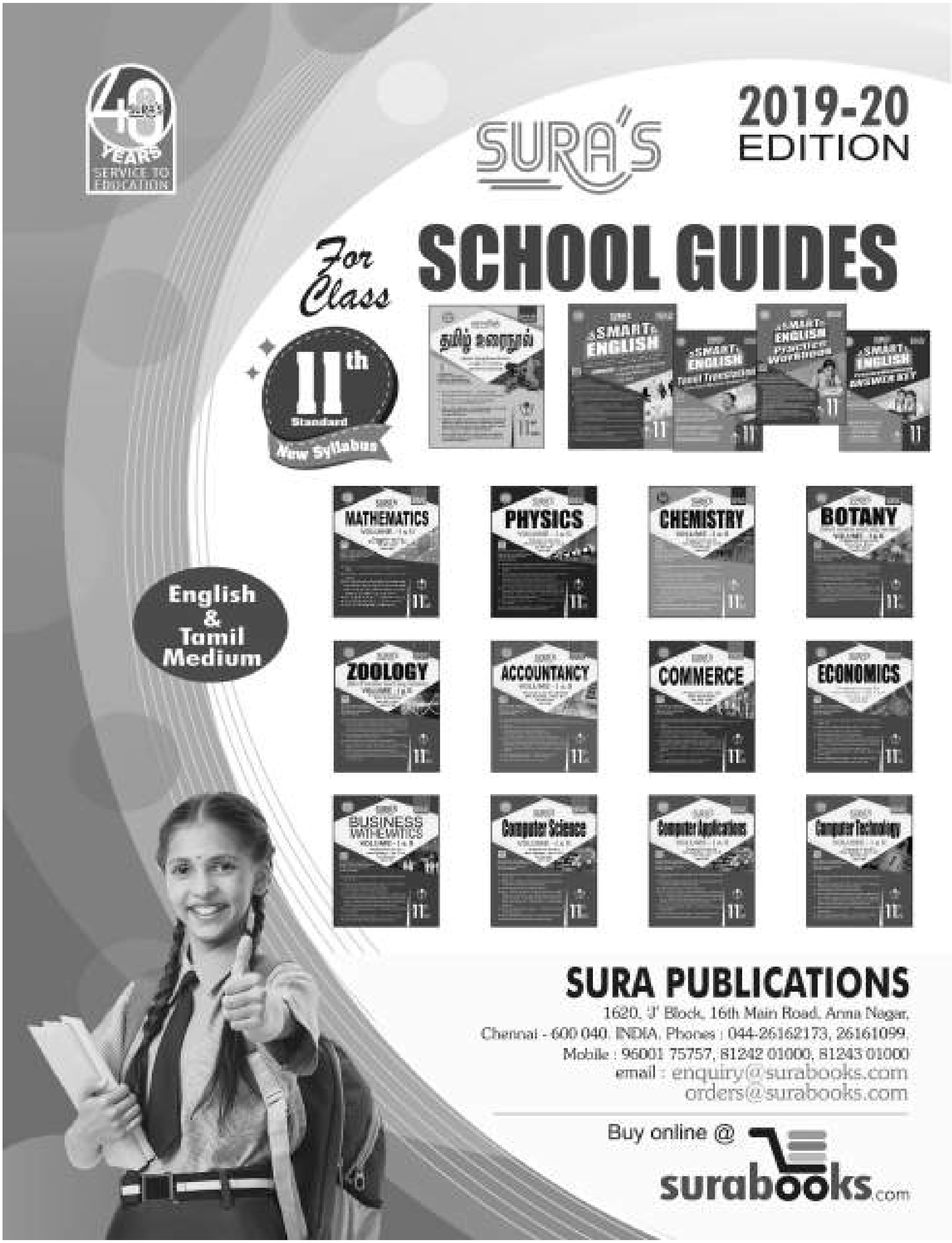
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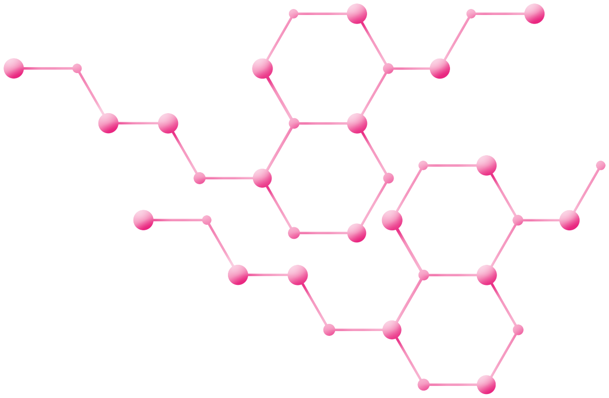

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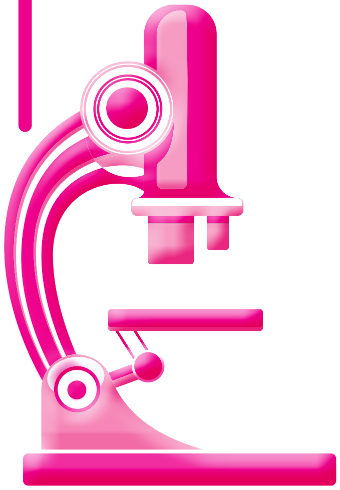

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01

BASIC CONCEPTS OF CHEMISTRY AND CHEMICAL CALCULATIONS

CHAPTER SNAPSHOT

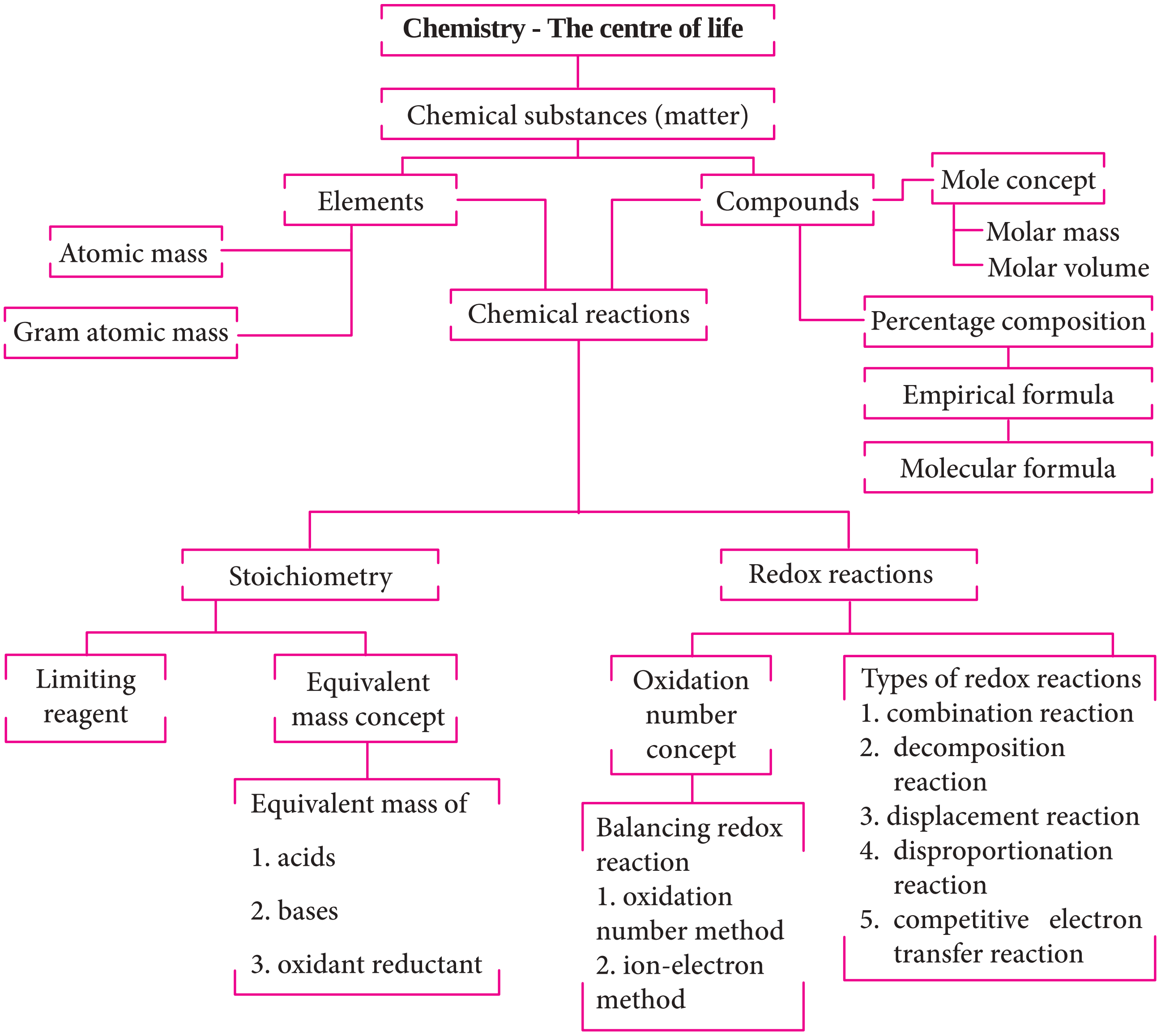
PART I : IMPORTANCE OF CHEMISTRY- CHEMISTRY, THE CENTRE OF LIFE

- Classification of matter
  - Physical classification of matter
  - Chemical Classification of matter
- Elements and compounds: chemical classification
  - Atom
  - Element
  - Molecule
  - Compound
- Atomic mass
  - Average atomic mass
  - Gram atomic mass
- Molecular mass
  - Relative atomic mass
  - Relative molecular mass
- Mole concept
  - Avogadro's hypothesis
  - Avogadro number
  - Mole definition
  - Molar mass
  - Molar volume of a gaseous substance
- Equivalent mass
  - Equivalent mass of acid
  - Equivalent mass of the base
  - Equivalent mass of a salt
  - Equivalent mass of an oxidising agent
  - Equivalent mass of a reducing agent
- Empirical formula
- Molecular formula
- Stoichiometric calculations
  - Mole – mole relationship
  - Mass - mass relationship
  - Mass – volume relationship
  - Volume – volume relationship
- Limiting reagents

PART II : REDOX REACTIONS

- Introduction
- Electronic concept of oxidation and reduction
- Oxidation number
- Types of redox reactions
  - Combination reactions
  - Decomposition reactions
  - Displacement reactions
  - Disproportionation reactions
  - Competitive electron transfer reactions
- Balancing of redox reactions
  - Oxidation number method
  - Ion-electron method for balancing redox reactions

CONCEPT MAP


Chemistry - The centre of life
Chemical substances (matter)
Elements
Compounds
Mole concept
Molar mass
Molar volume
Atomic mass
Gram atomic mass
Chemical reactions
Percentage composition
Empirical formula
Molecular formula
Stoichiometry
Redox reactions
Limiting reagent
Equivalent mass concept
Equivalent mass of
1. acids
2. bases
3. oxidant reductant
Oxidation number concept
Balancing redox reaction
1. oxidation number method
2. ion-electron method
Types of redox reactions
1. combination reaction
2. decomposition reaction
3. displacement reaction
4. disproportionation reaction
5. competitive electron transfer reaction

FORMULAE TO REMEMBER

- $\text{Atomic mass} = \dfrac{\text{Mass of an atom}}{\left(1/12\right)\times \text{mass of carbon atom } ^{12}\text{C}}$
- Molecular Mass = n × Vapour Density
- $\text{Molar mass} = \dfrac{\text{Mass}}{\text{Mole}}$
- Molecular Formula = n × Empirical Formula
- $\text{Mass \% of an element} = \dfrac{\text{Mass of that element in the compound}}{\text{Molar mass of the compound}} \times 100$
- $\text{Equivalent Mass of Acid} = \dfrac{\text{Molar mass of the Acid}}{\text{Basicity of Acid}}$
- $\text{Equivalent Mass of Base} = \dfrac{\text{Molar mass of the Base}}{\text{Acidity of Base}}$
- $\text{Molarity} = \dfrac{\text{No. of moles of solute}}{\text{Volume of solution in litres}}$
- $\text{Molality} = \dfrac{\text{No. of moles of solute}}{\text{Mass of solvent in Kg}}$
- $\text{Normality} = \dfrac{\text{No. of gram equivalents of solute}}{\text{Volume of solution in litres}}$
- Mole fraction = In a solution of two components A & B

$$\text{Mole fraction of A} = \frac{\text{No. of moles of A}}{\text{Total no. of moles in solution}} = \frac{nA}{nA + nB}$$

$$\text{Mole fraction of B} = \frac{nB}{nA + nB}$$

MUST KNOW DEFINITIONS

Matter	:	Matter is defined as anything that has mass and occupies space. All matter is composed of atoms.
Mixtures	:	Mixtures consist of more than one chemical entity present without any chemical interactions.
Pure substances	:	Pure substances are composed of simple atoms or molecules. They are further classified as elements and compounds.
Element	:	An element consists of only one type of atom. Element can exist as monatomic or polyatomic units. The polyatomic elements are called molecules.

Compound	Compounds are made up of molecules which contain two or more atoms of different elements.
Relative atomic mass	The relative atomic mass is defined as the ratio of the average atomic mass factor to the unified atomic mass unit.
Relative molecular mass	Relative molecular mass is defined as the ratio of the mass of a molecule to the unified atomic mass unit. The relative molecular mass of any compound can be calculated by adding the relative atomic masses of its constituent atoms.
Mole	One mole is the amount of substance that contains as many elementary particles as the number of atoms in 12 g of carbon-12 isotope.
Avogadro Number	The total number of entities present in one mole of any substance is equal to 6.022×10^{23}. This number is called Avogadro number
Molar Mass	Molar mass is defined as the mass of one mole of a substance. The molar mass of a compound is equal to the sum of the relative atomic masses of its constituents expressed in g mol^{-1}.
Molar Volume	The volume occupied by one mole of any substance in the gaseous state at a given temperature and pressure is called molar volume.
Gram equivalent mass	Gram equivalent mass of an element, compound or ion is the mass that combines or displaces 1.008 g hydrogen or 8 g oxygen or 35.5 g chlorine.
Empirical formula	Empirical formula of a compound is the formula written with the simplest ratio of the number of different atoms present in one molecule of the compound as subscript to the atomic symbol.
Molecular formula	Molecular formula of a compound is the formula written with the actual number of different atoms present in one molecule as a subscript to the atomic symbol.
Stoichiometry	Stoichiometry is the quantitative relationship between reactants and products in a balanced chemical equation in moles. The quantity of reactants and products can be expressed in moles or in terms of mass unit or as volume.
Limiting reagent	when a reaction is carried out using non-stoichiometric quantities of the reactants, the product yield will be determined by the reactant that is completely consumed. It limits the further reaction from taking place and is called as the limiting reagent.
Oxidation Number	It is defined as the imaginary charge left on the atom when all other atoms of the compound have been removed in their usual oxidation states that are assigned according to set of rules.
Combination reactions	Redox reactions in which two substances combine to form a single compound are called combination reaction.
Decomposition reaction	Redox reactions in which a compound breaks down into two or more components are called decomposition reactions. These reactions are opposite to combination reactions.
Displacement reactions	Redox reactions in which an ion (or an atom) in a compound is replaced by an ion (or atom) of another element are called displacement reactions.
Disproportionation reaction	In some redox reactions, the same compound can undergo both oxidation and reduction. In such reactions, the oxidation state of one and the same element is both increased and decreased. These reactions are called disproportionation reactions.

Oxidation	:	Classical concept - Addition of oxygen (or) Removal of hydrogen. Electronic concept - Loss of electrons (or) Increase in oxidation number.
Reduction	:	Classical concept - Addition of Hydrogen (or) Removal of oxygen. Electronic concept - Gain of electrons (or) Decrease in oxidation number
Redox Reaction	:	The reaction that involve the oxidation and reduction as its two half reactions are called redox reactions.
Oxidising Agent	:	**Classical Concept :** In a redox reaction, the substance which oxidises the other (or) reduces itself is called oxidising agent. **Electron Transfer concept :** The substance that gains electrons.
Reducing Agent	:	**Classical Concept :** In a redox reaction, the substance which reduces the other (or) oxidises it self is called reducing agent. **Electron Transfer concept :** The substance that loss or donate electrons.

EVALUATION

I. CHOOSE THE BEST ANSWER :

1. 40 ml of methane is completely burnt using 80 ml of oxygen at room temperature The volume of gas left after cooling to room temperature is

(a) 40 ml CO_2 gas
(b) 40 ml CO_2 gas and 80 ml H_2O gas
(c) 60 ml CO_2 gas and 60 ml H_2O gas
(d) 120 ml CO_2 gas

[Ans. (a) 40 ml CO_2 gas]

Hint: $CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(l)}$

2. An element X has the following isotopic composition ^{200}X = 90%, ^{199}X = 8% and ^{202}X = 2%. The weighted average atomic mass of the element X is closest to

(a) 201 u (b) 202 u (c) 199 u (d) 200 u

[Ans. (d) 200 u]

Hint: $= \frac{(200\times90)+(199\times8)+(202\times2)}{100}$

$= 199.96 = 200u$

3. Assertion : Two mole of glucose contains 12.044×10^{23} molecules of glucose

Reason : Total number of entities present in one mole of any substance is equal to 6.02×10^{22} *[FIRST MID-2018]*

(a) both assertion and reason are true and the reason is the correct explanation of assertion
(b) both assertion and reason are true but reason is not the correct explanation of assertion
(c) assertion is true but reason is false
(d) both assertion and reason are false

[Ans. (c) assertion is true but reason is false]

Hint: Based on Avogadro's law. One mole of any substance is equal to 6.022×10^{23}.

4. Carbon forms two oxides, namely carbon monoxide and carbon dioxide. The equivalent mass of which element remains constant?

(a) Carbon (b) oxygen
(c) both carbon and oxygen
(d) neither carbon nor oxygen

[Ans. (b) oxygen]

Hint: **React 1 :** $2C + O_2 \longrightarrow 2CO$

2 × 12g carbon combines with 32g of oxygen

$\therefore$ Equivalent mass of carbon $= \frac{2\times12}{32}\times8 = 6$

React 2 : $C + O_2 \longrightarrow CO_2$

12g carbon combines with 32g of oxygen

$\therefore$ Equivalent mass of carbon $\frac{12}{32}\times8 = 3$

5. The equivalent mass of a trivalent metal element is 9 g eq^{-1} the molar mass of its anhydrous oxide is

(a) 102 g (b) 27 g (c) 270 g (d) 78 g

[Ans. (a) 102 g]

Hint: Atomic mass of the metal oxide is equal to 2 multiple atomic mass of metal + 3 multiple atomic mass of oxygen

6. The number of water molecules in a drop of water weighing 0.018 g is ***[FIRST MID-2018]***

(a) 6.022×10^{26} (b) 6.022×10^{23}

(c) 6.022×10^{20} (d) 9.9×10^{22}

[Ans. (c) 6.022×10^{20}]

Hint: $0.001 \times 6.023 \times 10^{23}$

7. 1 g of an impure sample of magnesium carbonate (containing no thermally decomposable impurities) on complete thermal decomposition gave 0.44 g of carbon dioxide gas. The percentage of impurity in the sample is

(a) 0% (b) 4.4% (c) 16% (d) 8.4 %

[Ans. (c) 16%]

Hint: impurity is equal to 1 × 100/1.84.

8. When 6.3 g of sodium bicarbonate is added to 30 g of acetic acid solution, the residual solution is found to weigh 33 g. The number of moles of carbon dioxide is released in the reaction is

(a) 3 (b) 0.75 (c) 0.075 (d) 0.3

[Ans. (c) 0.075]

Hint: Number of moles of CO_2 is equal to given weight/ molecular weight.

9. When 22.4 litres of H_2 (g) is mixed with 11.2 litres of Cl_2(g), each at 273 K at 1 atm the moles of HCl (g), formed is equal to

(a) 2 moles of HCl (g) (b) 0.5 moles of HCl (g)

(c) 1.5 moles of HCl (g) (d) 1 moles of HCl (g)

[Ans. (d) 1 moles of HCl (g)]

Hint: $H_2(g) + Cl_2(g) \longrightarrow 2HCl$

1 mole of an ideal gas occupies at 22.4 L.

10. Hot concentrated sulphuric acid is a moderately strong oxidising agent. Which of the following reactions does not show oxidising behaviour?

(a) $Cu + 2H_2SO_4 \longrightarrow CuSO_4 + SO_2 + 2H_2O$

(b) $C + 2H_2SO_4 \longrightarrow CO_2 + 2SO_2 + 2H_2O$

(c) $BaCl_2 + H_2SO_4 \longrightarrow BaSO_4 + 2HCl$

(d) none of the above

[Ans. (c) $BaCl_2 + H_2SO_4 \longrightarrow BaSO_4 + 2HCl$]

11. Choose the disproportionation reaction among the following redox reactions.

(a) $3Mg_{(s)} + N_{2(g)} \longrightarrow Mg_3N_{2(s)}$

(b) $P_{4(s)} + 3\,NaOH + 3H_2O \longrightarrow PH_{3(g)} + 3NaH_2PO_{2(aq)}$

(c) $Cl_{2(g)} + 2KI_{(aq)} \longrightarrow 2KCl_{(aq)} + I_2$

(d) $Cr_2O_{3(s)} + 2Al_{(s)} \longrightarrow Al_2O_3(s) + 2Cr(s)$

[Ans. (b) $P_{4(s)} + 3\ NaOH + 3H_2O \longrightarrow PH_{3(g)} + 3NaH_2PO_{2(aq)}$]

12. The equivalent mass of potassium permanganate in alkaline medium is

$$MnO_4^- + 2H_2O + 3e^- \longrightarrow MnO_2 + 4OH^-$$

(a) 31.6 (b) 52.7

(c) 79 (d) None of these

[Ans. (b) 52.7]

Hint: The reduction reaction of the oxidising agent (MnO_4^-) involves gain of 3 electrons.

Hence the equivalent mass =

$$\frac{\text{Molar mass of } KMnO_4}{3} = \frac{158.1}{3} = 52.7.$$

13. Which one of the following represents 180g of water?

(a) 5 Moles of water (b) 90 moles of water

(c) $\dfrac{6.022 \times 10^{23}}{180}$ molecules of water

(d) 6.022×10^{24} molecules of water

[Ans. (d) 6.022×10^{24} molecules of water]

Hint: $10 \times 6.023 \times 10^{23}$

14. 7.5 g of a gas occupies a volume of 5.6 litres at 0° C and 1 atm pressure. The gas is **[HY. 2018]**

(a) NO (b) N_2O (c) CO (d) CO_2

[Ans. (a) NO]

Hint: $\dfrac{7.5g}{5.6L} \times 22.4L = 30g$

Molar mass of NO (14 + 16) = 30g.

15. **Total number of electrons present in 1.7 g of ammonia is** *[FIRST MID-2018]*

(a) 6.022×10^{23} (b) $\frac{6.022 \times 10^{22}}{1.7}$

(c) $\frac{6.022 \times 10^{24}}{1.7}$ (d) $\frac{6.022 \times 10^{23}}{1.7}$

[Ans. (a) 6.022×10^{23}]

Hint: Number of moles is equal to Atomic weight / valency

16. **The correct increasing order of the oxidation state of sulphur in the anions SO_4^{2-}, SO_3^{2-}, $S_2O_4^{2-}$, $S_2O_6^{2-}$ is**

(a) $SO_3^{2-} < SO_4^{2-} < S_2O_4^{2-} < S_2O_6^{2-}$

(b) $SO_4^{2-} < S_2O_4^{2-} < S_2O_6^{2-} < SO_3^{2-}$

(c) $S_2O_4^{2-} < SO_3^{2-} < S_2O_6^{2-} < SO_4^{2-}$

(d) $S_2O_6^{2-} < S_2O_4^{2-} < SO_4^{2-} < SO_3^{2-}$

[Ans. (c) $S_2O_4^{2-} < SO_3^{2-} < S_2O_6^{2-} < SO_4^{2-}$]

Hint: $\overset{+3}{S_2}O_4^{2-} < \overset{+4}{S}O_3^{2-} < \overset{+5}{S_2}O_6^{2-} < \overset{+6}{S}O_4^{2-}$

17. **The equivalent mass of ferrous oxalate is**

(a) $\frac{\text{molar mass of ferrous oxalate}}{1}$

(b) $\frac{\text{molar mass of ferrous oxalate}}{2}$

(c) $\frac{\text{molar mass of ferrous oxalate}}{3}$

(d) none of these **[Ans. (c)]**

Hint: $\overset{2+}{Fe}\overset{3+}{C_2}O_4 \xrightarrow{\text{Oxidising}} Fe^{3+} + CO_2^{4+}$

$n = 1 + 2(1) = 3$

18. **If Avogadro number were changed from 6.022×10^{23} to 6.022×10^{20}, this would change**

(a) the ratio of chemical species to each other in a balanced equation

(b) the ratio of elements to each other in a compound

(c) the definition of mass in units of grams

(d) the mass of one mole of carbon

[Ans. (d) the mass of one mole of carbon]

19. **Two 22.4 litre containers A and B contains 8 g of O_2 and 8 g of SO_2 respectively at 273 K and 1 atm pressure, then**

(a) Number of molecules in A and B are same

(b) Number of molecules in B is more than that in A.

(c) The ratio between the number of molecules in A to number of molecules in B is 2:1

(d) Number of molecules in B is three times greater than the number of molecules in A.

[Ans. (c) The ratio between the number of molecules in A to number of molecules in B is 2:1]

20. **What is the mass of precipitate formed when 50 ml of 8.5 % solution of $AgNO_3$ is mixed with 100 ml of 1.865 % potassium chloride solution?**

(a) 3.59 g (b) 7 g (c) 14 g (d) 28 g

[Ans. (a) 3.59 g]

Hint: Mass of $AgNO_3$ is equal to number of moles multiple molar mass.

21. **The mass of a gas that occupies a volume of 612.5 ml at room temperature and pressure (25° c and 1 atm pressure) is 1.1 g. The molar mass of the gas is**

(a) 66.25 g mol^{-1} (b) 44 g mol^{-1}

(c) 24.5 g mol^{-1} (d) 662.5 g mol^{-1}

[Ans. (b) 44 g mol^{-1}]

Hint:

$$= \frac{612.5 \times 10^{-3} L}{24.5 L\ mol^{-1}} = -0.025 \text{ moles}$$

$$\text{Molar mass} = \frac{\text{mass}}{\text{No. of. moles}}$$

$$= \frac{1.1\ g}{0.025\ mol} = 44\ g\ mol^{-1}.$$

22. **Which of the following contain same number of carbon atoms as in 6 g of carbon-12.**

(a) 7.5 g ethane (b) 8 g methane

(c) both (a) and (b) (d) none of these

[Ans. (c) both (a) and (b)]

23. **Which of the following compound(s) has /have percentage of carbon same as that in ethylene (C_2H_4)**

(a) propene (b) ethyne

(c) benzene (d) ethane

[Ans. (a) propene]

24. **Which of the following is/are true with respect to carbon -12.**

(a) relative atomic mass is 12 u
(b) oxidation number of carbon is +4 in all its compounds.
(c) 1 mole of carbon-12 contain 6.022 × 10^{22} carbon atoms.
(d) all of these

[Ans. (a) relative atomic mass is 12 u]

25. **Which one of the following is used as a standard for atomic mass.** *[GMQP-2018]*

(a) $_6C^{12}$ (b) $_7C^{12}$ (c) $_6C^{13}$ (d) $_6C^{14}$

[Ans. (a) $_6C^{12}$]

II. WRITE BRIEF ANSWER TO THE FOLLOWING QUESTIONS.

26. **Define relative atomic mass.** *[FIRST MID-2018]*

Ans. The relative atomic mass of element is defined as the ratio of mass of one atom of the element to the mass of 1/12th mass of one atom of carbon-12

Relative atomic mass (A_r)

$$= \frac{\text{Mass of one atom of the element}}{\text{Mass of } 1/12^{\text{th}} \text{ mass of one atom of Carbon-12}}$$

$$= \frac{\text{Mass of one atom of an element}}{1.6605 \times 10^{-27} \text{ Kg}}$$

27. **What do you understand by the term mole.**

The mole is defined as the amount of a substance which contains 6.023 × 10^{23} particles such as atoms, molecules or ions. It is denoted by the symbol "*n*".

28. **Define equivalent mass.** *[GMQP-2018; QY-2018]*

Ans. The equivalent mass of an element, compound or ion is the number of parts of mass of an element which combines with or displaces 1.008 parts of hydrogen or 8 parts of oxygen or 35.5 parts of chlorine.

29. **What do you understand by the term oxidation number.**

Ans. Oxidation number refers to the number of charges an atom would have in a molecule or an ionic compound, if electrons were transferred completely the oxidation numbers reflect the number of electron transferred.

30. **Distinguish between oxidation and reduction.**

Ans.

	Oxidation	**Reduction**
(i)	Addition of oxygen and removal of hydrogen	Additional of hydrogen and removal of oxygen
(ii)	This process involves loss of electrons $Fe^{2+} \longrightarrow Fe^{3+} + e^-$	This process involves gain electrons. $Cu^{2+} + 2^{e-} \longrightarrow Cu$
(iii)	Oxidation number increases	Oxidation number decreases
(iv)	$Ca + S \longrightarrow Ca^{2+} + 2e^-$	$Zn^{2+} + 2e^- \longrightarrow Zn$
(v)	Removal of Metal $2KI + H_2O_2 \longrightarrow 2KOH + I_2$	Addition of metal $HgCl_2 + Hg \longrightarrow Hg_2Cl_2$

31. **Calculate the molar mass of the following compounds.**

i) **Urea [$CO(NH_2)_2$]**
ii) **Acetone [CH_3COCH_3]**
iii) **Boric acid [H_3BO_3]**
iv) **Sulphuric acid [H_2SO_4]**

Ans. **(i)** **urea [$CO(NH_2)_2$] :**

C : 1 × 12.01 = 12.01
O : 1 × 16 = 16.00
N : 2 × 14.01 = 28.02
H : 4 × 1.01 = 4.04
$\underline{60.07}$ g mol^{-1}

(ii) **acetone [CH_3COCH_3]**

C : 3 × 12.01 = 36.03
H : 6 × 1.01 = 6.06
O : 1 × 16 = 16.00
$\underline{58.09}$ g mol^{-1}

(iii) **boric acid [H_3BO_3] :**

H : 3 × 1.01 = 3.03
B : 1 × 10 = 10.00
O : 3 × 16 = 48.00
$\underline{61.03}$ g mol^{-1}

(iv) **sulphuric acid [H_2SO_4] :**

H : 2 × 1.01 = 2.02
S : 1 × 32.06 = 32.06
O : 4 × 16 = 64.00
$\underline{98.08}$ g mol^{-1}

32. The density of carbon dioxide is equal to 1.965 kgm^{-3} at 273 K and 1 atm pressure. Calculate the molar mass of CO_2.

Ans. **Given :**

The density of CO_2 at 273 K and 1 atm pressure = 1.965 kgm^{-3}

Molar mass of CO_2 = ?

At 273 K and 1 atm pressure, 1 mole of CO_2 occupies a volume of 22.4 L

Mass of 1 mole of CO_2

$$= \frac{1.965\text{Kg}}{1\text{m}^3} \times 22.4\text{L}$$

$$= \frac{1.965 \times 10^3 \text{g} \times 22.4 \times 10^{-3} \cancel{\text{m}^3}}{1\cancel{\text{m}^3}}$$

$$= 44.01 \text{ g}$$

Molar mass of CO_2 = 44 gmol^{-1}.

33. Which contains the greatest number of moles of oxygen atoms

i) 1 mol of ethanol
ii) 1 mol of formic acid
iii) 1 mol of H_2O

Ans. **(i) 1 mol of ethanol :** C_2H_5OH (ethanol) - Molar mass = 24 + 6 + 16 = 46

46g of ethanol contains 1 × 6.023 × 10^{23} number of oxygen atoms.

(ii) 1 mol of formic acid : HCOOH (Formic acid) - Molar mass = 2 + 12 + 32 = 46

46g of HCOOH contains 2 × 6.023 × 10^{23} number of oxygen atoms

(iii) 1 mol of H_2O : H_2O (Water) - Molar mass = 2 + 16 = 18

18g of water contains 1 × 6.023 × 10^{23} number of oxygen atoms.

∴ mol of formic acid contains the greatest number of oxygen atoms.

34. Calculate the average atomic mass of naturally occurring magnesium using the following data

Isotope	**Isotopic atomic mass**	**Abundance (%)**
Mg^{24}	23.99	78.99
Mg^{25}	24.99	10.00
Mg^{26}	25.98	11.01

Ans. Isotopes of Mg

$$\text{Atomic mass} = Mg^{24} = 23.99 \times \frac{78.99}{100} = 18.95$$

$$\text{Atomic mass} = Mg^{25} = 24.99 \times \frac{10}{100} = 2.499$$

$$\text{Atomic mass} = Mg^{26} = 25.98 \times \frac{11.01}{100} = 2.860$$

Average atomic mass = 24.309

Average atomic mass of Mg = 24.309.

35. In a reaction x + y + $z_2 \longrightarrow xyz_2$ identify the Limiting reagent if any, in the following reaction mixtures.

(a) 200 atoms of x + 200 atoms of y + 50 molecules of z_2
(b) 1 mol of x + 1 mol of y + 3 mol of z_2
(c) 50 atoms of x + 25 atoms of y + 50 molecules of z_2
(d) 2.5 mol of x + 5 mol of y + 5 mol of z_2

Ans. **Reaction :** $x + y + z_2 \longrightarrow xyz_2$

Question	**Number of moles of reactants allowed to react**			**Number of moles of reactants consumed during reaction**			**Limiting reagent**
	x	**y**	**z_2**	**x**	**y**	**z_2**	
(a)	200 atoms	200 atoms	50 molecules	50 atoms	50 atoms	50 molecules	z_2
(b)	1 mol	1 mol	3 mol	1 mol	1 mol	1 mol	x and y
(c)	50 atom	25 atom	50 molecules	25 atom	25 atom	25 molecules	y
(d)	2.5 mol	5 mol	5 mol	2.5 mol	2.5 mol	2.5 mol	x

36. Mass of one atom of an element is 6.645×10^{-23}g. How many moles of element are there in 0.320 kg.

Ans. **Given :**

mass of one atom = 6.645×10^{-23} g

∴ mass of 1 mole of atom

$= 6.645 \times 10^{-23} \text{ g} \times 6.022 \times 10^{23}$

$= 40$ g

∴ number of moles of element in 0.320 kg

$$= \frac{1 \text{ mole}}{40\text{g}} \times 0.320\text{kg}$$

$$= \frac{1 \text{ mol} \times 320\text{g}}{40\text{g}}$$

$= 8$ mol.

37. What is the difference between molecular mass and molar mass? Calculate the molecular mass and molar mass for carbon monoxide.

Ans.

	Molecular mass	Molar mass
(i)	Molecular mass is defined as the ratio of the mass of a molecule to the unified this is relative molecular mass atomic mass unit.	Molar mass is defined as the mass of one mole of a substance.
(ii)	The relative molecular mass of any compound is calculated by adding the relative atomic masses of its constituent atoms	The molar mass of a compound is equal to the sum of the relative atomic masses of its constituents.
(iii)	Its unit is u or amu	Its unit is g mol^{-1}
(iv)	**Molecular mass of CO :** (1 × at.mass of C) + (1 × at.mass of O) 1 × 12.01 amu + 1 × 16 amu = 28.01 amu	**Molar mass of CO :** 1 × 12.01 + 1 × 16 = 28.01 g mol^{-1}

38. What is the empirical formula of the following ?

i) Fructose ($C_6H_{12}O_6$) found in honey

ii) Caffeine ($C_8H_{10}N_4O_2$) a substance found in tea and coffee. *[FIRST MID-2018; QY-2018]*

Ans.

Compound	Molecular formula	Empirical formula
Fructose	$C_6 H_{12} O_6$	CH_2O
Caffeine	$C_8 H_{10} N_4 O_2$	$C_4 H_5 N_2 O$

39. The reaction between aluminium and ferric oxide can generate temperatures up to 3273 K and is used in welding metals. (Atomic mass of Al = 27 u Atomic mass of O = 16 u)

$2Al + Fe_2O_3 \longrightarrow Al_2O_3 + 2Fe$; If, in this process, 324 g of aluminium is allowed to react with 1.12 kg of ferric oxide.

i) Calculate the mass of Al_2O_3 formed.

ii) How much of the excess reagent is left at the end of the reaction? *[GMQP-2018]*

Ans. i) $2Al + Fe_2O_3 \longrightarrow Al_2O_3 + 2Fe$

54g 160g 102g 112g

As per balanced equation 54g Al is required for 112g of Iron and 102g of Al_2O_3.

∴ 324g of Al will give $\frac{102}{54} \times 324 = 612\text{g}$ of Al_2O_3

ii) 54g of Al required 160g of Fe_2O_3 for welding reaction

∴ 324g of Al will require $\frac{160}{54} \times 324 = 960\text{g}$ of Fe_2O_3

∴ Excess Fe_2O_3 - unreacted Fe_2O_3 = 1120 – 960 = 160g.

40. How many moles of ethane is required to produce 44 g of $CO_{2(g)}$ after combustion. *[FIRST MID-2018]*

Ans. Balanced equation for the combustion of ethane

$$C_2H_6 + \frac{7}{2}O_2 \longrightarrow 2CO_2 + 3H_2O$$

$$\Rightarrow \quad 2C_2H_6 + 7O_2 \longrightarrow 4CO_2 + 6H_2O$$

To produce 4 moles of CO_2, 2 moles of ethane is required

∴ To produce 1 mole (44 g) of CO_2 required number of moles of ethane

$$= \frac{2 \text{ mol ethane}}{4 \ \cancel{\text{mol CO}_2}} \times 1 \cancel{\text{mol CO}_2}$$

$$= \frac{1}{2} \text{ mole of ethane}$$

= 0.5 mole of ethane.

41. Hydrogen peroxide is an oxidising agent. It oxidises ferrous ion to ferric ion and reduced itself to water. Write a balanced equation.

Ans. H_2O_2 – Oxidising agent

$Fe^{2+} + H_2O_2 \longrightarrow Fe^{3+} + H_2O$ (Acetic Medium)

Ferrous ion is oxidized by H_2O_2 to Ferric ion

The balanced equation is $Fe^{2+} \longrightarrow Fe^{3+} + e^- \times 2$

$$H_2O_2 + 2H^+ + \cancel{2e^-} \longrightarrow 2H_2O$$

$$2Fe^{2+} \longrightarrow 2Fe^{3+} + \cancel{2e^-}$$

$$H_2O_2 + 2H^+ \longrightarrow 2H_2O$$

$$\overline{2Fe^{2+} + H_2O_2 + 2H^+ \longrightarrow 2Fe^{3+} + 2H_2O}$$

42. **Calculate the empirical and molecular formula of a compound containing 76.6% carbon, 6.38 % hydrogen and rest oxygen its vapour density is 47.**

Ans.

Element	Percentage	Atomic mass	Relative number of atoms	Simple ratio	Whole no
C	76.6	12	$\frac{76.6}{12} = 6.38$	$\frac{6.38}{1.06} = 6$	6
H	6.38	1	$\frac{6.38}{1} = 6.38$	$\frac{6.38}{1.06} = 6$	6
O	17.02	16	$\frac{17.02}{16} = 1.06$	$\frac{1.06}{1.06} = 1$	1

Empirical formula = $C_6 H_6 O$

$$n = \frac{\text{Molar mass}}{\text{Calculated empirical formula mass}}$$

$$= \frac{2 \times \text{vapour density}}{94} = \frac{2 \times 47}{94} = 1$$, since Molar mass = 2 × Vapour density

molecular formula n × n empirical formula

∴ molecular formula $(C_6H_6O) \times 1 = C_6H_6O$.

43. **A Compound on analysis gave Na = 14.31% S = 9.97% H = 6.22% and O = 69.5% calculate the molecular formula of the compound, if all the hydrogen in the compound is present in combination with oxygen as water of crystallization. (molecular mass of the compound is 322).**

Ans.

Element	%	Relative number of atoms	Simple ratio
Na	14.31	$\frac{14.31}{23} = 0.62$	$\frac{0.62}{0.31} = 2$
S	9.97	$\frac{9.97}{32} = 0.31$	$\frac{0.31}{0.31} = 1$
H	6.22	$\frac{6.22}{1} = 6.22$	$\frac{6.22}{0.31} = 20$
O	69.5	$\frac{69.5}{16} = 4.34$	$\frac{4.34}{0.31} = 14$

∴ Empirical formula is = $Na_2 SO_4.10H_2O$

$$\text{Empirical formula mass} = (23 \times 2) + (32 \times 1) + (16 + 4) + (10 \times 18)$$
$$= 46 + 32 + 64 + 180 = 322$$
$$n = \frac{\text{Molecular mass}}{\text{Emprical formula mass}} = \frac{322}{322} = 1$$
$$\text{Molecular formula} = Na_2\,SO_4.10H_2O.$$

44. Balance the following equations by oxidation number method

i) $K_2Cr_2O_7 + KI + H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + I_2 + H_2O$

ii) $KMnO_4 + Na_2SO_3 \longrightarrow MnO_2 + Na_2SO_4 + KOH$

iii) $Cu + HNO_3 \longrightarrow Cu(NO_3)_2 + NO_2 + H_2O$

iv) $KMnO_4 + H_2C_2O_4 + H_2SO_4 \longrightarrow K_2SO_4 + MnSO_4 + CO_2 + H_2O$ *[FIRST MID-2018]*

Ans. **(i)**

$$K_2\underset{\underset{2\times 3e^-}{\uparrow}}{\overset{+6}{Cr_2}}O_7 + K\underset{\underset{1e^-}{\downarrow}}{\overset{-1}{I}} + H_2SO_4 \longrightarrow K_2SO_4 + \overset{+3}{Cr_2}(SO_4)_3 + \overset{0}{I_2} + H_2O$$

$$\mathbf{K_2Cr_2O_7 + 6KI} + H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + I_2 + H_2O$$
$$K_2Cr_2O_7 + 6KI + H_2SO_4 \longrightarrow K_2SO_4 + \mathbf{Cr_2(SO_4)_3 + 3I_2} + H_2O$$
$$K_2Cr_2O_7 + 6KI + \mathbf{7H_2SO_4} \longrightarrow \mathbf{4K_2SO_4} + Cr_2(SO_4)_3 + 3I_2 + \mathbf{7H_2O}$$

(ii)

$$K\underset{\underset{3e^-}{\uparrow}}{\overset{+7}{M}}nO_4 + Na_2\underset{\underset{2e^-}{\downarrow}}{\overset{+4}{S}}O_3 \longrightarrow \overset{+4}{M}nO_2 + Na_2\overset{+6}{S}O_4 + KOH$$

$$\Rightarrow \quad \mathbf{2KMnO_4 + 3Na_2SO_3} \longrightarrow MnO_2 + Na_2SO_4 + KOH$$
$$\Rightarrow \quad 2KMnO_4 + 3Na_2SO_3 \longrightarrow \mathbf{2MnO_2 + 3Na_2SO_4} + KOH$$
$$\Rightarrow \quad 2KMnO_4 + 3Na_2SO_3 + \mathbf{H_2O} \longrightarrow 2MnO_2 + 3Na_2SO_4 + 2KOH$$

(iii)

$$\underset{\underset{2e^-}{\downarrow}}{\overset{0}{C}}u + H\underset{\underset{1e^-}{\uparrow}}{\overset{+5}{N}}O_3 \longrightarrow \overset{+2}{C}u\,(NO_3)_2 + \overset{+4}{N}O_2 + H_2O$$

$$\mathbf{Cu + 2HNO_3} \longrightarrow Cu(NO_3)_2 + NO_2 + H_2O$$
$$Cu + 2HNO_3 + \mathbf{2HNO_3} \longrightarrow Cu(NO_3)_2 + \mathbf{2NO_2} + 2H_2O$$
$$Cu + 4HNO_3 \longrightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$$

(iv)

$$K\underset{\underset{5e^-}{\downarrow}}{\overset{+7}{M}}nO_4 + H_2\underset{\underset{1e^-\times 2}{\uparrow}}{\overset{+3}{C_2}}O_4 + H_2SO_4 \longrightarrow K_2SO_4 + \overset{+2}{M}nSO_4 + \overset{+4}{C}O_2 + H_2O$$

$$\mathbf{2KMnO_4 + 5H_2C_2O_4} + H_2SO_4 \longrightarrow K_2SO_2 + MnSO_4 + CO_2 + H_2O$$
$$2KMnO_4 + 5H_2C_2O_4 + H_2SO_4 \longrightarrow K_2SO_4 + \mathbf{2MnSO_4 + 10CO_2} + H_2O$$
$$2KMnO_4 + 5H_2C_2O_4 + 3H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 10CO_2 + 8H_2O$$

45. Balance the following equations by ion electron method.

i) $KMnO_4 + SnCl_2 + HCl \longrightarrow MnCl_2 + SnCl_4 + H_2O + KCl$

ii) $C_2O_4^{2-} + Cr_2O_7^{2-} \longrightarrow Cr^{3+} + CO_2$ **(in acid medium)**

iii) $Na_2S_2O_3 + I_2 \longrightarrow Na_2S_4O_6 + NaI$

iv) $Zn + NO_3^- \longrightarrow Zn^{2+} + NO$ **(in acid medium)** *[FIRST MID-2018]*

Ans. **(i) Half reaction are :**

$\overset{+7}{M}nO_4^- \longrightarrow Mn^{2+}$ ......(1)

and $Sn^{2+} \longrightarrow Sn^{4+}$ ......(2)

$(1) \Rightarrow MnO_4^- + 8H^- + 5e^- \longrightarrow Mn^{2+} + 4H_2O$

$(2) \Rightarrow Sn^{2+} \longrightarrow Sn^{4+} + 2e^-$

$(1) \times 2 \Rightarrow 2MnO_4^- + 16H^+ + \cancel{10e^-} \longrightarrow 2Mn^{2+} + 8H_2O$

$(2) \times 5 \Rightarrow 5Sn^{2+} \longrightarrow 5Sn^{4+} + \cancel{10e^-}$

$\Rightarrow 2MnO_4^- + 5Sn^{2+} + 16H^+ \longrightarrow 2Mn^{2+} + 5Sn^{4+} + 8H_2O$

(ii)

$\overset{+3}{C_2}O_4^{2-} \longrightarrow \overset{+4}{C}O_2$ ......(1)

$\overset{+6}{C}r_2O_7^{2-} \longrightarrow Cr^{3+}$ ......(2)

$(1) \Rightarrow C_2O_4^{2-} \longrightarrow 2CO_2 + 2e^-$ ......(3)

$Cr_2O_7^{2-} + 14H^+ \longrightarrow 2Cr^{3+} + 7H_2O$ ......(4)

$(3) \times 3 \Rightarrow 3C_2O_4^{2-} \longrightarrow 6CO_2 + \cancel{6e^-}$ ......(5)

$Cr_2O_7^{2-} + 14H^+ + \cancel{6e^-} \longrightarrow 2Cr^{3+} + 7H^2O$ ......(4)

$\Rightarrow Cr_2O_7^{2-} + 3C_2O_4^{2-} + 14H^+ \longrightarrow 2Cr^{3+} + 6CO_2 + 7H^2O$

(iii)

$S_2O_3^{2-} \longrightarrow S_4O_6^{2-}$ ......(1)

half reaction $\Rightarrow$ $I_2 \longrightarrow I^-$ ......(2)

$(1) \Rightarrow 2S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + \cancel{2e^-}$ ......(3)

$(2) \Rightarrow I_2 + \cancel{2e^-} \longrightarrow 2I^-$ ......(4)

$(3) + (4) \Rightarrow 2S_2O_3^{2-} + I_2 \longrightarrow S_4O_6^{2-} + 2I^-$

(iv)

$\overset{0}{Z}n \longrightarrow Zn^{2+}$ ......(1)

$\overset{+5}{N}O_3^- \longrightarrow \overset{+2}{N}O$ ......(2)

$(1) \Rightarrow Zn \longrightarrow Zn^{2+} + 2e^-$ ......(3)

$(2) \Rightarrow NO_3^- + 3e^- + 4H^+ \longrightarrow NO + 2H_2O$ ......(4)

$(3) \times 3 \Rightarrow 3Zn \longrightarrow Zn^{2+} + \cancel{6e^-}$ ......(5)

$(4) \times 2 \Rightarrow 2NO_3^- + \cancel{6e^-} + 8H^+ \longrightarrow 2NO + 4H_2O$ ......(6)

$3Zn + 2NO_3^- + 8H^+ \longrightarrow 3Zn^{2+} + 2NO + 4H_2O$

ADDITIONAL QUESTIONS

ADDITIONAL CHOOSE THE CORRECT ANSWERS

1 MARK

1. **Match the list I with List II correctly by using the code given below the list.** *[QY-2018]*

List I (no. of moles)		List II (Amount)	
A	0.1 mole	1	4480 mL of CO_2
B	0.2 mole	2	200 mg of hydrogen gas
C	0.25 mole	3	9 mL of water
D	0.5 mole	4	1. 51 × 10^{23} molecules of oxygen

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

[Ans. (b) 2 1 4 3]

Hint: Number of moles is equal to Mass/ Molar mass
Number of moles is equal to Volume/ molar volume

2. **The equivalent mass of a divalent metal element is 10 g eq^{-1}. The molar mass of its anhydrous oxide is**
(a) 46 g (b) 36 g
(c) 52 g (d) none of these
[Ans. (c) 52 g]

Hint: Atomic mass of divalent metal is equal to 2 multiple of atomic mass of metal + 2 multiple of atomic mass of oxygen

3. **Consider the following statements**
1 **Matter possesses mass.**
2 **22 carat gold is a mixture.**
3 **Dry ice is a compound.**
Which of the following statement(s) given above is/ are correct?
(a) 1 & 3 (b) only 1
(c) 1 & 2 (d) 1, 2 & 3
[Ans. (d) 1, 2 & 3]

4. **The solid state of matter is converted into gas by**
(a) sublimation (b) deposition
(c) freezing (d) condensation
[Ans. (a) sublimation]

5. **Match the list I with List II and select the correct answer using the code given below the list.**

List I		List II	
A	Diamond	1	Heterogeneous mixture
B	Aerated drinks	2	Element
C	Distilled water	3	Homogeneous mixture
D	Sand	4	Compound

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

[Ans. (a) 2 3 4 1]

6. **The characteristic feature of orderly arrangement of molecules belongs to**
(a) Solids (b) Liquid
(c) Gases (d) None of these
[Ans. (a) Solids]

7. **The volume occupied by any gas at S.T.P. is ____ .**
(a) 22.4 litres (b) 2.24 litres
(c) 224 litres (d) 0.224 litres
[Ans. (a) 22.4 litres]

8. **Identify the incorrect statement about a compound.**
(a) A molecule cannot be separated into its constituent elements by physical methods of separation
(b) A molecule of a compound has atoms of different elements
(c) A compound retains the physical properties of its constituent element
(d) The ratio of atoms of different elements in a compound is fixed
[Ans. (c) A compound retains the physical properties of its constituent element]

9. **Which among the following statement(s) describe an element?**
i) **It is pure substance which could be split into two or more simpler substance.**
ii) **It is a pure substance which cannot be split into simpler substance**
iii) **It's composition is not uniform**
iv) **All the above**

(a) only (iv) (b) only (ii)
(c) (ii) and (iii) (d) (i) and (iii)

[Ans. (b) only (ii)]

10. What will be the basicity of H_3BO_3, which is not a protic acid?

(a) one (b) two (c) three (d) four

[Ans. (a) one]

11. Which form of based on physical characteristics possess neither definite volume nor definite shape?

(a) Solids (b) Liquids
(c) Gases (d) Both (a) and (b)

[Ans. (c) Gases]

12. Atoms are too small with diameter of 10^{-10} m and weigh approximately

(a) 10^{-27} kg (b) 10^{-27} g
(c) 10^{-31} kg (d) 10^{-31} g

[Ans. (a) 10^{-27} kg]

13. 1 amu (or) 1u ≈

(a) 1.6605×10^{-25} kg (b) 1.6605×10^{-26} kg
(c) 1.6605×10^{-27} kg (d) 1.6605×10^{-28} kg

[Ans. (c) 1.6605×10^{-27} kg]

14. 12 g of carbon-12 contains _______ carbon atoms.

(a) 6.022×10^{23} (b) 6
(c) 12 (d) 12.022×10^{23}

[Ans. (a) 6.022×10^{23}]

15. Atomicity of nitrogen is

(a) 1 (b) 2
(c) 3 (d) zero **[Ans. (b) 2]**

Hint: Atomicity is defined as total number of atoms is present in the molecule

16. 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) Both the statements are individually true]

17. Match list I with list II and identify the correct code.

List I		**List II**	
A	Bronze	**1**	Element
B	Table salt	**2**	Homogeneous mixture
C	Gold	**3**	Alloy
D	Petrol	**4**	Compound

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

[Ans. (b) 3 4 1 2]

18. One mole of sulphuric acid contains _______ oxygen atoms.

(a) 4×10^{23} (b) $4 \times 6.023 \times 10^{-23}$
(c) $4 \times 6.023 \times 10^{23}$ (d) $4 \times 6.023 \times 10^{32}$

[Ans. (c) $4 \times 6.023 \times 10^{-23}$]

19. Unit of Avogadro's number is

(a) mol (b) g (c) mol^{-1}
(d) no unit **[Ans. (c) mol^{-1}]**

20. Assertion : An element that has a fractional atomic mass.

Reason : An element exist as isotope.

(a) Both assertion and reason are correct and reason is the correct explanation for assertion.
(b) Both assertion and reason are correct but reason is not the correct explanation for assertion
(c) Assertion is true but reason are false.
(d) Both assertion and reason are false.

[Ans. (a) Both assertion and reason are correct and reason is the correct explanation for assertion.]

21. The empirical formula and molecular mass of a compound are CH_2O and 180 g respectively. What will be the molecular formula of the compound?

(a) $C_9H_{19}O$ (b) CH_2O
(c) $C_6H_{12}O_6$ (d) $C_2H_4O_2$

[Ans. (c) $C_6H_{12}O_6$]

Hint: Molecular formula is equal to empirical formula multiple molecular weight

22. One 'U' stands for the mass of

(a) An atom of carbon-12
(b) 1/12th of the carbon-12
(c) 1/12th of hydrogen atom
(d) One atom of any of the element

[Ans. (b) 1/12th of the carbon-12]

23. **In the reaction $NH_3 + H_2O \longrightarrow NH_4^+ + O\overline{H}$, NH_3 is acidic in nature. The reason for its acidity is _______.**

(a) Acceptance of one H^+ from water
(b) Release of one OH^- ion
(c) Due to the nitrogen atom
(d) All the above.

[Ans. (a) Acceptance of one H^+ from water]

24. **The oxidation number of hydrogen in LiH is ___ .**

(a) +1 (b) –1 (c) +2 (d) –2

[Ans. (b) –1]

25. **The oxidation number of oxygen in O_2 is ______ .**

(a) 0 (b) +1 (c) +2 (d) –2

[Ans. (a) 0]

26. **Calculate the percentage of N in ammonia molecule.**

(a) 121.42% (b) 28.35%
(c) 82.35% (d) 28.53%

[Ans. (c) 82.35%]

Sol : Molar mass of NH_3 = $14 + 1 \times 3 = 17 \text{ g mol}^{-1}$

Percentage of N = $\dfrac{\text{mass of N in } NH_3}{\text{molar mass of } NH_3} \times 100$

$= \dfrac{14}{17} \times 100 = 82.35\%.$

27. **If a beaker holds 576 g of water, what will be the gram molecules of water in that beaker?**

(a) 23 gram molecule (b) 23%
(c) 32% (d) 32 gram molecule

[Ans. (d) 32 gram molecule]

Sol : Molecular mass of H_2O = $2 \times 1 + 16$

= 18 g mol^{-1}

18 g of water = 1 gram molecule

$\therefore$ 576 g of water = $\dfrac{1 \times 576}{18}$

= 32 gram molecules.

28. **Match the following prefixes with their multiples.**

	Equivalent Mass (E)		Molecular Mass (M)
A	E_{KMnO_4} (Acidic)	**1**	M/2
B	E_{KMnO_4} (Neutral)	**2**	M
C	$E_{H_3PO_2}$	**3**	M/3
D	$E_{H_3PO_3}$	**4**	M/5

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

[Ans. (a) 4 3 2 1]

29. **The oxidation number of chromium in dichromate lion is** *[QY-2018]*

(a) +4 (b) +6 (c)+5 (d) 0

[Ans. (b) +6]

30. **The oxidation state of a element in its uncombined state is**

(a) zero (b)+1 (c) –1 (d) none

[Ans. (a) zero]

31. **$Fe^{2}{}_{+} \longrightarrow Fe^{3+} + e^-$ is a _______ reaction.**

(a) redox (b) reduction
(c) oxidation (d) decomposition

[Ans. (c) oxidation]

32. **Assertion : The atomic masses of most of the elements are in fraction.**

Reason : The atomic mass represents the ratio of the average mass of the atom to one avogram.

(a) Both assertion and reason are correct and reason is the correct explanation for assertion.
(b) Both assertion and reason are correct but reason is not the correct explanation for assertion
(c) Assertion is true but reason are false.
(d) Both assertion and reason are false.

[Ans. (b) Both assertion and reason are correct but reason is not the correct explanation for assertion]

33. **Assertion : The number of oxygen atoms in 16 g of oxygen and 16 g of ozone is same.**

Reason : Each of the species represent 1 g atom of oxygen.

(a) Both assertion and reason are correct and reason is the correct explanation for assertion.
(b) Both assertion and reason are correct but reason is not the correct explanation for assertion
(c) Assertion is true but reason are false.
(d) Both assertion and reason are false.

[Ans. (a) Both assertion and reason are correct and reason is the correct explanation for assertion.]

34. Identify disproportionation reaction.

(a) $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$
(b) $CH_4 + 4Cl_2 \longrightarrow CCl_4 + 4HCl$
(c) $2F_2 + 2OH^- \longrightarrow 2F^- + OF_2 + H_2O$
(d) $2NO_2 + 2OH^- \longrightarrow NO^-_2 + NO^-_3 + H_2O$

[Ans. (d) $2NO_2 + 2OH^- \longrightarrow NO^-_2 + NO^-_3 + H_2O$]

35. The oxidation number of Cr in $Cr_2O_7^{2-}$ is ______ .

(a) +6 (b) –6 (c) +7 (d) –7

[Ans. (a) +6]

36. Assertion : The ash is produced by burning paper in air is lighter than the original mass of paper.

Reason : The residue is left after the combustion of a chemical reaction that entities is always lighter.

(a) Both assertion and reason are correct and reason is the correct explanation for assertion.
(b) Both assertion and reason are correct but reason is not the correct explanation for assertion
(c) Assertion is true but reason are false.
(d) Both assertion and reason are false.

[Ans. (c) Assertion is true but reason are false.]

37. Assertion : Oxalic acid is a dibasic acid

Reason : It contains two basic radicals

(a) Both assertion and reason are correct and reason is the correct explanation for assertion.
(b) Both assertion and reason are correct but reason is not the correct explanation for assertion
(c) Assertion is true but reason are false.
(d) Both assertion and reason are false.

[Ans. (c) Assertion is true but reason are false.]

38. How many moles of magnesium phosphate, $Mg_3(PO_4)_2$ will contain 0.25 moles of oxygen atoms?

(a) 0.02 (b) 3.125×10^{-2}
(c) 1.25×10^{-2} (d) 2.5×10^{-2}

[Ans. (b) 3.125×10^{-2}]

Sol : 8 mol of O = 1 mol of $Mg_3(PO_4)_2$

$$0.25 \text{ mol O} = \frac{1 \times 0.25}{8} \text{ mol of } Mg_3(PO_4)_2$$

$$= 3.125 \times 10^{-2} \text{ mol of } Mg_3(PO_4)_2.$$

39. Assertion : Equal volumes of all the gases do not contain equal number of atoms.

Reason : Atom is the smallest particle which takes part in chemical reactions.

(a) Both assertion and reason are correct and reason is the correct explanation for assertion.
(b) Both assertion and reason are correct but reason is not the correct explanation for assertion
(c) Assertion is true but reason are false.
(d) Both assertion and reason are false.

[Ans. (b) Both assertion and reason are correct but reason is not the correct explanation for assertion]

40. Assertion : Fluorine has an oxidation state of – 1 in all its compounds.

Reason : Fluorine is the most electronegative element of the periodic table .

(a) Both assertion and reason are correct and reason is the correct explanation for assertion.
(b) Both assertion and reason are correct but reason is not the correct explanation for assertion
(c) Assertion is true but reason are false.
(d) Both assertion and reason are false.

[Ans. (a) Both assertion and reason are correct and reason is the correct explanation for assertion.]

41. The compound in which mass percentage of carbon is 75% and that of hydrogen is 25% is

(a) C_2H_6 (b) C_2H_2 (c) CH_4 (d) C_2H_4

[Ans. (c) CH_4]

42. Among the three metals, zinc, copper and silver, the electron releasing tendency decreases in the following order.

(a) zinc >silver>copper (b) zinc >copper >silver
(c) silver>copper >zinc (d) copper >silver>zinc

[Ans. (b) zinc >copper >silver]

43. Consider the following statements :

(i) Oxidation number of He = zero
(ii) Increase in oxidation number results in reduction.
(iii) The substance undergoing increase in oxidation number is reducing agent.

Which among the above statement(s) is/are correct?

(a) only (i) (b) (ii) and (iii)
(c) (i) and (iii) (d) only (ii)

[Ans. (c) (i) and (iii)]

44. What is the ratio of empirical formula mass to molecular formula mass of benzene?

(a) 1:6 (b) 6:1 (c) 2:3 (d) 3:2

[Ans. (a) 1:6]

45. Rusting of iron is an example of ...... reaction.

(a) Combustion (b) decomposition
(c) reduction reaction and redox reaction
(d) hydrolysis

[Ans. (c) reduction reaction and redox reaction]

46. Maximum oxidation state is present in the central metal atom of which compound

(a) CrO_2Cl_2 (b) MnO_2
(c) $[Fe(CN)_6]^{3-}$ (d) MnO

[Ans. (a) CrO_2Cl_2]

47. Which of the following statement(s) is/are not true about the following decomposition reaction.

$$2KClO_3 \longrightarrow 2KCl + 3O_2$$

(i) Potassium is undergoing oxidation
(ii) Chlorine is undergoing oxidation
(iii) Oxygen is reduced
(iv) None of the species are under going oxidation and reduction.

(a) only (iv) (b) (i) and (iv)
(c) (iv) and (iii) (d) All of these

[Ans. (b) (i) and (iv)]

48. Identify the correct statement(s) with respect to the following reaction :

$$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$$

(i) Zinc is acting as an oxidant
(ii) Chlorine is acting as a reductant
(iii) Hydrogen is not acting as an oxidant
(iv) Zn is acting as a reductant

(a) only (ii) (b) only (iv)
(c) both (ii) and (iii) (d) both (ii) and (i)

[Ans. (b) only (iv)]

49. Match the list-I with list-II and select the correct answer using the code given below the list.

List-I		List-II	
A	$Cr_2O_7^{2-}$	1	+5
B	MnO_4^{2-}	2	+6
C	VO_3^{2-}	3	+3
D	FeF_6^{3-}	4	+7

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

[Ans. (c) 2 4 1 3]

50. Identify the correct statements with reference to the given reaction

$$P_4 + 3OH^- + 3H_2O \longrightarrow PH_3 + 3H_2PO_2^-$$

(i) Phosphorous is undergoing reduction only
(ii) Phosphorous is undergoing oxidation only
(iii) Phosphorous is undergoing both oxidation and reduction.
(iv) Hydrogen is undergoing neither oxidation nor reduction.

(a) only (iii) (b) both (iii) and (iv)
(c) only (i) (d) None of these

[Ans. (b) both (iii) and (iv)]

51. Match the items in column list-I with relevant items in list-II.

List-I		List-II	
A	Ions having positive charge	1	anion
B	Ions having negative charge	2	–1
C	Oxidation number of fluorine in NaF	3	0
D	The sum of oxidation number of all atoms in a neutral molecule	4	cation

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

[Ans. (d) 4 1 2 3]

54. Give an example of molecule in which the ratio of the molecular formula is six times the empirical formula.

(a) $C_6H_{12}O_6$ (b) CH_2O (c) CH_4
(d) Na_2CO_3

[Ans. (a) $C_6H_{12}O_6$]

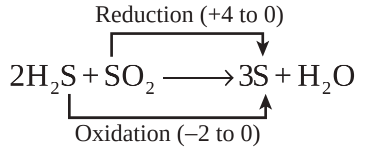
55. The change in the oxidation number of S in H_2S and SO_2 in the following industrial reaction :

$$2H_2S_{(g)} + SO_{2(g)} \longrightarrow 3S_{(s)} + H_2O_{(g)}$$

(a) –2 to 0, +4 to 0 (b) –2 to 0, +4 to –1
(c) –2 to –1, +4 to 0 (d) –2 to –1, +4 to –2

[Ans. (a) –2 to 0, +4 to 0]

Sol :



56. **Assertion (A) : In the reaction between potassium permanganate and potassium iodide, permanganate ions act as oxidising agent.**

Reason (R) : Oxidation state of manganese changes from +2 to +7 during the reaction.

(a) Both A and R are true and R explains A
(b) Both A and R are true but R does not explain A
(c) A is true but R is false
(d) Both A and R are false

[Ans. (c) A is true but R is false]

57. **In which of the following reactions, hydrogen peroxide acts as an oxidising agent?**

(a) $I_2 + H_2O_2 + 2OH^- \longrightarrow 2I^- + 2H_2O + O_2$
(b) $PbS + 4H_2O_2 \longrightarrow PbSO_4 + 4H_2O$
(c) $2MnO_4^- + 3H_2O_2 \longrightarrow 2MnO_2 + 3O_2 + 2H_2O + 2OH^-$
(d) $HOCl + H_2O_2 \longrightarrow H_3O^+ + Cl^- + O_2$

[Ans. (b) $PbS + 4H_2O_2 \longrightarrow PbSO_4 + 4H_2O$]

58. **Two elements X and Y (atomic mass of X = 75; Y = 16) combine to give a compound having 76% of X. The formula of the compound is?**

(a) XY (b) X_2Y (c) X_2Y_2 (d) X_2Y_3

[Ans. (d) X_2Y_3]

59. **Assertion (A) : Among halogens fluorine is the best oxidant.**

Reason (R) : Fluorine is the most electronegative atom.

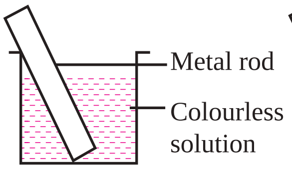
(a) Both A and R are true and R explains A
(b) Both A and R are true but R does not explain A
(c) A is true but R is false
(d) Both A and R are false

[Ans. (a) Both A and R are true and R explains A]

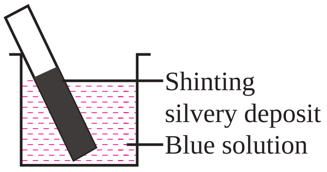
60. **Equal volume of nitrogen and Hydrogen gases will react to form ammonia in favourable condition then the limiting reagent is**

(a) H_2 (b) N_2 (c) NH_3
(d) No reactant is a limiting regent **[Ans. (b) N_2]**

61. **Identify the redox reaction taking place in a beaker.**



Initial stage



Final stage

(a) $Zn_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$
(b) $Cu_{(s)} + 2Ag^+_{(aq)} \longrightarrow Cu^{2+}_{(aq)} + 2Ag_{(s)}$
(c) $Cu_{(s)} + Zn^{2+}_{(aq)} \longrightarrow Zn_{(s)} + Cu^{2+}_{(aq)}$
(d) $2Ag_{(s)} + Cu^{2+}_{(aq)} \longrightarrow 2Ag^+_{(aq)} + Cu_{(s)}$

[Ans. (d) $2Ag_{(s)} + Cu^{2+}_{(aq)} \longrightarrow 2Ag^+_{(aq)} + Cu_{(s)}$]

Reason : Since Cu is more reactive than Ag, it displaces Ag^+ ions from its salt solution. Which get deposited on the copper rod.

62. **Match the list I with List II and select the correct answer using the code given below the list.**

List-I		List-II	
A	n	**1**	6.02×10^{23} Ne atoms
B	Vapour density	**2**	0.01 moles of solute in one L of solution
C	22.4 L at S.T.P	**3**	Molecular mass/2
D	Centimolar solution	**4**	Molecular mass/ empirical formula mass

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

[Ans. (b) 4 3 1 2]

65. **A compound has an empirical formula C_2H_4O. If the value of n = 2 the molecular formula of the compound is _________ .**

(a) C_2H_4O (b) CH_2O
(c) CH_2 (d) $C_4H_8O_2$

[Ans. (d) $C_4H_8O_2$]

66. **If ten volumes of dihydrogen gases react with five volumes of dioxygen gases that, how many volumes of water vapour would be produced?**

(a) 1 (b) 2 (c) 5 (d) 10

[Ans. (d) 10]

Hint : $2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(g)}$

67. **Limiting reagent is in a chemical reaction is the reactant in which**

(a) left some amount unreacted after the completion of reaction
(b) reacts completely in the reaction
(c) does not react in the reaction
(d) All of these

[Ans. (b) reacts completely in the reaction]

68. Assertion : When 4 moles of H_2 reacts with 2 moles of O_2, then 4 moles of water is formed.

Reason : O_2 will act as limiting reagent.

(a) Both assertion and reason are true and reason is the correct explanation of assertion.
(b) Both assertion and reason are true but reason is not the correct explanation of assertion.
(c) Only assertion is true but reason is false.
(d) Both assertion and reason are false.

[Ans. (b) Both assertion and reason are true but reason is not the correct explanation of assertion.]

69. Match the list-I with list-II and select the correct answer using the code given below the list.

List-I		List-II	
A	Molecular formula	1	Completely consumed
B	Stoichiometric Equation	2	Left unreacted
C	Limiting reagent	3	$n \times$ Empirical formula
D	Excess reagent	4	Balanced equation

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

[Ans. (b) 3 4 1 2]

72. Assertion : K_{20}. Al_2O_3. SiO_2. $6H_2O$ is the empirical formula of potash alum.

Reason : It is a double salt.

(a) Both assertion and reason are correct and reason is the correct explanation for assertion.
(b) Both assertion and reason are correct but reason is not the correct explanation for assertion
(c) Assertion is true but reason are false.
(d) Both assertion and reason are false.

[Ans. (b) Both assertion and reason are correct but reason is not the correct explanation for assertion]

73. Anything that has mass and occupies space is called _________.

(a) matter (b) weight
(c) energy (d) system

[Ans. (a) matter]

74. The mass of one mole of a substance is ________.

(a) molecular mass (b) Atomic mass
(c) molar mass (d) Nuclear mass

[Ans. (c) molar mass]

75. Which of the following is correct?

(a) Elemental analysis of a compound gives the mass percentage of atoms present in the compound
(b) Using the mass percentage, we can determine the empirical formula of the compound
(c) Molecular formula of the compound can be arrived at from the empirical formula using the molar mass of the compound.
(d) All the above are correct

[Ans. (d) All the above are correct]

76. Which formula of a compound is a whole number multiple of the empirical formula?

(a) matter (b) mass
(c) energy (d) weight

[Ans. (a) matter]

77. All oxidation reactions are accompanied by ________ reactions.

(a) accession (b) addition
(c) reduction (d) decomposition

[Ans. (c) reduction]

78. Hema attached to the _________ molecule.

(a) hydrogen (b) oxygen
(c) protein (d) water

[Ans. (c) protein]

79. During which reactions the oxidation number of elements changes?

(a) metabolic reactions
(b) reduction reactions
(c) exchange reactions
(d) redox reactions **[Ans. (d) redox reactions]**

80. An ion in a compound is replaced by an ion of another element are called _________ reactions.

(a) displacement (b) ionic
(c) chemical (d) physical

[Ans. (a) displacement]

81. Which method is used for ionic redox reactions?

(a) Ionic method
(b) Ion–Electron method
(c) Proton-Electron method
(d) Oxidation number method

[Ans. (b) Ion–Electron method]

ADDITIONAL SHORT ANSWERS

1. Statement 1 : Two mole of glucose contains 12.044×10^{23} molecules of glucose

Statement 2 : Total number of entities present in one mole of any substance is equal to 6.02×10^{22}. *[GMQP-2018]*

Whether the above statements are true? Is there any relation between these two statements?

Ans. The statements 1 & 2 are true. But there is no relation between statement 1 and statement 2.

2. How many moles of hydrogen is required to produce 10 moles of ammonia ? *[HY-2018]*

Ans. $N_2(g) + 3\,H_2(g) \xrightarrow{\quad} 2\,NH_3(g)$

To produce 2 moles of ammonia, 3 moles of hydrogen are required

To produce 10 moles of ammonia

$$= \frac{3 \text{ moles of } H_2}{\cancel{2 \text{ moles of } NH_3}} \times \overset{5}{\cancel{10 \text{ moles of } NH_3}}$$

= 15 moles of hydrogen are required.

3. Calculate the total number of electrons present in 17g of ammonia.

Ans. No. of electrons present in one ammonia (NH_3) molecule (7 + 3) = 10

No. of moles of $NH_3 = \frac{\text{Mass}}{\text{Molar mass}} = \frac{17g}{17g\ \text{mol}^{-1}} = 1 \text{ mol}$

No. of molecules present in 1 mol of NH_3

$= 6.023 \times 10^{23}$

No. of electrons present in 1 mol of NH_3

$= 10 \times 6.023 \times 10^{23}$

$= 6.023 \times 10^{24}$

4. Mixture of salt and water is a solution while that of oil and water is not. Explain.

Ans. Solution is a homogeneous mixture of two or more components. Salt in water is homogeneous and therefore it is a solution. Whereas oil in water is heterogeneous or immiscible mixture and so is not a solution.

5. Why is air sometimes considered as a heterogeneous mixture?

Ans. Air sometimes considered as a heterogeneous mixture due to the presence of dust particles which form a separate phase.

6. By applying the knowledge of chemical classification, classify each of the following into elements, compounds or mixtures.

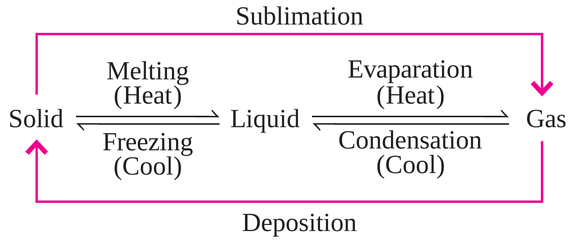
(i) Sugar
(ii) Sea water
(iii) Distilled water
(iv) Carbon dioxide
(v) Copper wire
(vi) Table salt
(vii) Silver plate
(viii) Naphthalene balls

Ans.

Element	Compound	Mixture
Copper wire (cu)	Sugar	Sea water
Silver plate (Ag)	distilled water carbon dioxide Table salt Naphthalene balls	

7. Matter is defined as anything that has mass and occupies space. All matter is composed of atoms.

Ans.



8. List the differences between elements and compounds.

Ans.

ELEMENTS		COMPOUNDS
(i)	An element consists of only one type of atom.	Compounds are made up of molecules which contain two or more atoms of different elements.
(ii)	Element can exist as monatomic or polyatomic units. The polyatomic elements are called molecules.	Properties of compounds are different from those of their constituent elements.
(iii)	**Eg : Monatomic unit** - Gold (Au), Copper (Cu); **Polyatomic unit** - Hydrogen (H_2)	**Eg :** Carbon dioxide (CO_2), Glucose ($C_6H_{12}O_6$)

9. Write a note on 'mixture' based on the chemical classification of matter.

Ans. Two or more substances mix together in any ratio without any chemical intraction is called mixture.

(i) Homogeneous mixture :

A mixture having uniform composition throughout is called homogeneous mixture. **Eg :** salt solution, air etc.,

(ii) Heterogeneous mixture :

A mixture in which the composition is not uniform throughout and different components can be observed is called heterogeneous mixture. **Eg :** Mixture of salt and sugar, cereals and pulse etc.,

10. How will you classify matter based on physical state?

Ans. **Physical Classification of Matter :** Matter can be classified as solids, liquids and gases based on their physical state. The physical state of matter can be converted into one another by modifying the temperature and pressure suitably.

11. Explain the classification of matter based on chemical composition.

Ans. **Chemical Classification :** Pure substances are composed of simple atoms or molecules. They are further classified as elements and compounds.

(a) Element :

- An element consists of only one type of atom.
- Element can exist as monatomic or polyatomic units. The polyatomic elements are called molecules.
- **Eg : Monatomic unit** - Gold (Au), Copper (Cu); **Polyatomic unit** - Hydrogen (H_2)

(b) Compound :

- Compounds are made up of molecules which contain two or more atoms of different elements.
- **Eg :** Carbon dioxide (CO_2), Glucose ($C_6H_{12}O_6$).

12. Define Avogadro number.

Ans. The total number of entities present in one mole of any substance is equal to 6.022×10^{23}.This number is called Avogadro number.

13. Define molar volume.

Ans. The volume occupied by one mole of any substance in the gaseous state at a given temperature and pressure is called molar volume. One mole of an Ideal gas is equal to 22.4 L (Or) 22400mL at STP conditions.

14. State Avogadro's hypothesis.

Ans. Equal volume of all gases under the same conditions of temperature and pressure contain equal number of molecules.

15. Which law co-relates the mass and volume of a gas?

Ans. Avogadro's law. It states equal volume of all gases under the same conditions of temperature and pressure contain equal number of molecules.

16. Does one gram mole of a gas occupy 22.4 L under all conditions of temperature and pressure.

Ans. No, one gram mole of a gas occupies 22.4 L only under STP conditions, i.e. at 273 K temperature and 760mm of pressure. (1.0315×10^{15} Pa)

17. Bring about the dissimilarities in mole concept and molar mass by clearly analysing them.

Ans.

Mole	Molar Mass
1. It is defined as the amount of the substance that contains as many specified elementary particles as the number of atoms in 12g of C^{12}.	It is defined as the mass of one mole of the substance.
2. 1 mole = 6.023×10^{23} particles	Molar mass $= \dfrac{\text{Mass}}{\text{mol}}$ g mol^{-1}

18. (i) If an acid is mono basic, how will you relate their equivalent mass and molecular mass.

(ii) What is the basicity of $H_4 P_2 O_7$?

(iii) Give any two examples for dibasic acids.

Ans. (i) If an acid is mono basic, then its equivalent mass = Molecular mass.

(ii) Basicity of $H_4P_2O_7$ is 4 (Tetrabasic acid)

(iii) Examples of dibasic acid are H_2SO_4, H_3PO_3.

19. Why are the atomic mass of most of the elements fractional?

Ans. It is because most of the elements occur in nature as a **mixture of isotopes** and their atomic masses are the average relative atomic masses of the isotopes depending in their abundance.

20. Write down the formulae for calculating the equivalent mass of an acid, base and oxidising agent.

Ans. **(i) Equivalent Mass of Acids :**

$$E = \frac{\text{Molar mass of the acid}}{\text{Basicity of the acid}}$$

(ii) Equivalent Mass of Bases :

$$E = \frac{\text{Molar mass of the base}}{\text{Acidity of the base}}$$

(iii) Equivalent Mass of Oxidising agent :

$$E = \frac{\text{Molar mass of the oxidising agent}}{\text{no. of moles of electrons gained by one mole of the oxidising agent}}$$

21. Define limiting reagent. *[GMQP-2018; QY-2018]*

Ans. **Limiting reagent :** When a reaction is carried out using non-stoichiometric quantities of the reactants, the product yield will be determined by the reactant that is completely consumed. It limits the further reaction from taking place and is called as the limiting reagent.

22. Define stoichiometry.

Ans. Stoichiometry is the quantitative relationship between reactants and products in a balanced chemical equation in moles.

23. What do you understand by stoichiometric co-efficients in a chemical equation?

Ans. The co-efficients of reactants and products involved in a chemical equation represented by the balanced form are known as stoichiometric co-efficients.

Eg : $N_{2(g)} + 3H_{2(g)} \longrightarrow 2NH_{3(g)}$

The stoichiometric co-efficients are 1, 3 and 2 respectively.

24. Write the simplest formula for the following.

(i) N_2O_4 (ii) $C_6H_{12}O_6$ (iii) H_2O (iv) H_2O_2

Ans. **(i)** NO_2 **(ii)** CH_2O
(iii) H_2O **(iv)** HO.

25. Write the electronic concept of oxidation and reduction reactions. *[QY. & HY. 2018]*

Ans. The process can be explained on the basis of electrons. The reaction involving loss of electron is termed oxidation

$Fe^{2+} \rightarrow Fe^{3+} + e^-$ (loss of electron-oxidation).

The reaction involving gain of electron is termed reduction.

$Cu^{2+} + 2e^- \rightarrow Cu$ (gain of electron-reduction)

26. Calculate the amount of water produced by the combustion of 32 g of methane. *[QY-2018]*

Ans. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

As per the stoichiometric equation,

Combustion of 1 mole (16 g) CH_4 produces 2 moles (2 × 18 = 36 g) of water.

$$\begin{tikzcd}[column sep=tiny] & CH_4 \arrow[dl] \arrow[dr] & \\ (12) & + & (4 \times 1) \end{tikzcd} = 16\ g\ mol^{-1}$$

$$\begin{tikzcd}[column sep=tiny] & H_2O \arrow[dl] \arrow[dr] & \\ (2 \times 1) & + & (1 \times 16) \end{tikzcd} = 18\ g\ mol^{-1}$$

Combustion of 32 g CH_4 produces

$$\frac{36\ g\ H_2O}{\cancel{16\ g\ CH_4}} \times \overset{2}{\cancel{32\ g\ CH_4}} = 72\ g \text{ of water}$$

27. Categorise the redox reactions that occur in our daily life.

Ans.
- Fading of the colour of the clothes
- Burning of cooking gas, fuel, wood, etc.
- Rusting of Iron
- Extraction of Metals.

28. $2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2$

(i) In this reaction which substance is getting oxidised and which substance is getting reduced?

(ii) Name the oxidising and reducing agents.

Ans. **(i)** Oxygen is being added to Cu, (ie.,) Cu_2S is oxidised to Cu_2O and the other reactant O_2 is getting reduced.

(ii) Cu_2S is the a reducing agent.
O_2 is an oxidising agent.

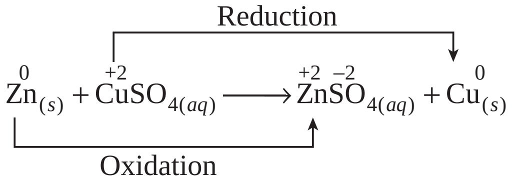
29. How would you know whether a redox reaction is taking place in an acidic, alkaline or neutral medium.

Ans.
- If H^+ any acid appears on either side of the chemical equation, the reaction occurs in acidic solution.
- If OH^- or any base appears on either side of the chemical equation, the reaction occurs in basic solution.
- If neither H^+, OH^- nor any acid or base is present in the chemical equation, the solution is neutral.

30. Zn rod is immersed in $CuSO_4$ solution. What will you observe after an hour? Explain you observation in terms of redox reaction.

Ans.
- The blue colour of $CuSO_4$ solution will get discharged and reddish brown copper metal will be deposited on Zn rod.

- This is because blue colour Cu^{2+} (in $CuSO_4$) gets reduced to Cu by accepting two electrons from Zn, which gets oxidised to colourless $ZnSO_4$.



$$\overset{0}{Zn}_{(s)} + \overset{+2}{Cu}SO_{4(aq)} \longrightarrow \overset{+2}{Zn}\overset{-2}{SO}_{4(aq)} + \overset{0}{Cu}_{(s)}$$

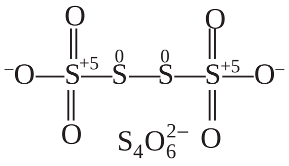
31. What will be oxidation number of sulphur in $S_2O_8^{2-}$ ion and $S_4O_6^{2-}$ ion? *[HOTS]*

Ans. **(i)** In $S_2O_8^{2-}$, there is one peroxide bond (–O–O–) therefore, two oxygen atoms having oxidation number –1 (i.e., O_2^{2-}) and for the other six oxygen atoms, the oxidation number is –2.

$S_2O_8^{2-} = 2x + (-2 \times 6) + (-1 \times 2) = -2$

$2x = +12 \Rightarrow x = +6$

(ii) In $S_4O_6^{2-}$, two S-atoms have oxidation state +5 while another two S-atoms have 0 oxidation state.



32. Nitric acid is an oxidising agent and reacts with PbO but it does not react with PbO_2. Explain why? *[HOTS]*

Ans. **(i)** Nitric acid in an oxidising agent. It oxidises an element from lower oxidation state to higher oxidation state. In PbO, lead is in lower oxidation state of +2. HNO_3 oxidises lead from Pb^{2+} to Pb^{4+}

$$PbO + 2\,HNO_3 \rightarrow Pb\,(NO_3)_2 + H_2\,O$$

(ii) In PbO_2, lead is in +4 oxidation state and cannot be oxidised further. Therefore no reaction takes place.

33. Which one of the two, ClO_2^- or ClO_4^- shows disproportionation reaction and why? *[HOTS]*

Sol : The oxidation state of Cl in ClO_2^- is +3. So, chlorine can get oxidised as well as reduced and can act as reductant and oxidant.

The disproportionation reaction of ClO_2^- is

$$3\overset{+1}{Cl}O_2^- \longrightarrow Cl^- + \overset{+5}{Cl}O_3^-$$

In ClO_4^-, Cl is in its highest oxidation state, So it can only be an oxidant.

34. Identify the type of redox reaction taking place in the following.

(i) $$3\overset{0}{Mg}_{(s)} + \overset{0}{N}_{2(g)} \longrightarrow \overset{+2}{Mg}_3\,\overset{-3}{N}_{2(s)}$$

(ii) $$\overset{+5}{Y}_2\,\overset{-2}{O}_{5(s)} + 5\overset{0}{Ca}_{(s)} \longrightarrow 2\overset{0}{V}_{(s)} + 5\,\overset{+2}{Ca}\overset{-2}{O}_{(s)}$$

(iii) $$2\overset{+1}{K}\,\overset{+5}{Cl}\,\overset{-2}{O}_{3(s)} \longrightarrow 2\overset{+1}{K}\,\overset{-1}{Cl}_{(s)} + 3\overset{0}{O}_{2(g)}$$

(iv) $$\overset{0}{Ca}_{(s)} + 2\,\overset{+1}{H}_2\overset{-2}{O}_{(l)} \longrightarrow \overset{+2}{Ca}(\overset{-2+1}{OH})_{2(aq)} + \overset{0}{H}_{2(g)}$$

(v) $$Br_{2(l)} + 2I_{(aq)} \longrightarrow 2Br^-_{(aq)} + I_{2(s)}$$

(vi) $$\overset{0}{Cl}_{2(g)} + 2OH^-_{(aq)} \longrightarrow \overset{-1}{Cl}\,O^-_{(aq)} + \overset{-1}{Cl}^-_{(aq)} + H_2O_{(l)}$$

Ans. **(i)** Combination reaction
(ii) Displacement reaction
(iii) Decomposition reaction
(iv) Metal displacement reaction
(v) Non-metal displacement reaction
(vi) Disproportionation reaction.

35. What is molar Volume?

Ans. Molar volume is the volume occupied by one mole of any substance in the gaseous state at STP. It is equal to 2.24×10^{-2} m^3 (22.4 L)

36. How can we say sugar has solid and water has liquid?

Ans. When a sugar dissolves into tea or coffee, the liquid transforms the sugar into a liquid. So it can fit in with the liquid and slide in with the molecules. If you try to evaporate the water for long enough, you will turn the sugar back into a solid.

37. Define Average atomic mass?

Ans. Average atomic mass is defined as the average atomic mass of all atoms in their naturally occurring isotopes.

Examples:

Chlorine consist of chlorine isotope $_{17}Cl^{35}$ and $_{17}Cl^{37}$ are in the ratio 77:23, the average atomic mass of chlorine

A(– is bar) is equal to $A_1X_1 + A_2X_2 / X_1 + X_2$ is equal to $35 \times 77 + 37 \times 23/100$ is equal to 35.46 u.

38. State Avogadro's Hypothesis.

Ans. It states that "Equal volume of all gases under the same conditions of temperature and pressure contain equal number of molecules."

39. The approximate production of Na_2CO_3 per month is 424×10^6 g while that of methyl alcohol is 320×10^6 g. Which is produced more in terms of moles?

Ans. Na_2CO_3 mass $= 424 \times 10^6$ g

Molecular mass of Na_2CO_3 $= (23 \times 2) + 12 + (16 + 3)$

$= 46 + 12 + 18$

$= 106$ g

$$\text{No. of moles of } Na_2CO_3 = \frac{\text{Mass of } Na_2CO_3}{\text{molecular mass of } Na_2CO_3}$$

$$= \frac{424 \times 10^6 \text{g}}{106\text{g}}$$

$= 4 \times 10^6$ moles

Methyl alcohol mass $= 320 \times 10^6$ g

40. How many moles of glucose and present in 720g of glucose?

Ans. Glucose $= C_6H_{12}O_6$

Molecular mass of glucose $= (12 \times 6) + (1 \times 12) + (16 \times 6)$

$= 72 + 12 + 96 = 180$

$$\text{Number of mole of glucose} = \frac{\text{Mass of glucose}}{\text{Molecular mass of glucose}}$$

$$= \frac{720}{180} = 4 \text{ moles.}$$

41. What do you understand by the terms acidity and Basicity?

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

Basicity : The number of replaceable hydrogen atoms present in a molecule of the acid is referred to as its basicity.

42. What is meant by plasma state? Give an example.

Ans. Gaseous state of matter at very high temperature containing gaseous ions and free electron is referred to as the plasma state eg., Lightning.

43. What is meant by limiting agend?

Ans. A large excess of one reactant is supplied to ensure the more expensive reactant is completely converted to the desired product. The reactant use up first in a reaction is called the limiting reagent.

44. What is combination reaction? Give example.

Ans. When two or more substance combine to form a single substance, the reactions are combination reactions.

$$A + B \longrightarrow C$$

Ex – $2Mg + O_2 \longrightarrow 2MgO$

45. What is decomposition reaction? Give 2 example.

Ans. Chemical reactions in which a compound splits up into tow or more simpler substances are called decomposition reaction.

$$AB \longrightarrow A + B$$

Ex – $2KCl\,O_3 \longrightarrow 2KCl + O_2$

$PCl_5 \longrightarrow PCl_3 + Cl_2$

46. What is disproportionation reaction? Give example.

Ans. The reaction in which an element undergoes simultaneously both oxidation and reduction are called as disproportional reactions.

Ex : $P_4 + 3NaOH + 3H_2O \longrightarrow PH_3 + 3NaH_2\,PO_2$

$2HCHO + H_2O \longrightarrow CH_3OH + HCOOH$

47. What is displacement reactions? Give its types. Explain with example.

Ans. The reaction in which one ion or atom in a compound is replaced by an ion or atom of the other element are called displacement reactions.

$$AB + C \longrightarrow AC + B$$

Ex – Metal displacement

$CuSO_4 + Zn \longrightarrow ZnSO_4 + Cu$

Ex – Non-metal displacement

$2KBr + Cl_2 \longrightarrow 2KCl + Br_2$

48. What are competive electron transfer reaction? Give example.

Ans. These are the reaction in which redox reactions take place in different vessels and it is an indirect redox reaction. There is a competition for the release of electrons among different metals.

Eg : Zn releases electrons to Cu and Cu releases electrons to silver and SO on

$Zn_{(s)} + Cu^{2+} \longrightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$

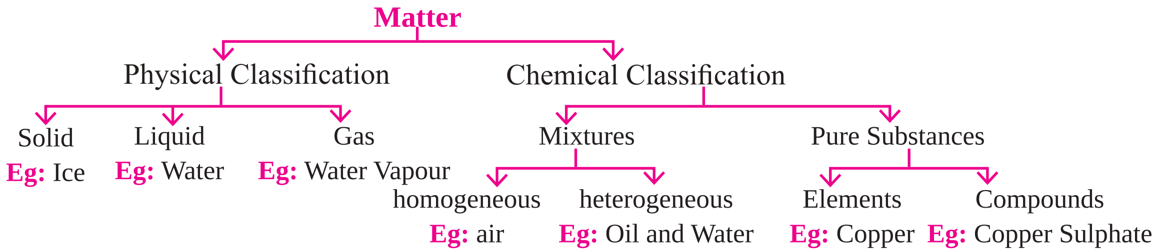
(Here Zn oxidised Cu^{2+} – reduced)

$Cu_{(s)} + 2Ag^{+} \longrightarrow Cu^{2+}_{(aq)} + 2Ag_{(g)}$

(Here Cu oxidised Ag^{+} – reduced)

49. **Draw a flow chart to illustrate classification of matter.**

Ans.



50. **An organic compound present in vinegar has 40 % carbon, 6.6 % hydrogen and 53.4 % oxygen. Find the empirical formula of the compound.**

Ans.

Element	Percentage	Atomic mass	Relative No. of moles	Simple ratio mole	Simplest ratio (in whole no)
C	40	12	$\frac{40}{12} = 3.3$	$\frac{3.3}{3.3} = 1$	1
H	6.6	1	$\frac{6.6}{1} = 6.6$	$\frac{6.6}{3.3} = 2$	2
O	53.4	16	$\frac{53.4}{16} = 3.3$	$\frac{3.3}{3.3} = 1$	1

The Empirical formula is CH_2O.

51. **Discuss the characteristic the properties of physical classification of matter.** ***[LOTS]***

Ans.

S.No	PROPERTIES	SOLID	LIQUID	GAS
1.	Volume	definite	definite	indefinite
2.	Shape	definite	indefinite	indefinite
3.	Compressibility	cannot be compressed	can be compressed	can be highly compressed
4.	Arrangement of molecules	regular and close to each other	random or irregular but almost close to each other.	random and wide apart
5.	Bonding	strong intermolecular bonds	relatively strong intermolecular bonds; slightly weaker than solid	very weak intermolecular bonds.
6.	Fluidity	cannot flow	can flow from higher to lower level	can flow in all directions
	Example	Ice	Water	Water vapour

ADDITIONAL LONG ANSWERS 5 MARK

1. Define oxidation number. Balance the following equation using oxidation number method.

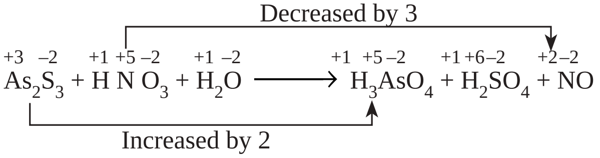
$As_2S_3 + HNO_3 + H_2O \longrightarrow H_3AsO_4 + H\ _2SO_4 + NO$ *[GMQP-2018]*

Ans. **Oxidation number :** It is defined as the imaginary charge left on the atom when all other atoms of the compound have been removed in their usual oxidation states that are assigned according to set of rules.

Solution :

Step 1 : $As_2S_3 + HNO_3 + H_2O \longrightarrow H_3AsO_4 + H_2SO_4 + NO$

Step 2 : Assign the oxidation numbers and identify the redox couples.



$$\overset{+3\ -2}{As_2S_3} + \overset{+1}{H}\overset{+5}{N}\overset{-2}{O_3} + \overset{+1\ -2}{H_2O} \longrightarrow \overset{+1\ +5\ -2}{H_3AsO_4} + \overset{+1\ +6-2}{H_2SO_4} + \overset{+2-2}{NO}$$

Step 3 : Multiply As_2S_3 by 3 and HNO_3 by 2.

$3As_2S_3 + 2HNO_3 + H_2O \longrightarrow H_3AsO_4 + H_2SO_4 + NO$

Step 4 : Balance all the elements in the equation (As, S and N) except H and O.

$3As_2S_3 + 2HNO_3 + H_2O \longrightarrow 6H_3AsO_4 + 9H_2SO_4 + 2NO$

Step 5 : Balance the complete equation including O & H.

$3As_2S_3 + 28HNO_3 + H_2O \longrightarrow 6H_3AsO_4 + 9H_2SO_4 + 28NO$

2. What is the condition for molar Volume?

Ans. The molar volume of any ideal gas at 273 degree kelvin and 1 atm pressure is equal to 22.4 L (or) 22400ml.

Ideal gas equation is PV is equal to nRT

where P is pressure at 1 atm. and temperature 273 degree kelvin is called Standard Temperature and Pressure.

R is the gas constant and is equal to 0.082 dm^3. atm. k^{-1}.mol^{-1}.

Hence V is equal to nRT/P.

V is equal to 22.4L.

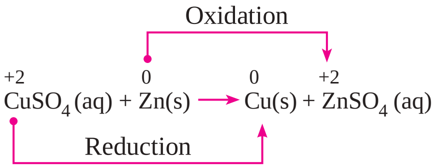
3. Define auto-oxidation (disproportination) reaction and its examples.

Ans. **Displacement reaction :** Redox reactions in which an ion (or an atom) in a compound is replaced by an ion (or atom) of another element are called displacement reactions.

They are further classified into (i) metal displacement reactions (ii) non-metal displacement reactions.

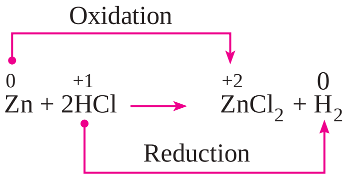
(i) Metal displacement reactions :

- Place a zinc metal strip in an aqueous copper sulphate solution taken in a beaker. Observe the solution, the intensity of blue colour of the solution slowly reduced and finally disappeared.
- The zinc metal strip became coated with brownish metallic copper. This is due to the following metal displacement reaction.



$$\overset{+2}{CuSO_4}(aq) + \overset{0}{Zn}(s) \longrightarrow \overset{0}{Cu}(s) + \overset{+2}{ZnSO_4}(aq)$$

(ii) Non-metal displacement :



$$\overset{0}{Zn} + 2\overset{+1}{H}Cl \longrightarrow \overset{+2}{Zn}Cl_2 + \overset{0}{H_2}$$

4. Write any three rules assigning for the oxidation number?

Ans.

- The oxidation state of a free elements (i.e. in its uncombined state) is zero.

  Example : each atom in H_2, Cl_2, Na, S_8 have the oxidation number of zero.
- For a monatomic ion, the oxidation state is equal to the net charge on the ion.

  Example : The oxidation number of sodium in Na^+ is +1.

  The oxidation number of chlorine in Cl^- is –1.
- The algebric sum of oxidation states of all atoms in a molecule is equal to zero, while in ions, it is equal to the net charge on the ion.

5. Distinguish between the following.

(i) Atomic and molecular mass **(ii) Atomic mass and atomic weight**

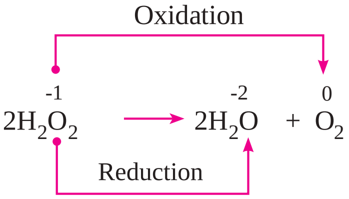
(iii) Empirical and molecular formula **(iv) Moles and molecules.**

Ans.

(i)	**Atomic Mass**	**Molecular Mass**
	Atomic mass is the mass of a single atom, which is its collective mass of neutron, proton and electrons.	Molecular weight is the mass of one molecule. Molecular mass can be calculated from the sum of atomic masses of all atoms present in a compound.
(ii)	**Atomic Mass**	**Atomic Weight**
	Atomic mass is the mass of a single atom, which is its collective mass of neutron, proton and electrons.	Atomic weight is the average weight of an elements with respect to all its isotopes and their relative abundance.
(iii)	**Empirical Formula**	**Molecular Formula**
	It represents the simplest whole number ratio of various atoms present in one molecule of the compound. Empirical formula of Benzene is CH	The molecular formula shows the exact number of different types of atoms present in a molecules of a compound. Molecular formula of Benzene is C_6H_6
(iv)	**Moles**	**Molecules**
	The amount of the substance that contains specified particles as the number of atoms in 12g of carbon - 12 isotope	Two or more atoms joint together by chemical bonds.

6. What are disproportionation reaction. (or) Define auto redox reaction.

Ans. **Disproportionation reaction (Auto redox reactions) :** In some redox reactions, the same compound can undergo both oxidation and reduction. In such reactions, the oxidation state of one and the same element is both increased and decreased. These reactions are called disproportionation reactions.



$$2H_2O_2 \longrightarrow 2H_2O + O_2$$

✶ ✶ ✶

NUMERICAL PROBLEMS

1. Calculate the number of atoms in each of the following.

(i) 52 g of He and (ii) 52 moles of He.

Ans. (i) 1 mol of He ≡ 4g ≡ 6.022 × 10^{23} He atoms

(ie) 4g of He contains 6.022 × 10^{23} He atoms

$$\therefore \text{ 52g of He contains } = \frac{6.023\times10^{23}\times52}{4}$$

$$=7.83\times10^{24}$$

52g of He contains 7.83 × 10^{24} He atoms.

(ii) 1 mol of He contains 6.023 × 10^{23} He atoms

$$\therefore \text{ 52 moles of He contains } = \frac{6.023\times10^{23}\times52}{1}$$

$$=3.132\times10^{25}$$

52 moles of He contains 3.132 × 10^{25} He atoms.

2. Calculate the mass of the following :

(i) 1 atom of silver (ii) 1 molecule of benzene

(iii) 1 molecule of water.

Ans. (i) Molecular mass of silver (Ag) = 107.87 u

Molar mass of Ag = 107.87 g mol^{-1}

$$\therefore \text{ Mass of 1 atom of Ag } = \frac{\text{Molar mass}}{\text{Avogadro's number}}$$

$$= \frac{107.87 \text{ g mol}^{-1}}{6.023\times10^{23}\text{ mol}^{-1}}$$

$$= 17.91 \times 10^{-23} \text{ g.}$$

Mass of 1 atom of Ag = 17.91 × 10^{-23} g.

(ii) Molecular mass of benzene (C_6H_6) =

(6 × 12.01 u) + (6 × 1u) = 78.06 u

Molar mass of benzene = 78.06 g mol^{-1}

Then, mass of 1 molecule of benzene

$$= \frac{\text{Molar mass of benzene}}{\text{Avogadro's number}}$$

$$= \frac{78.06 \text{ g mol}^{-1}}{6.023\times10^{23}\text{mol}^{-1}} = 12.96 \times 10^{-23} \text{ g}$$

Mass of 1 molecule of benzene = 12.94 × 10^{-23} g.

(iii) Molecular mass of water = (2 × 1u) + (1 × 16u)

= 18 u

Molar mass of water = 18 g mol^{-1}

Mass of 1 molecule of water

$$= \frac{\text{Molar mass of water}}{\text{Avogadro's number}}$$

$$= \frac{18\text{g mol}^{-1}}{6.023\times10^{23}\ \text{mol}^{-1}} = 2.99 \times 10–23 \text{ g}$$

Mass of 1 molecule of water = 2.99 × 10^{-23} g.

3. One million silver atoms weigh 1.79 × 10^{-16} g. Calculate the atomic mass of silver.

Ans. No. of silver atoms = 1 million = 1 × 10^6

Mass of one million Ag atoms = 1.79 × 10^{-16} g

Mass of 6.023 × 10^{23} atoms of silver

$$= \frac{1.79\times10^{-16}\text{g}}{1\times10^{6}}\times6.023\times10^{23}$$

$$= 107.8 \text{ g.}$$

Atomic mass of silver = 6.023 × 10^{23} atoms of Ag

∴ The atomic mass of Ag = 107.8 g.

4. How much mass (in gram units) is represented by the following?

(i) 0.2 mol of NH_3 (ii) 3.0 mol of CO_2

(iii) 5.14 mol of H_5IO_6

Ans. **(a)** Molar mass of NH_3 = (1×14 + 3×1) = 17g mol^{-1}

Mass of 0.2 mol of NH_3 = 0.2 mol × 17g mol^{-1}

= **3.4 g**

(b) Molar mass of CO_2 = (1×12 + 2×16)

= 44 g mol^{-1}

Mass of 3 moles of CO_2 = 3 mol × 44g mol^{-1}

= **132 g**

(c) Molar mass of H_5IO_6 = (5×1 + 1×127 + 6×16)

= **228 g mol^{-1}**

Mass of 5.14 mol of H_5IO_6 = 5.14 mol × 228g mol^{-1}

= **1171.9 g.**

5. What mass of N_2 will be required to produce 34g of NH_3 by the reaction, $N_2 + 3H_2 \longrightarrow 2NH_3$.

Ans. The reaction is

N_2	+ $3H_2$	$\longrightarrow$	$2NH_3$
1 mol	3 mol		2 mol
2 × 14			2(1×14 + 3×1)
28g			= 34g

Thus, to produce 34.0 g ammonia, 28g of N_2 is required.

6. Calculate the Formula Weights of the following compounds.

(a) NO_2 (b) Glucose ($C_6H_{12}O_6$) (c) NaOH (d) $Mg(OH)_2$

Ans. **(a) NO_2**

1 × AW of N = 1×14 = 14 amu

2 × AW of O = 2×16 = 32 amu

Formula weight of NO_2 = 46 amu

(b) $C_6H_{12}O_6$ - Glucose

6 × AW of C = 6×12.01 = 72.06 amu

12 × AW of H = 12×1.008 = 12.096 amu

6 × AW of O = 6×16 = 96.0 amu

Formula weight of Glucose is = 180.156 amu

Formula weight of Glucose is = 180 amu

(c) NaOH

1 × AW of Na = 1× 22.99 = 22.99 amu

1 × AW of O = 1×16 = 16.00 amu

1 × AW of H = 1×1.008 = 1.008 amu

Formula weight of NaOH is = 39.998 amu

Formula weight of NaOH is = 40 amu.

(d) $Mg(OH)_2$

1 × AW of Mg = 1 × 24.305 = 24.305 amu

2 × AW of O = 2 × 16 = 32.000 amu

2 × AW of H = 2 × 1.008 = 2.016 amu

Formula weight of $Mg(OH)_2$ is = 58.321 amu

Formula weight of $Mg(OH)_2$ is = 58 amu.

7. Calculate the equivalent weight of H_3PO_4 and $Ca(OH)_2$ on the basis of given reaction.

$$H_3PO_4 + NaOH \longrightarrow NaH_2PO_4 + H_2O$$

$$Ca(OH)_2 + HCl \longrightarrow Ca(OH)Cl + H_2O$$

Sol : Equivalent weight of H_3PO_4

$$= \frac{\text{Molecular mass}}{\text{No. of replaceable H}^+} = \frac{98}{1} = 98$$

Equivalent weight of $Ca(OH)_2$

$$= \frac{\text{Molecular mass}}{\text{No. of replacement OH}^-} = \frac{74}{1} = 74$$

8. (i) Calculate the gram molecular mass of sugar having molecular formula $C_{12}H_{22}O_{11}$.

(ii) Calculate (a) The mass of 0.5g molecule of sugar and (b) Gram molecule of sugar in 547.2 g.

Ans. **(i)** Molecular mass of Sugar ($C_{12}H_{22}O_{11}$)

= 12 × 12 + 22 × 1 + 11 × 16 = 342

(ii) **(a)** 1 gram molecule of sugar = 342 g

$\therefore$ 0.5 g molecule of sugar = 342 × 0.5

= 171 g

(b) 342 g of sugar = 1 gram molecule

$$547.2 \text{ of sugar} = \frac{1}{342} \times 547.2$$

= 1.6 gram molecule.

9. Calculate the number of moles in the following.
(i) 7.85 g of copper (ii) 4.66 mg of silicon
(iii) 65.6 mg of oxygen.

Sol :

(i) $$\text{Moles of copper} = \frac{\text{Mass of copper}}{\text{atomic mass}} = \frac{7.85}{63.546} = 0.123 \text{ mol.}$$

(ii) $$\text{Moles of silicon} = \frac{\text{Mass of silicon}}{\text{atomic mass}} = \frac{4.66 \times 10^{-3}}{28.1} = 1.658 \times 10^{-4} \text{ mol}$$

(iii) $$\text{Moles of oxygen} = \frac{\text{Mass of oxygen}}{\text{atomic mass}} = \frac{65.6 \times 10^{-6}}{16} = 4.1 \times 10^{-6} \text{ mol.}$$

10. What will be the molecular formula for the compound, whose empirical formula is CH_2Cl and molar mass is 98.96 g?

Sol : Empirical formula = CH_2Cl;

Empirical formula mass = 12.01 + 2 × 1.008 + 35.453

= 49.48 *g*

$$n = \frac{\text{molecular mass}}{\text{empirical formula mass}} = \frac{98.96g}{49.48g} = 2(n)$$

Molecular formula = *n* × Empirical formula

= 2 × CH_2Cl = $C_2H_4Cl_2$

11. Calculate the oxidation number of nitrogen in nitrous acid and nitric acid

Ans. **(i)** Nitrous acid : HNO_2

$$+1 + x - 2 \times 2 = 0$$
$$x = +3$$

(ii) Nitric acid : HNO_3

$$+1 + x - 2 \times 3 = 0$$
$$x = +5.$$

12. Balance the following reaction by oxidation number method.

Ans. $MnO_4^{-1} + H_2S + H^+ \longrightarrow Mn^{2+} + S$ (Acidic Medium)

(i) Write oxidation number of elements

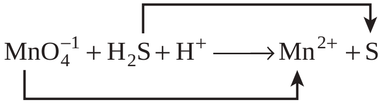
$$\underset{(+7)(-2)}{MnO_4^{-1}} + \underset{(+1)(-2)}{H_2S} \longrightarrow \underset{+2}{Mn^{2+}} + \underset{0}{S}$$

(ii) Balance the number of atoms of the elements in which oxidation number changes

$$\underset{(+7)}{MnO_4^{-1}} + \underset{(-2)}{H_2S} \longrightarrow \underset{(+2)}{Mn^{2+}} + \underset{0}{S}$$

(iii) Decide the oxidation and reduction reaction on the basis of difference of oxidation number.

Increase in oxidation number by 2(Oxidation)



$$MnO_4^{-1} + H_2S + H^+ \longrightarrow Mn^{2+} + S$$

Decrease in oxidation number by 5(Reduction)

(iv) On multiplying oxidation reaction by 5 and reduction reaction by 2 to balance the change in oxidation number.

$$2MnO_4^{-1} + 5H_2S \longrightarrow 2Mn^{2+} + 5S$$

(v) Balance the electric charge and atoms which do not change in oxidation number (spectators).

$$2MnO_4^{-1} + 5H_2S + 6H^+ \longrightarrow 2Mn^{2+} + 5S + 8H_2O$$

$$2(-1)\ 5(0) + 6(+1) = 2(+2) + 5(0) + 8(0)$$
$$-2 + 6 = +4$$
$$+4 = +4$$

In the above reaction the reactants and products are balanced in terms of electric charge and mass equivalence.

13. A compound on analysis was found to contain C = 34.6%; H = 3.85% and O = 61.55%. Calculate its empirical formula.

Ans.

Element	%	$\frac{\text{Percentage mass}}{\text{At. mass}}$	Molar Ratio	Simplest Whole Number Ratio
C	34.6	$\frac{34.6}{12} = 2.88$	$\frac{2.88}{2.88} = 1$	3
H	3.85	$\frac{3.85}{1} = 3.85$	$\frac{3.85}{2.88} = 1.335$	4
O	61.55	$\frac{61.55}{16} = 3.85$	$\frac{3.85}{2.88} = 1.335$	4

The empirical formula of the compound = $C_3H_4O_4$.

14. Calculate the mass of the atom in amu.

Ans. Oxygen

Mass of Oxygen atom = 2.656×10^{-23}

1 a.m.u (or) 1 u is equal to 1.66075 multiple

The mass of oxygen atom in amu

$$= \frac{2.656 \times 10^{-23}}{1.66075 \times 10^{-24}} \approx 15.992 \text{ a.m.u}$$

15. How many moles of barium suphate is precipitated when 1 mole of aluminium sulphate reacts completely with barium chloride?

Ans. $Al_2(SO_4)_3 + 3\,BaCl_2 \rightarrow 3\,Ba\,SO_4 + 2\,AlCl_3$

When 1 mole of aluminium sulphate reacts with barium chloride, 3 moles of $BaSO_4$ is precipitated.

16. Calculate the molecular mass of the following:

a) $KMnO_4$ **b) Crystalline Oxalic acid**

c) Methane

***Ans.* (a) $KMnO_4$**

1 × atomic mass of K = 1 × 39 = 39

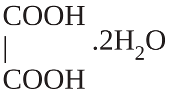
Mn = 1 × 55 = 55

O = 4 × 16 = 64

158

∴ Molecular mass of $KMnO_4$ = 158

(b) Crystalline Oxalic acid



$$\begin{array}{l} COOH \\ | \qquad .2H_2O \\ COOH \end{array}$$

C → 2 × 12 = 24

O → 4 × 16 = 64

H 2 × 1 = 2

90

4 × 1 = 4

2 × 16 = 32

126

∴ Molecular mass of oxalic acid = 126

(c) Methane CH_4

C → 1 × 12 = 12

H → 4 × 1 = 4

16

∴ Molecular mass of CH_4 = 16

17. Calculate the number of atoms/molecules present in the following:

a) 10g of Hg

b) 1.8g of water

c) 100g of sulpurdioxide

d) 1kg of acetic acid

***Ans.* (a) 10g of Hg**

Atomic mass of Hg = 200 g mol^{-1}

200 g of mercury contains 6.023×10^{23} atoms of mercury.

$$10 \text{ g of mercury contains } = \frac{10 \times 6.023 \times 10^{23}}{200}$$

$= 0.301 \times 10^{23}$

$= 3.01 \times 10^{24}$

atoms of mercury.

(b) 1.8g of water

1 mole of water = 18 g mol^{-1}

18 g of water contains 6.023×10^{23} molecules of water

$$1.8\text{g of water contains } = \frac{1.8 \times 6.023 \times 10^{23}}{18}$$

$= 0.602 \times 10^{23}$

$= 6.02 \times 10^{24}$

Molecules of water

(c) 100g of sulphur dioxide

Molecular mass of SO_2 = 64

64g of sulphur dioxide contains = 6.023×10^{23} Molecules of SO_2

$$\therefore 100\text{g of } SO_2 \text{ contains } = \frac{100 \times 6.023 \times 10^{23}}{64}$$

= 9.41

molecules of SO_2

(d) 1Kg of acetic acid

Molecular mass of acetic acid = 60

60g of acetic acid contains = 6.023×10^{23} Molecules of acetic acid

$\therefore$ 1000g of acetic acid contains

$$= \frac{1000 \times 6.023 \times 10}{60}$$

$= 100 \times 10^{23}$ molecules of acetic acid

18. Calculate the number of moles present in the following:

a) 50 g of calcium chloride

b) 120 g of sodium hydroxide

c) 46 g of ethanol

d) 90 g of magnesium oxide

e) 19.5 g of potassium

***Ans.* (a) 50 g of calcium chloride**

Molar mass of calcium chloride = 111

$$\text{No. of moles} = \frac{\text{Mass}}{\text{Molar mass}}$$

$$\text{No. of moles} = \frac{50}{111}$$

= 0.450 moles

(b) 120 g of sodium hydroxide

Molar mass of sodium hydroxide = 40

$$\text{No. of moles} = \frac{\text{Mass}}{\text{Molar mass}}$$

$$\text{No. of moles (n)} = \frac{120}{40}$$

= 3 moles

(c) 46 g of ethanol

Molecular mass of ethanol = 46

$$\text{No. of moles} = \frac{\text{Mass}}{\text{Molar mass}}$$

$$\text{No. of moles (n)} = \frac{46}{46} = 1 \text{ mole}$$

(d) 90 g of magnesium oxide

Molecular mass of MgO = 40

$$\text{No. of moles} = \frac{\text{Mass}}{\text{Molar mass}}$$

$$\text{No. of moles} = \frac{90}{40} = 2.25 \text{ moles}$$

(e) 19.5 g of potassium

Atomic mass of pottassium = 39

$$\text{No. of moles} = \frac{\text{Mass}}{\text{Molar mass}}$$

$$\text{No. of moles} = \frac{19.5}{39} = 0.5 \text{ moles}$$

19. Calculate the molar volume of the following:

a) 88 g of CO_2

b) 5 moles of methane

c) 460 g of formic acid

d) 3.0115×10^{23} molecules of SO_2gas

***Ans.* (a) 88 g of CO_2**

Molar mass of CO_2 = 44 g

Molar volume of 44 g (1mole) of CO_2

$= 2.24 \times 10^{-2}$ m^3

$$\text{The volume of 88g (2 moles)} = \frac{2.24 \times 10^{-2} \times 88}{44}$$

$= 4.48 \times 10^{-2}$ m^3

(b) 5 moles of methane

Molar mass of methane = 16 g

Molar volume of 16 g (1mole) of methane

$= 2.24 \times 10^{-2}$ m^3

volume of 5 moles (80g) of methane

$$= \frac{2.24 \times 10^{-2} \times 80}{16}$$

$= 11.2 \times 10^{-2}$ m^3

(c) 460 g of formic acid

Molar mass of formic acid = 46 g

Molar volume of 46 g (1mole) of formic acid

$= 2.24 \times 10^{-2}$ m^3

Molar volume of 460g of (10 moles) of formic acid

$$= \frac{2.24 \times 10^{-2} \times 460}{46}$$

$= 22.4 \times 10^{-2}$ m^3

(d) 3.0115×10^{23} molecules of SO_2gas

6.023×10^{23} molecules = 1 mole

$$3.0115 \times 10^{23} \text{ molecules} = \frac{1}{6.023 \times \cancel{10^{23}}}$$

$\times 3.0115 \times 10^{\cancel{23}}$

= 0.5 moles

Molar volume of 1mole of $SO_2 = 2.24 \times 10^{-2} m^3$

Molar volume of 0.5 moles of SO_2

$$= 2.24 \times 10^{-2} \times 0.5$$

$$= 1.12 \times 10^{-2}\ m^3$$

20. Calculate the equivalent mass of the following

a) Zn b) Nitrate ion c) sodium

Ans. **(a) Zn**

$$\text{Equivalent mass} = \frac{\text{Atomic mass}}{\text{Valency}}$$

$$= \frac{65}{2} = 32.5 \text{ g eq}^{-1}$$

(b) Nitrate ion (NO_3^-)

$$\text{Equivalent mass of an ion} = \frac{\text{Formula mass}}{\text{Change of ion}}$$

$$\text{Equivalent mass of } NO_3^- = \frac{62}{1} = 62$$

(c) Sodium

$$\text{Equivalent mass} = \frac{\text{Atomic mass}}{\text{Valency}}$$

$$\text{Equivalent mass of sodium} = \frac{23}{1} = 23$$

21. 0.456 g of a metal gives 0.606g of its chloride. Calculate the equivalent mass of the metal.

Ans. Mass of the metal = W_1 = 0.606g

∴ Mass of chlorine = W_2 = 0.606 – 0.456 = 0.15g

0.15 g of chlorine combine with 0.456 g of metal

∴ 35.46 g of chlorine will combine with

$$\frac{0.456}{0.15} \times 35.46 = 107.76\text{g eq}^{-1}$$

Mass of chloride = 0.606 – 0.456 = 0.146 g

0.146g of chlorine combines with 0.456 g of metal.

∴ 35.5 g of chlorine will combines with

$$= \frac{35.5 \times 0.456}{0.146}$$

= 110.8g of metal

∴ equivalent mass of metal = 110.8g equ $^{-1}$

22. 1.05 g of a metal gives on oxidation 1.5g of its oxide. Calculate its equivalent mass.

Ans. Mass of oxygen = 1.5 – 1.05

= 0.45 g

0.45g of oxygen combines with 1.05 g of metal.

∴ 8 g of oxygen combines with $\frac{8 \times 1.05}{0.45}$ g of metal

= 18.66 g of metal

∴ equivalent mass of metal = 18.66g equ $^{-1}$

23. Calculate equivalent mass of the following

a) Sodium hydroxide

b) Aluminium hydroxide

c) ammonium hydroxide

d) Calcium hydroxide

e) Magnesium hydroxide

Ans. **(a) NaOH**

$$\text{equivalent mass of NaOH} = \frac{40}{1} = 40$$

(b) Aluminium hydroxide

$$\text{equivalent mass of } Al(OH)_3 = \frac{78}{3} = 26$$

(c) Ammonium hydroxide

$$\text{equivalent mass of } NH_4OH = \frac{35}{1} = 35$$

(d) Calcium hydroxide

$$\text{equivalent mass of } Ca(OH)_2 = \frac{74}{2} = 37$$

(e) Magnesium hydroxide $Mg(OH)_2$

equivalent mass of Magnesium hydroxide

$$= \frac{58}{2} = 29$$

24. Calculate the equivalent mass of potassium dichromate in acid medium

$[K_2Cr_2O_7 + 4H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3(O)\ 3 \times 16 = 48\ \ 294\text{ g}]$

Ans. 48 parts by mass of oxygen are made available from 294 parts by mass of $K_2Cr_2\ O_7$

∴8 parts by mass of oxygen will be furnished by

$$= \frac{294 \times 8}{48} = 49$$

Equivalent mass of $K_2Cr_2\ O_7$ = 49 g equiv^{-1}

25. Calculate Equivalent mass of the following

a) Hydrochloric acid

b) Nitric acid

c) Acetic acid

d) Crystalline oxalic acid

e) Phosphorous acid

Ans. **(a) Hydrochloric acid**

equivalent mass of an acid

$$= \frac{\text{Molar mass of the acid}}{\text{Basicity of the acid}}$$

$$\text{Equivalent mass of HCl} = \frac{36.5}{1}$$

$$= 36.5$$

(b) Nitric acid

$$\text{equivalent mass of } HNO_3 = \frac{\text{Molar mass}}{\text{basicity}} = \frac{63}{1} = 63$$

(c) Acetic acid (CH_3 COOH)

$$\text{equivalent mass of acetic acid} = \frac{\text{Molar mass}}{\text{basicity}} = \frac{60}{1} = 60$$

(d) Crystalline oxalic acid

$$\text{equivalent mass of oxalic acid} = \frac{\text{Molar mass}}{\text{basicity}}$$

$$\text{equivalent mass} = \frac{126}{2} = 63$$

(e) Phosphorous acid (H_3 PO_3)

equivalent mass of phosphorous acid

$$= \frac{\text{Molar mass}}{\text{basicity}} = \frac{82}{2} = 41$$

$\therefore$ equivalent mass of $H_3PO_3 = 41$

26. 3.24 g of titanium reacts with oxygen to form 5.40 g of the metal oxide. Find the empirical formula of the metal oxide?

Ans. Weight of Titanium = 3.24 g; Weight of metal oxide = 5.40 g

Weight of Oxygen = (5.40 – 3.24) = 2.16 g

Element	Percentage	Atomic mass	Relative No. of moles	Simple ratio mole	Simplest whole Number Ratio
Ti	3.24	48	$\frac{3.24}{48} = 0.0675$	$\frac{0.067}{0.067} = 1$	1
O	2.16	16	$\frac{2.16}{16} = 0.135$	$\frac{0.135}{0.067} = 2$	2

$\therefore$ The empirical formula is Ti O_2

27. A compound contains 11.99% N, 13.70% O, 9.25% B and 65.06% F. Find its empirical formula

Ans.

Element	Percentage	Atomic mass	Relative No. of moles	Simple ratio mole	Simplest whole Number Ratio
N	11.99	14	$\frac{11.99}{14} = 0.856$	$\frac{0.856}{0.856} = 1$	1
O	13.70	16	$\frac{13.70}{16} = 0.856$	$\frac{0.856}{0.856} = 1$	1
B	9.25	10	$\frac{9.25}{10} = 0.925$	$\frac{0.925}{0.856} = 1$	1
F	65.06	19	$\frac{65.06}{19} = 3.424$	$\frac{3.424}{0.856} = 4$	4

$\therefore$ Empirical formula of the compound in $NOBF_4$

28. **A organic compound used for welding operation contains the following composition by mass: C = 92.3%, H= 7.7%. Find out the molecular formula of the compound. At STP, 10.0 L of this gas is found to weight 11.6g.**

Ans. Determination of Molecular formula

Element	Percentage	Atomic mass	Relative No. of moles	Simple ratio mole	Simplest whole Number Ratio
C	92.3	12	$\frac{92.3}{12} = 7.7$	$\frac{7.7}{7.7} = 1$	1
H	7.7	1	$\frac{7.7}{1} = 7.7$	$\frac{7.7}{7.7} = 1$	1

Empirical formula is CH

Molecular formula = n × emprical formula

Emperical formula mass (1 × 12) + (1 ×1) 12 + 1 = 13

$$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}}$$

$$\text{Molar mass} = \frac{\text{wt. of the substance} \times \text{Molar volume}}{\text{vol.of the substance}} \text{ at STP}$$

Molar volume at STP = 2.24×10^{-2} m^3 = 22.4 l = 22400 ml

$$\text{Molar mass of the gas at STP} = \frac{11.6 \times 22.4}{10} = 25.9 = 26$$

$$n = \frac{26}{13} = 2$$

Molecular formula = n × (emp. formula) = 2 × (CH) = C_2 H_2

29. **The organic compound Vitamin-C, has the following composition by mass: 40.92% C, 4.58% H, and the rest is oxygen. Determine its molecular formula. Molar mass of the substance is 176 g mol^{-1}.**

Ans.

Element	Percentage	Atomic mass	Relative No. of moles	Simple ratio mole	Simplest whole Number Ratio
C	40.92	12	$\frac{40.92}{14} = 3.41$	$\frac{3.41}{3.406} = 1.001$	3
H	4.58	1	$\frac{4.58}{1} = 4.58$	$\frac{4.58}{3.406} = 1.344$	4
O	100 – [40.92 +458]	16	$\frac{54.5}{10} = 3.406$	$\frac{3.406}{3.406} = 1$	3

Empirical formula is C_3H_4 O_3

Empirical formula mass = (12 × 3) + (1 ×4)+ (3 × 16) = 36 + 4 + 48 = 88

Molecular formula = n × empirical formula

$$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}} = \frac{176}{88} = 2$$

n = 2

∴ Molecular formula = n × (emp. formula) = 2 × (C_3 H_4O_3) = C_6 H_8O_6

REDOX REACTION ACTIVITY

1. A piece of cut apple becomes brown. Why? Can you prevent it by a simple method?

Ans. Apple turns brown when cut since the surface is exposed to air and undergoes oxidation. It can be prevented by dipping sliced apples in lemon juice. Lemon juice is an antioxidant which takes in all the available oxygen and prevents it from reaching the apple's tissues.

2. Place an iron piece in a moist atmosphere and observe it after two days. Is there any deposition of new substance? Why does it happen? What is this phenomenon called?

Ans. When iron is exposed to moist air, the iron reacts with oxygen in the presence of moisture to from a reddish - brown chemical compound, iron - oxide. This phenonaenon is called rusting. A new substance Iron (III) oxide is formed.

$4\ Fe(OH)_2 + O_2 + xH_2O \rightarrow 2\ Fe_2O_3\ (x + 4)H_2O$

3. Calculate the oxidation number of underlined atoms of the following:

1. $K_2\underline{Mn}O_4$
2. $K_2\underline{Cr}O_4$
3. $\underline{N}O_3^-$
4. $H_4\underline{P}_2O_7$
5. $\underline{Cl}O_3^-$
6. $\underline{As}O_3^{3-}$

***Ans.* 1.** $K_2\underline{Mn}O_4$

Oxidation number of Mn be x

$$\begin{aligned} 2\,(1) + x + 4\,(-2) &= 0 \\ 2 + x - 8 &= 0 \\ x - 6 &= 0 \\ x &= 6 \end{aligned}$$

Oxidation number of Mn in $K_2\ MnO_4$ is +6.

2. $K_2\underline{Cr}O_4$

$$\begin{aligned} 2\,(1) + x + 4\,(-2) &= 0 \\ 2 + x - 8 &= 0 \\ x - 6 &= 0 \\ x &= +6 \end{aligned}$$

Oxidation number of Cr in $K_2\ CrO_4$ is +6.

3. $\underline{N}O_3^-$

$$\begin{aligned} x + 3(-2) &= -1 \\ x - 6 &= -1 \\ x &= -1 + 6 = +5 \end{aligned}$$

Oxidation number of N in NO_3^- is +5.

4. $H_4\underline{P}_2O_7$

$$\begin{aligned} 4(1) + 2x + 7(-2) &= 0 \\ 4 + 2x - 14 &= 0 \\ 2x - 10 &= 0 \\ 2x &= 10 \\ x &= 5 \end{aligned}$$

Oxidation number of P in $H_4P_2O_7$ is +5.

5. $\underline{Cl}O_3^-$

$$\begin{aligned} x + 3(-2) &= -1 \\ x - 6 &= -1 \\ x &= +5 \end{aligned}$$

Oxidation number of Cl in $ClO_3^-$is +5.

6. $\underline{As}O_3^{3-}$

$$\begin{aligned} x + 3(-2) &= -3 \\ x - 6 &= -3 \\ x &= -3 + 6 \\ x &= +3 \end{aligned}$$

Oxidation number of As in AsO_3^{3-} is +3.

4. An iron nail is placed in copper sulphate solution taken in the beaker. Observe it for some time? Find the changes that takes place and why?

Ans. When iron nail is dipped in copper sulphate solution, the colour of copper sulphate tuns from blue to light green and reddish brown deposits is formed on iron nail. This is because iron is more reactive than copper, so it displaces Cu from $CuSO_4$ solution.

The displacement reaction can be written as

$CuSO_4 + Fe \rightarrow\ FeSO_4 + Cu$

5. The approximate production of Na_2CO_3 per month is 424×10^6g while that of methyl alcohol is 320×10^6g. Which is produced more in terms of moles?

Ans. Mass of Na_2CO_3 = 424×10^6g

No of moles (n) = $\dfrac{\text{Mass of the substance}}{\text{Molar mass of the substance}}$

$= \dfrac{424 \times 10^6}{106}$

$= 4$ moles $\times 10^6$

Mass of CH_3OH = 320×10^6g

No of moles = $\dfrac{\text{Mass of the substance}}{\text{Molar mass of the substance}}$

$= \dfrac{320 \times 10^6}{32}$

$= 10 \times 10^6$ moles

Methyl alcohol is produced more.

6. Find the molecular mass of $FeSO_4 7H_2O$.

Ans. Molecular mass of $FeSO_4 7H_2O$

Atomic mass of Fe = 55.845

Atomic mass of S = 32.065

Atomic mass of O = 15.994 × 11 = 63.304

Atomic mass of H = 1.00794 × 14 = 5.076

Molecular mass of $FeSO_4 . 7H_2O$ = 55.945 + 32.065 + (4 × 15.994) + 7 × (1.0079 × 2 + 15.9994)

= 278.014g/mol

7. The density of $CO_2 = 1.977$ kgm^{-3} at STP. Calculate the molecular mass of CO_2.

Ans. Density of CO_2 = 1.977 Kgm^{-3}

PV = nRT

No of moles = $\dfrac{\text{Mass}}{\text{Molar Mass}}$

PV = $\dfrac{\text{Mass}}{\text{Molar Mass}} \times R \times T$

Molar Mass = $\dfrac{\text{Mass}}{V} \times \dfrac{R \times T}{P}$

Density = $\dfrac{\text{Mass}}{V}$

Molar Mass of CO_2 = $\dfrac{D \times R \times T}{P}$

Standard Temperature = 273 K

Standard Pressure = 760mm of Hg = 1 atm

$= \dfrac{1.977 \times 0.0821 \times 273}{1}$

$= 44$

8. How many moles of glucose are present in 720 g of glucose?

Ans. Mass of glucose = 720g

Molecular weight of glucose ($C_6H_{12}O_6$) = 180

No. of moles = $\dfrac{\text{Mass}}{\text{Molar Mass}}$

$= \dfrac{720}{180} = 4$ moles

9. Calculate the weight of 0.2 mole of sodium carbonate.

Ans. No. of moles of Na_2CO_3 = 0.2 mole

Molar mass of Na_2CO_3 = 106g/mol

Mass = No of moles × molar mass of Na_2CO_3

= 0.2 × 106 = 21.2g

10. Calculate the equivalent mass of bicarbonate ion.

Ans. Bicarbonate ion = $HCO^-{}_3$

Molar of $HCO^-{}_3$ = 61

Equivalent mass of ion = $\dfrac{\text{Molar mass}}{\text{Charge of ion}}$

Equivalent mass of $HCO^-{}_3$ = $\dfrac{61}{1} = 61$

11. Calculate the equivalent mass of barium hydroxide

Ans. Equivalent mass of $Ba(OH)_2$

Molar mass of $Ba(OH)_2$ = 171.34 g/mol

Acidity of the $Ba(OH)_2$ = 2

Equivalent mass of the $Ba(OH)_2$

$= \dfrac{\text{Molar mass of the base}}{\text{Acidity of the base}}$

$= \dfrac{171.34}{2} = 85.5$

21. Define enthalpy.

Ans. **Enthalpy** is a thermodynamic property of a system. Enthalpy H is defined as sum of the internal energy (U) of a system and the product of Pressure and Volume of the system. That is,

$$H = U + PV$$

22. Define standard enthalpy changes.

Ans. The standard enthalpy of a reaction is the enthalpy change for a reaction when all the participating substances are present in their standard states. Standard conditions are denoted by adding the superscript 0 to the symbol (ΔH°).

23. Applications of the heat of combustion?

Ans. Heat of combustion is used

- **(i)** to calculate heat of formation
- **(ii)** to find the calorific value of food and fuel

24. Define the following.

- **(a) Molar Heat of Fusion**
- **(b) Molar Heat of Vapourisation**
- **(c) Molar Heat of Sublimation**
- **(d) Heat of Transition**

Ans. **a. Molar Heat of Fusion :** The molar heat of fusion is defined as "The change in enthalpy when one mole of a solid substance is converted into the liquid state at its melting point".

For example heat of fusion of ice can be represented as

$$H_2O_{(s)} \xrightarrow{273K} H_2O_{(l)} \quad \Delta H_{fusion} = + 5.98 \text{ KJ}$$

b. Molar Heat of Vapourisation : The molar heat of vaporisation is defined as "The change in enthalpy when one mole of liquid is converted into vapour or gaseous state at its boiling point".

For example, heat of vaporisation of water can be represented as

$$H_2O_{(l)} \xrightarrow{373K} H_2O_{(g)} \quad \Delta H_{vap} = + 40.626 \text{ KJ}$$

c. Molar Heat of Sublimation : Molar Heat of sublimation is defined as "The change in enthalpy when one mole of a solid is directly converted into the gaseous state at its sublimation temperature". For example, the heat of sublimation of iodine is represented as

$$I_{2(s)} \longrightarrow I_{2(g)} \quad \Delta H_{sub} = + 62.42 \text{ KJ}$$

d. Heat of Transition : The heat of transition is defined as "The change in enthalpy when one mole of an element changes from one allotropic form to another. For example, the transition of diamond into graphite may be represented as

$$C_{(diamond)} \longrightarrow C_{(graphite)} \quad \Delta H_{trans} = + 13.81 \text{ KJ}$$

$$S_{(monoclinic)} \longrightarrow S_{(rhombic)} \quad \Delta H_{trans} = -0.067 \text{ KJ}$$

25. List out the applications of bomb calorimeter.

Ans. **Applications of bomb calorimeter :**

- **(i)** Bomb calorimeter is used to determine the amount of heat released in combustion reaction.
- **(ii)** It is used to determine the calorific value of food.
- **(iii)** bomb calorimeter is used in many industries such as metabolic study, food processing, explosive testing and etc.

26. For an isolated system, $\Delta U = 0$ what will be ΔS? ***[HOTS]***

Ans. ΔU for an isolated system is zero because it does not exchange any energy with the surrounding. But the spontaneous change will occurs only if $\Delta S > 0$. Therefore $\Delta S > 0$.

27. What happens to work when

- **(i) gas expands against external pressure**
- **(ii) gas is compressed**
- **(iii) gas expands into vacuum**
- **(iv) an ideal gas expands reversibly and isothermally.** ***[HOTS]***

Ans.

- **(i)** When a gas expands against external pressure, work is done by the system.
- **(ii)** When a gas is compressed, work is done on the system.
- **(iii)** When the gas expands into vacuum, no work is done because external pressure is zero.
- **(iv)** When the gas is allowed to expand under reversible condition, work done by the gas is maximum.

28. What information is observed from positive, zero and negative values of change in entropy?

Ans. $\Delta S < 0$ = The process is non-spontaneous.

$\Delta S = 0$ = The process exist in equilibrium.

$\Delta S > 0$ = The process is spontaneous

29. Consider the following changes in the physical state of water and state whether orderliness has increased or decreased and consequently predict the direction of entropy of the system.

- **(i)** $H_2O_{(l)} \longrightarrow H_2O_{(s)}$
- **(ii) Steam ⟶ water**

Ans.

- **(i)** Orderliness increases, entropy decreases.
- **(ii)** Orderliness increases, entropy decreases.

30. What is the need for second Law of thermodynamics.

Ans.

- **(i)** The second law of thermodynamics helps us to predict whether the reaction is feasible or not
- **(ii)** It tells about the direction of the flow of heat.

(iii) It also tells that energy cannot be completely converted into equivalent work.

31. Define standard entropy change.

Ans. The absolute entropy of a substance at 298 K and one atmosphere pressure is called the standard entropy S°.

32. Define entropy of fusion.

Ans. The heat absorbed, when one mole of a solid melts at its melting point reversibly, is called molar heat of fusion. The entropy change isgiven by

$$\Delta S_f = \frac{\Delta H_f}{T_f}$$

Where ΔH_f is molar heat of fusion. T_f is melting point.

33. Define entropy of vapourisation.

Ans. The heat absorbed, when one mole of liquid is boiled at its boiling point reversibly, is called molar heat of vapourisation. The entropy change is given by

$$\Delta S_v = \frac{\Delta H_v}{T_b}$$

where ΔH_v is Molar heat of vaporisation. T_b is boiling point.

34. Define entropy of transition.

Ans. When one mole of a solid changes reversibly from one allotropic form to another at its transition temperature. The entropy change is given

$$\Delta S_t = \frac{\Delta H_t}{T_t}$$

Where ΔH_t is the Molar heat of transition, T_t is transition temperature.

35. What are spontaneous process?

Ans. A reaction that occurs under the given set of conditions without any external driving force is called a spontaneous reaction.

Spontaneous (irreversible)

$\Delta H < 0$

$\Delta S > 0$

$\Delta G < 0$

36. Predict the sign of entropy change in each of the following: ***[HOTS]***

(i) A liquid crystallises into solid.

(ii) C (graphite) $\longrightarrow$ C (Diamond)

(iii) Temperature of perfectly crystalline solid is raised from 0 K to 115 K.

(iv) $AgNO_{3(s)} \longrightarrow AgNO_{3\,(aq)}$

Ans. **(i)** Negative **(ii)** Negative

(iii) Positive **(iv)** Positive.

37. What is the nature of the reaction for the following?

(i) $\Delta G > 0$ (ii) $\Delta G < 0$ (iii) $\Delta G = 0$

Ans. **(i)** $\Delta G > 0$: The process is non-spontaneous and non-feasible

(ii) $\Delta G < 0$: The process is spontaneous and feasible.

(iii) $\Delta G = 0$: The process is in equilibrium.

38. Explain the relationship between free energy and equilibrium constant.

Ans. Let us consider a general equilibriuam reaction

$$A + B \rightleftharpoons C + D$$

The free energy change of the above reaction in any state (ΔG) is related to the standard free energy change of the reaction ($\Delta G°$) according to the following equation.

$$\Delta G = \Delta G° + RT \text{ In } Q$$

where Q is reaction quotient. When equilibrium is attained, there is no further free energy change i.e. $\Delta G = 0$ and Q becomes equal to equilibrium constant. Hence the above equation becomes.

$$\Delta G° = -RT \ln K_{eq}$$

This equation is known as Van't Hoff equation.

$$\Delta G° = -2.303 \text{ RT} \log K_{eq}$$

We also know that

$$\Delta G° = \Delta H° - T\Delta S° = -RT \ln K_{eq}$$

39. How does entropy vary when external pressure is less than internal pressure of the gaseous system? ***[HOTS]***

Ans. In a gaseous system, when external pressure is less than the internal pressure, the gas expands spontaneously and the volume increases .Thereby increasing the disorderliness of gas molecules Hence entropy increases in such a system.

40. Give some examples of spontaneous processes.

Ans. Burning wood, fireworks and alkali metals are added to water. When a radioactive atom splits up, it releases energy, this a spontaneous, exothermic nuclear reaction.

41. Why C_p is always greater than C_v?

Ans. At constant pressure processes, a system has to do work against the surroundings. Hence, the system would require more heat to effect a given temperature rise than at constant volume, so C_p is always greater than C_v.

ADDITIONAL LONG ANSWERS 5 MARK

1. Write a short note on the following terms.

(i) Open System
(ii) Closed System
(iii) Isolated System
(iv) Homogeneous System
(v) Heterogeneous System.

Ans. (i) **Open System :** A System which can exchange both matter and energy with its surroundings is called an open system. Hot water contained in an open beaker is an example for open system.

(ii) **Closed System :** A system which can exchange only energy but not matter with its surroundings is called a closed system. A gas contained in a cylinder fitted with a piston constitutes a closed system.

(iii) **Isolated System :** System which can exchange neither matter and nor energy with its surroundings is called an isolated system. Hot water contained in a thermos flask.

(iv) **Homogeneous System :** A system is called homogeneous if physical states of all its matter are uniform. Example: mixture of gases, completely miscible mixture of liquids etc.

(v) **Heterogeneous System :** A system is called heterogeneous, if physical states of all its matter are not uniform.
Ex., Mixture of oil and water.

2. State any five ways of enunciating the first law of thermodynamics.

Ans. (i) Whenever energy of a particular type disappears equivalent amount of another type must be produced.

(ii) Total energy of a system and surroundings remains constant (or conserved)

(iii) "Energy can neither be created nor destroyed, but may be converted from one form to another".

(iv) "The change in the internal energy of a closed system is equal to the energy that passes through its boundary as heat or work".

(v) "Heat and work are two ways of changing a system's internal energy".

3. Discuss in detail about the variation of internal energy with respect to various thermodynamic processes.

Ans. Mathematical statement of the first law of thermodynamics is

$\Delta U = q + w$

Case 1 : For a cyclic process involving isothermal expansion of an ideal gas

$\Delta U = 0; \quad \therefore q = -w$

In other words, during a cyclic process, the amount of heat absorbed by the system is equal to work done by the system.

Case 2 : For an isochoric process (no change in volume) there is no work of expansion.

$\Delta V = 0; w = 0; \Delta U = q_v$

In other words, during isochoric process, the amount of heat supplied to the system is converted to its internal energy.

Case 3 : For an adiabatic process there is no change in heat. i.e. q = 0. Hence

$q = 0; \Delta U = w$

In other words, in an adiabatic process, the decrease in internal energy is exactly equal to the work done by the system on its surroundings.

Case 4 : For an isobaric process. There is no change in the pressure. P remains constant. Hence

$\Delta U = q + w$

$\Delta U = q - P\Delta V$

In other words, in an isobaric process a part of heat absorbed by the system is used for PV expansion work and the remaining is added to the internal energy of the system.

4. Write down the conventions that are followed while framing a thermo chemical equation.

Ans. A thermo chemical equation is a balanced stoichiometric chemical equation that includes the enthalpy change(ΔH).The following conventions necessarily adopted in thermo chemical equations:

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

(ii) The enthalpy change of the reaction ΔH_r has unit kJ .

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

(iv) Physical states of all species must be specified in a thermo chemical reaction.

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

(vi) The negative sign of ΔH_r indicates an is exothermic and the positive sign of ΔH_r indicates an endothermic type of reaction.
For example, consider the following reaction,

$$2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(g)} \; \Delta H_r^0 = -967.4 \text{ kJ}$$

$$2H_2O_{(g)} \longrightarrow 2H_{2(g)} + O_{2(g)}$$

$$\Delta H_r^0 = + 967.4 \text{ kJ}$$

5. The enthalpy of combustion for H_2, $C_{(graphite)}$ and CH_4 are –285.8, –393.5 and –890.4 kJ mol^{-1} respectively. Calculate the standard enthalpy of formation ΔH_f^0 for CH_4.

Ans. Lets **interpret the information** about enthalpy of formation by writing out the equations:

$$H_{2(g)} + \frac{1}{2}O_2 \longrightarrow H_2O_{(l)} \quad \Delta H° = -285.8 \text{ kJ} \quad (1)$$

$$C_{(graphite)} + O_2 \longrightarrow CO_2 \quad \Delta H° = -393.5 \text{ kJ} \quad (2)$$

$$CH_{4(g)} + 2O_2 \longrightarrow CO_{2(g)} + 2H_2O_{(l)}$$
$$\Delta H° = -890.4 \text{ kJ} \quad (3)$$

equation (1) X_2 + (2) – (3)

$$C_{(graphite)} + 2H_{2(g)} \longrightarrow CH_{4(g)} \quad \Delta H_f^0 = -74.7 \text{ kJ.}$$

$(2 \times -285.8) + (-393.5) - (-890.4)$
$= -571.6 - 393.5 + 890.4$
$= -965.1 + 890.4$
$= -74.7$KJ.

6. Calculate the lattice energy of $MgBr_2$ from the given data

Ans. $Mg_{(s)} + Br_{2(l)} \longrightarrow MgBr_{2(s)}$

$\Delta H_f^\circ = -524 \text{ kJ mol}^{-1}$

sublimation : $Mg_{(s)} \longrightarrow Mg_{(g)}$
$\Delta H_1^\circ = +148 \text{ kJ mol}^{-1}$

Ionisation : $Mg_{(g)} \longrightarrow Mg^{2+}_{(g)} + 2e^-$
$\Delta H_2^\circ = +2187 \text{ kJ mol}^{-1}$

vapourisation : $Br_{2(l)} \longrightarrow Br_{2(g)}$
$\Delta H_3^\circ = +31 \text{ kJ mol}^{-1}$

Dissociation : $Br_{2(g)} \longrightarrow 2Br_{(g)}$
$\Delta H_4^\circ = +193 \text{ kJ mol}^{-1}$

Electron affinity : $2Br_{(g)} + 2e^- \longrightarrow 2Br^-_{(g)}$
$\Delta H_5^\circ = -662 \text{ kJ mol}^{-1}$

Lattice enthalpy : $Mg_{(g)}{}^{2+} + 2Br^-_{(g)} \longrightarrow MgBr_{2(s)} \quad \Delta H_6^\circ = ?$

$\Delta H_f^\circ = \Delta H_1^\circ + \Delta H_2^\circ + \Delta H_3^\circ + \Delta H_4^\circ + \Delta H_5^\circ + \Delta H_6^\circ$

$-524 = 148 + 2187 + 31 + 193 - 662 + \Delta H_6^\circ$

$\Delta H_6^\circ = -2421 \text{ kJ mol}^{-1}$

$Mg_{(g)}{}^{2+} + 2Br^-_{(g)} \longrightarrow MgBr_{2(s)} =$
$\Delta H_6^\circ = -2421 \text{ kJ mol}^{-1}$

By definition

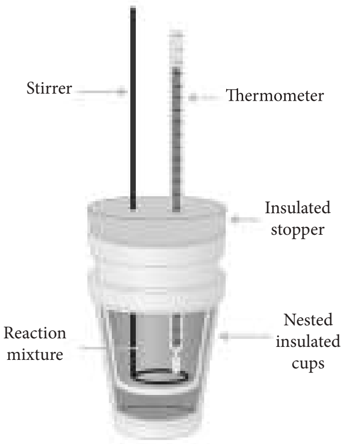
$MgBr_{2(s)} \longrightarrow Mg_{(g)}{}^{2+} + 2Br^-_{(g)}$
$\Delta H_6^\circ = -2421 \text{ kJ mol}^{-1}$.

7. Explain the measurement of heat change at constant pressure with a neat diagram.

Ans. Heat change at constant pressure (at atmospheric pressure) can be measured using a coffee cup calorimeter. A schematic representation of a coffee cup calorimeter is given in Figure. Instead of bomb, a styrofoam cup is used in this calorimeter. It acts as good adiabatic wall and doesn't allow transfer of heat produced during the reaction to its surrounding. This entire heat energy is absorbed by the water inside the cup. This method can be used for the reactions where there is no appreciable change in volume. The change in the temperature of water is measured and used to calculate the amount of heat that has been absorbed or evolved in the reaction using the following expression.

$$q = m_w C_w \Delta T$$

where m_w is the molar mass of water and C_w is the molar heat capacity of water (75.29 kJ K^{-1} mol^{-1})



Coffee cup Calorimeter

8. Distinguish between reversible and irreversible process.

Ans.

S.No	REVERSIBLE PROCESS	IRREVERSIBLE PROCESS
1.	It takes place in both forward and backward directions.	It takes place in one direction only.
2.	The driving force for reversible process is small.	There is a definite driving force required.
3.	Work done in a reversible process is greater.	Work done in a irreversible process is always lower.

NUMERICAL PROBLEMS

1. The entropy change in the conversion of water to ice at 272 k for the system is −22.88 $Jk^{-1}\ mol^{-1}$ and that of surrounding is + 24.85 $Jk^{-1}\ mol^{-1}$. State whether the process is spontaneous or not?

Sol : $\Delta S_{univ} = \Delta S_{sys} + \Delta S_{surr}$

$= -22.88 + (+24.85)$

$= 1.97\ JK^{-1}\ mol^{-1}$

$\therefore$ $\underline{\Delta S}_{univ} > 0$ at 272 K

$\therefore$ The process freezing of water is spontaneous.

2. The heat of combustion of solid naphthalene ($C_{10}H_{10}$) at constant volume was −4984 kJ mol^{-1} at 298 K. Calculate the value of enthalpy change.

Given:

$$C_{10}H_{8(s)} + 12O_{2(g)} \longrightarrow 10CO_{2(g)} + 4H_2O_{(l)};$$

$$\Delta U = -4984\ kJ\ mol^{-1}$$

$\Delta U = -4984\ kJ\ mol^{-1}$, $R = 8.314\ JK^{-1}\ mol^{-1}$

$T = 298\ K$

Sol :

$\Delta n = 10 - 12 = -2\,mol$

$\boxed{\Delta H = \Delta U + RT\ (\Delta n)}$

$= -4984 \times 10^3 J + 8.314\, Jk^{-1}\, mol^{-1} \times 298\, k \times (-2)\, mol.$

$= -4984000\, J - 4955.144\, J = -4988955.144 J$

$\Delta H = -4988.955\, kJ$

3. Calculate the standard entropy of formation ΔS°_f of $CO_{2(g)}$. Given the standard entropies of $CO_{2(g)}$, $C_{(s)}$, $O_{2(g)}$ as 218.8, 8.740 and 205.60 Jk^{-1} respectively.

Ans. $C + O_2 \longrightarrow CO_2 \qquad \Delta S^\circ_f = ?$

$\Delta S^\circ_f, CO_2 = \Sigma S^\circ_{compound} - \Sigma S^\circ_{elements}$

$= 218.8 - (8.74 + 205.60)$

$\Delta S^\circ_f, CO_2 = 4.46\ Jk^{-1}$

4. The standard heat of formation of $H_2O_{(l)}$ from its elements H_2 and O_2 is −290.83 kJ mol^{-1} and the standard entropy change for the same reaction is −330 JK^{-1} at 25°C. Will the reaction be spontaneous at 25°C.

Given: $\Delta H^\circ = -290.83\ kJ\ mol^{-1}$

$= -290830\ J\ mol^{-1}$

$\Delta S^\circ = -330\ JK^{-1}$

$T = 25°C = 298\ K$

Sol : $\boxed{\Delta G^o = \Delta H^o - T\Delta S^o}$

$= -290830 - 298\ (-330)$

$= -290830 + 98340 = -192490$

$\Delta G^\circ = -192490\ J\ mol^{-1}$

Since ΔG° is negative, the reaction is spontaneous.

5. ΔH and ΔS for the reaction

$Ag_2O_{(s)} \longrightarrow 2Ag_{(s)} + \frac{1}{2}O_{2(g)}$ are 30.56 kJ mol^{-1} and 66.0 $Jk^{-1}\ mol^{-1}$ respectively. Calculate the temperature at which the free energy for this reaction will be zero. What will be the direction of reaction at this temperature and at temperature below this and why?

Given: $\Delta H = 30.56\ kJ\ mol^{-1} = 30560\ J\ mol^{-1}$

$\Delta S = 66.0\ JK^{-1}\ mol^{-1}$

$\Delta G = 0$

Sol : $\Delta G = \Delta H - T\Delta S$

$\boxed{T = \dfrac{\Delta H - \Delta G}{\Delta S}} = \dfrac{30560 - 0}{66} = 463$

$T = 463 K.$

At 463 K, the reaction is at equilibrium

At T < 463 K, ΔG will have positive value hence backward reaction is favoured.

6. Will the reaction, $I_{2(g)} + H_2S_{(g)} \longrightarrow 2HI_{(g)} + S_{(s)}$ proceed spontaneously in the forward direction at 298 K? You are given with ΔG° for HI and H_2S as 1.8 and −33.8 kJ mol^{-1} respectively.

Given: $I_{2(g)} + H_2S_{(g)} \longrightarrow 2HI_{(g)} + S_{(s)}$

$\Delta G^o_{HI} = 1.8\ kJ\ mol^{-1}$

$\Delta G^o_{H_2S} = -33.8\ kJ\ mol^{-1}$

Sol : $\boxed{\Delta G^o_{reaction} = \Sigma\Delta G^o_{products} - \Sigma\Delta G^o_{reactants}}$

$= 2(1.8) - (-33.8)$

$= 3704\ kJ\ mol^{-1}$

$\Delta G^o_{reaction} = +37.4\ kJ\ mol^{-1}$

Since **ΔG° is positive**, the reaction will **not proceed spontaneously** in the forward direction.

7. Calculate the standard free energy change (ΔG°) of the following reaction and say whether it is feasible at 373 K or not

$$\frac{1}{2}H_{2(g)} + \frac{1}{2}I_{2(g)} \longrightarrow HI_{(g)};\ \Delta H_r^o\ is\ +25.95\ kJ\ mol^{-1}$$

standard entropies of $HI_{(g)}$, $H_{2(g)}$ and $I_{2(g)}$ are 206.3, 140.6 and 118.7 Jk^{-1} mol^{-1}.

Given: $S^o_{I_2} = 118.7\ JK^{-1}\ mol^{-1}$; $S^o_{HI} = 206.3\ JK^{-1}\ mol^{-1}$; $S^o_{H_2} = 140.6\ JK^{-1}\ mol^{-1}$

Formula: $\Delta S^o = S^o_{HI} - \frac{1}{2}\left(S^o_{H_2} + S^o_{I_2}\right)$

$$\boxed{\Delta G^o = \Delta H^o - T\Delta S^o}$$

Sol : $\Delta H^o_f = +25.95\ kJ\ mol^{-1}$

$$\boxed{\Delta S^o = \sum S^o_{Products} - \sum{}^o_{Reactants}}$$

$$= 206.3 - \frac{1}{2}(140.6 + 118.7)$$

$$= 206.3 - 129.65$$

$$\Delta S^\circ = 76.65\ kJ^{-1}\ mol^{-1}$$

$$\Delta G = \Delta H - T\Delta S$$

$$= 25.95 - (373 \times 76.65 \times 10^{-3})$$

$$= 25.95 - 28.59$$

$$= -2.640\ kJ^{-1}\ mol^{-1}$$

When ΔG is *–ve*. The reaction is spontaneous.

8. Calculate the maximum % efficiency of thermal engine operating between 110° and25°.

Ans. % Efficiency $= \left[\frac{T_1 - T_2}{T_1}\right] \times 100$

$T_1 = 110 + 273 = 383$ K.

$T_2 = 25 + 273 = 298$ K.

% Efficiency $= \left[\frac{383 - 298}{383}\right] \times 100$

= 22%.

9. Calculate the entropy change in the system, and in the surroundings and the total entropy change in the universe when during a process 75 J of heat flow out of the system at 55° C to the surroundings at 20° C.

Ans. $T_{system} = 273 + 55 = 328\ K$

$T_{surroundings} = 20 + 273 = 293\ K$

$$\Delta S_{univ} = \Delta S_{total} = \Delta S_{system} + \Delta S_{surroundings}$$

$$\Delta S_{system} = \frac{q_{system}}{T_{system}} = \frac{-75J}{328K} = -0.2287\ JK^{-1}$$

$$\Delta S_{surroundings} = \frac{q_{surroundings}}{T_{surroundings}} = \frac{+75J}{293K} = 0.260\ JK^{-1}$$

$$\Delta S_{univ} = \Delta S_{total} = [-0.2287 + 0.26]$$

$$= 0.0313\ JK^{-1}.$$

10. Calculate the entropy change of a process $H_2O_{(l)} \longrightarrow H_2O_{(g)}$ at 373K. Enthalpy of vaporization of water is 40850 J Mole^{-1}.

Ans. $\Delta S_{vap} = \frac{\Delta H_{vap}}{T_{vap}}$

$$= \frac{40850\ J\ mole^{-1}}{373\ K}$$

$$= 109.51\ JK^{-1}\ mol^{-1}$$

11. The boiling point of water at a pressure of 50 atm is 538 K. Compare the theoretical efficiencies of a steam engine operating between the boiling point of water at

(i) 1 atm pressure

(ii) 50 atm pressure, assuming the temperature of the sink to be 35° C in each case.

Ans. (i) $T_1 = 265 + 273 = 538\ K$

$T_2 = 100 + 273 = 373\ K$

$$\eta = \left(\frac{T_1 - T_2}{T_1}\right) \times 100$$

$$= \left(\frac{538 - 373}{538}\right) \times 100$$

$$= \frac{165}{538} \times 100$$

η = 42.75%.

(ii) $T_1 = 265 + 273 = 538\ K$

$T_2 = 35 + 273 = 308\ K$

$$\eta = \left(\frac{T_1 - T_2}{T_1}\right) \times 100$$

$$= \left(\frac{538 - 308}{538}\right) \times 100$$

$$= \left(\frac{230}{538}\right) \times 100$$

η = 42.75%.

12. From the following data,

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O \qquad \Delta H^\circ = -890 \text{ kJ mol}^{-1}$$

$$H_2O_{(l)} \longrightarrow H_2O_{(g)} \; \Delta H^\circ = 44 \text{ kJ mol}^{-1} \text{ at } 298 \text{ K}$$

Calculate the enthalpy of the reaction

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O \qquad \Delta H^\circ = ?$$

Ans. $CH_4 + 2O_2 \longrightarrow CO2_{(g)} + 2H_2O_{(l)}$ $\Delta H^\circ = -890 \text{ kJ mol}^{-1}$

$H_2O_{(l)} \longrightarrow H_2O_{(g)}$ $\Delta H^\circ = 44 \text{ kJ mol}^{-1}$ at 298 K

ΔH° for $CH_4 + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(g)}$

$= -890 + 44 = -846 \text{ KJ mol}^{-1}$.

13. Calculate the heat of glucose and its calorific value from following data:

(i) $C_{(graphite)} + O_{2(g)} \longrightarrow CO_{2(g)}$; $\Delta H = -395 \text{ KJ}$

(ii) $H_{2(g)} + \frac{1}{2} O_2 \longrightarrow H_2O_{(l)}$; $\Delta H = -269.4 \text{ KJ.}$

(iii) $C + 6H_{2(g)} + 3O_{2(g)} \longrightarrow C_6H_{12}O_{6(s)}$; $\Delta H = -1169.8 \text{ KJ.}$

Ans. The required equation is

$C_6H_{12}O_{6(s)} + 6O_{2(g)} \longrightarrow 6CO_{2(g)} + 6H_2O_{(l)}$

(i) $C_{(graphite)} + O_{2(g)} \longrightarrow CO_{2(g)}$; $\Delta H = -395.0 \text{ KJ}$

(ii) $H_{2(g)} + \frac{1}{2} O_{2(g)} \longrightarrow H_2O_{(l)}$; $\Delta H = -269.4 \text{ KJ.}$

(iii) $6C_{(graphite)} + 6H_{2(g)} + 3O_{2(g)} \longrightarrow C_6H_{12}O_{6(s)}$; $\Delta H = -1169.8 \text{ KJ.}$

Multiply equation (i) and (ii) by 6 and add them up

(iv) $6C_{(graphite)} + 6H_{2(g)} + 9O_{2(g)} \longrightarrow 6CO_{2(g)} + 6H_2O_{(l)}$; $\Delta H = -3986.4 \text{ KJ.}$

Subtracting equation (iii) from (iv)

$C_6H_{12}O_{6(s)} + 6O_{2(g)} \longrightarrow 6CO_{2(g)} + 6H_2O_{(l)}$ $\Delta H = -2816.6 \text{ KJ.}$

$\therefore$ Enthalpy of combustion of glucose $= -2816.6$ KJ.

14. Calculate the entropy change in the engine that receives 957.5 kJ of heat reversibly at 110°C temperature.

Ans. $q = 957.7$ kJ

$T = 110 + 273 = 383$ K

$$\Delta S = \frac{q_{rev}}{T}$$

$$\Delta S = \frac{957.7}{383}$$

$\Delta S = 2.5 \text{ kJ K}^{-1}$.

15. Calculate the entropy change of a process possessing $\Delta H_t = 2090$ J mole^{-1}.

Ans. $\Delta H_t = 2090 \text{ Jmol}^{-1}$

$T_t = 13 + 273 = 286\text{K}$

$$\Delta S_t = \frac{\Delta H_t}{T_t}$$

$$\Delta S_t = \frac{2090}{286}$$

$\Delta S_t = 7.307\text{JK}^{-1} \text{ mol}^{-1}$

16. 250 J of work is done on the system and at the same time 100 J of heat is given out. What is the change in the internal energy?

Given: $w = 250$ J **[Work done on the system, $w > 0$ Heat given out of the system, $q < 0$]**

$q = 100$ J

Sol : $\boxed{\Delta U = q + w}$

$= (-100) + (+250) = 50$

$\boxed{\Delta U = +50 \text{ J}}$

17. The heat of combustion of ethyl alcohol is 34,600 cals. The heat of formation of CO_2 and water are −96,200 and −68,000 calories respectively at constant pressure. What is the heat of formation of ethyl alcohol?

Given:

ΔH_f°, $CO_2 = -96200$ cal; ΔH_f°, $H_2O = -68000$ cal

ΔH_C°, $C_2H_5OH = 34{,}600$ cal

Sol :

$$C_2H_5OH_{(l)} + 3O_{2(g)} \longrightarrow 2CO_{2(g)} + 3H_2O_{(l)}$$

$$\Delta H^\circ = \sum H^\circ_{\text{Products}} - \sum H^\circ_{\text{Reactants}}$$

$$= (-2 \times 96200) + (-3 \times 68000) - 34600$$

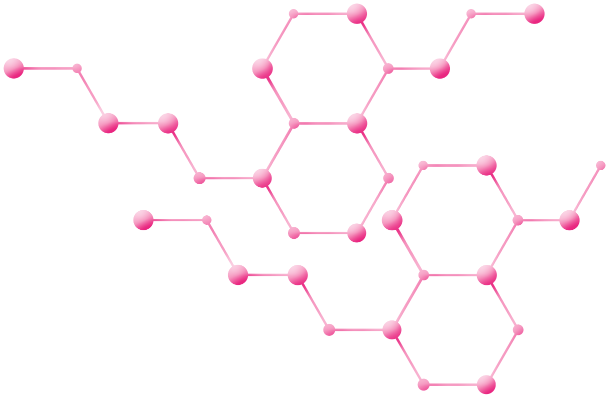
$$= -192400 - 204000 - 34600 = -431000$$

$$\Delta H^\circ = -431000 \text{ cal.}$$

18. Calculate the change of entropy for the process, water (liq) to water (vapor, 373 K) involving ΔH_{vap} = 40850 J mol^{-1} at 373 K.

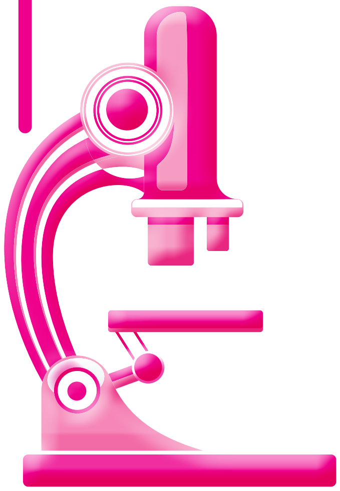
Ans. $\Delta S_{vap} = \dfrac{\Delta H_{vap}}{T_b \text{ (K)}} = \dfrac{40850 \text{ J}/mol}{373\text{K}} = 109.517 \text{ J K}^{-1} mol^{-1}$

✶ ✶ ✶



CHEMISTRY

Volume II



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08

PHYSICAL AND CHEMICAL EQUILIBRIUM

CHAPTER SNAPSHOT

Equilibrium state

Types of Equilibrium

- ✶ Physical Equilibrium
  - ✶ Solid $\longrightarrow$ Liquid
  - ✶ Liquid $\longrightarrow$ Vapour
  - ✶ Solid $\longrightarrow$ Vapour
  - ✶ Dissolution of solid or gas in liquid
- ✶ Chemical Equilibrium
  - ✶ Homogeneous equilibrium
  - ✶ Heterogeneous equilibrium

Law of mass action

Equilibrium constant

Relationship between K_p and K_c

Application of equilibrium constant

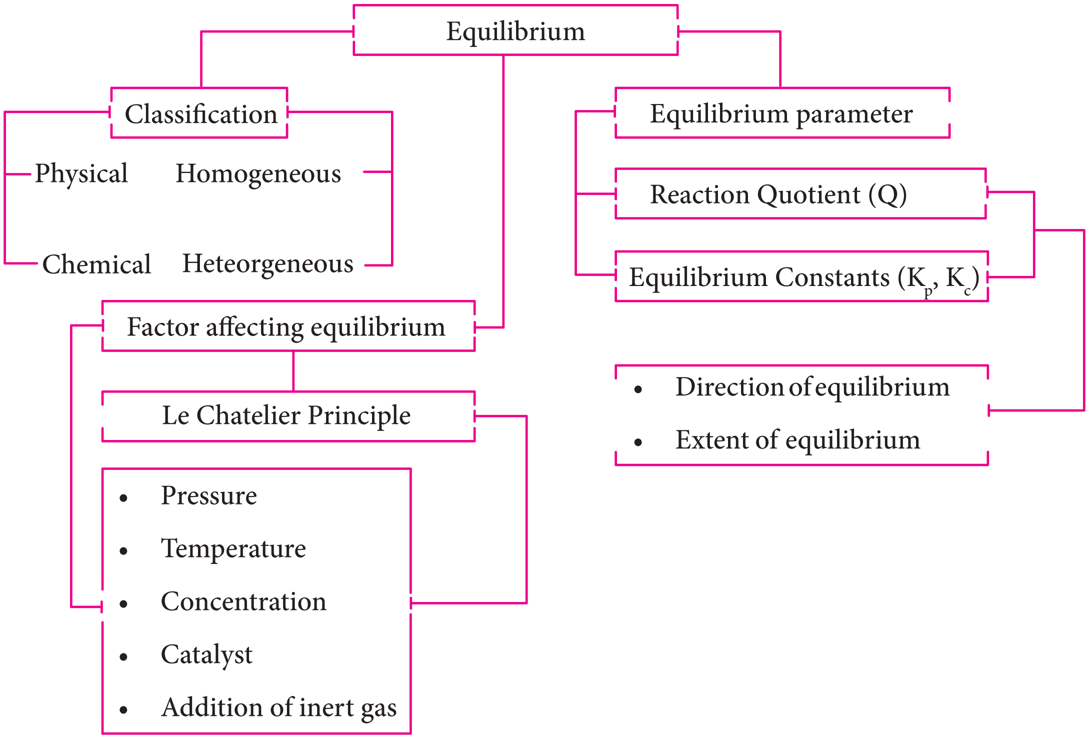
- ✶ Predicting the extent of a reaction
- ✶ Predicting the direction of a reaction

Factors affecting equilibrium

Le-Chatelier's principle

- ✶ Effect of concentration change
- ✶ Effect of temperature change
- ✶ Effect of pressure change
- ✶ Effect of inert gas addition
- ✶ Effect of catalyst.

CONCEPT MAP



FORMULAE TO REMEMBER

- $aA + bB \rightleftharpoons cC + dD$
- **Rate of forward reaction (R_f) :**
  $R_f = k_f\ [A]^a\ [B]^b$
  k_f - rate constant of forward reaction
  $[A]^a\ [B]^b$ - molar concentrations of A and B.
- **Rate of backward reaction (R_b) :**
  $R_b = k_b\ [C]^c\ [D]^d$
  k_b - rate constant of backward reaction
  $[C]^c\ [D]^d$ - molar concentrations of C and D.
- **Equilibrium constant in terms of moles (K_c) :**
  $$K_C = \frac{[C]^c\,[D]^d}{[A]^a\,[B]^b}$$
- **Equilibrium constant in terms of partial pressure (K_p) :**
  $$K_p = \frac{p_C^c\ p_D^d}{p_A^a\ p_B^b}$$
  p_A, p_B, p_C, and p_D - partial pressures of A, B, C and D in the reaction.

- **Relation between K_p and K_c :**
  $K_p = K_c (RT)^{\Delta n_g}$
  K_p & K_c
  R - Gas constant
  $\Delta n_g = n_p - n_r$
  Δn_g = Total no. of moles of gaseous products (n_p) - Total no. of moles of reactants (n_r).

- **Reaction Quotient (Q) :**
  Under non-equilibrium condition

  $$Q_c = \frac{[C]^c [D]^d}{[A]^a [B]^b} \qquad Q_p = \frac{p_A^a \; p_B^b}{p_C^c \; p_D^d}$$

  Q_c and Q_p - reaction quotient in terms of molar concentration and partial pressure.

- **Vant - Hoff Equation :**

  $$\log \frac{K_2}{K_1} = \frac{\Delta H}{2.303\ R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

  $$\log \frac{K_2}{K_1} = \frac{\Delta H}{2.303\ R}\left[\frac{T_2 - T_1}{T_1 T_2}\right]$$

MUST KNOW DEFINITIONS

Irreversible reaction	:	Reaction when go to completion and never proceed in the reverse direction are called irreversible reactions.
Reversible reaction	:	Reaction which can go in the forward and backward direction simultaneously are called reversible reactions.
State of chemical equilibrium	:	In case of reversible reactions, when the concentration of reactants and products do not change with time (or) the stage at which the rate of forward reaction becomes equal to rate of backward reaction is called chemical equilibrium state.
Physical equilibrium	:	If the opposing process involve only physical changes, the equilibrium is called physical equilibrium.
Solid - liquid equilibrium	:	Melting of Ice $\underset{\text{Ice}}{H_2O_{(s)}} \rightleftharpoons \underset{\text{Water}}{H_2O_{(l)}}$
Liquid - vapour equilibrium	:	Evaporation of water in a closed vessel $H_2O_{(l)} \rightleftharpoons H_2O_{(g)}$
Solid - vapour equilibrium	:	Sublimation equilibrium $\text{Camphor}_{(s)} \rightleftharpoons \text{Camphor}_{(\text{Vapour})}$
Solid in liquid	:	Dissolution of sugar in water $\text{Sugar}_{(s)} \rightleftharpoons \text{Sugar}_{(\text{in solution})}$

Gas in liquids	:	Dissolution of gas in liquid under pressure in a closed cell. $CO_{2(g)} \rightleftharpoons CO_{2(\text{in solution})}$
Chemical equilibrium	:	If the opposing process involve chemical changes, the equilibrium is called chemical equilibrium.
Heterogeneous equilibrium	:	If the reactants and products of an equilibrium reaction are not in the same phase, then its is called as heterogeneous equilibrium.
Homogeneous equilibrium	:	If all the reactants and products of an equilibrium reaction are in the same phase, the equilibrium is called homogeneous equilibrium.
Dynamic equilibrium	:	At equilibrium, the rate of forward reaction becomes equal to the rate of backward reaction and hence the equilibrium is dynamic in nature.
Law of mass action	:	At any instant, the rate of a chemical reaction at a given temperature is directly proportional to the product of the active masses of the reactants at that instant
Law of chemical equilibrium and equilibrium constant	:	At a given temperature, the product of concentration of products raised to the stoichiometric coefficient in the balanced chemical equation divided by the product of concentration of reactants raised to their individual stoichiometric coefficient has a constant value which is called equilibrium constant. This is called as equilibrium law. For a reaction, $aA + bB \rightleftharpoons cC + dD$ $K_C = \frac{[C]^c [D]^d}{[A]^a [B]^b}$
Relationship between K_p and K_c	:	$K_p = K_c (RT)^{\Delta n_g}$ Δn_g = No. of moles of products – No. of moles of reactants.
Vant - Hoff equation	:	This equation gives the quantitative temperature dependence of equilibrium constant (K). $\log \frac{K_2}{K_1} = \frac{\Delta H}{2.303\,R}\left[\frac{T_2 - T_1}{T_1 T_2}\right]$
Reaction quotient	:	The ratio of the product of active masses of reaction products raised to the respective stoichiometric coefficients in the balanced chemical equation to that of the reactants. $Q_c = \frac{[C]^c [D]^d}{[A]^a [B]^b}$
Le-Chatelier's principle	:	If a system at equilibrium is disturbed, then the system shifts itself in a direction that nullifies the effect of that disturbance.

EVALUATION

I. CHOOSE THE BEST ANSWER :

1. If K_b and K_f for a reversible reactions are 0.8×10^{-5} and 1.6×10^{-4} respectively, the value of the equilibrium constant is,

(a) 20 (b) 0.2×10^{-1} (c) 0.05
(d) none of these **[Ans. (a) 20]**

Hint: Equilibrium constant, K_C is equal to K_b/k_f

2. At a given temperature and pressure, the equilibrium constant values for the equilibria

$$3A_2 + B_2 + 2C \overset{K_1}{\rightleftharpoons} 2A_3BC \text{ and}$$

$$A_3BC \overset{K_2}{\rightleftharpoons} \frac{3}{2}[A_2] + \frac{1}{2}B_2 + C$$

The relation between K_1 and K_2 is

(a) $K_1 = \frac{1}{\sqrt{K_2}}$ (b) $K_2 = K_1^{-1/2}$

(c) $K_1^2 = 2K_2$ (d) $\frac{K_1}{2} = K_2$

[Ans. (b) $K_2 = K_1^{-1/2}$]

3. The equilibrium constant for a reaction at room temperature is K_1 and that at 700 K is K_2. If $K_1 > K_2$, then

(a) The forward reaction is exothermic
(b) The forward reaction is endothermic
(c) The reaction does not attain equilibrium
(d) The reverse reaction is exothermic

[Ans. (a) The forward reaction is exothermic]

4. The formation of ammonia from $N_{2(g)}$ and $H_{2(g)}$ is a reversible reaction

$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ + Heat

What is the effect of increase of temperature on this equilibrium reaction

(a) equilibrium is unaltered
(b) formation of ammonia is favoured
(c) equilibrium is shifted to the left
(d) reaction rate does not change

[Ans. (c) Equilibrium is shifted to the left]

5. Solubility of carbon dioxide gas in cold water can be increased by

(a) increase in pressure (b) decrease in pressure
(c) increase in volume (d) none of these

[Ans. (a) increase in pressure]

Hint: It is because due to increase in intra molecular force of attraction. Solubility of carbon dioxide gas in cold water is increased.

6. Which one of the following is incorrect statement ?

(a) for a system at equilibrium, Q is always less than the equilibrium constant.
(b) equilibrium can be attained from either side of the reaction.
(c) presence of catalyst affects both the forward reaction and reverse reaction to the same extent.
(d) equilibrium constant varied with temperature.

[Ans. (a) For a system at equilibrium, Q is always less than the equilibrium constant.]

7. K_1 and K_2 are the equilibrium constants for the reactions respectively.

$$N_{2(g)} + O_{2(g)} \overset{K_1}{\rightleftharpoons} 2NO_{(g)}$$

$$2NO_{(g)} + O_{2(g)} \overset{K_2}{\rightleftharpoons} 2NO_{2(g)}$$

What is the equilibrium constant for the reaction $NO_{2(g)} \rightleftharpoons \frac{1}{2}N_{2(g)} + O_{2(g)}$

(a) $\frac{1}{\sqrt{K_1K_2}}$ (b) $(K_1 = K_2)^{1/2}$

(c) $\frac{1}{2K_1K_2}$ (d) $\left(\frac{1}{K_1K_2}\right)^{3/2}$

[Ans. (a) $\frac{1}{\sqrt{K_1K_2}}$]

8. In the equilibrium,

$$2A(g) \rightleftharpoons 2B(g) + C_2(g)$$

the equilibrium concentrations of A, B and C_2 at 400 K are 1×10^{-4} M, 2.0×10^{-3} M, 1.5×10^{-4} M respectively. The value of K_C for the equilibrium at 400 K is

(a) 0.06 (b) 0.09 (c) 0.62 (d) 3×10^{-2}

[Ans. (a) 0.06]

Hint: Law of mass action formula.

9. An equilibrium constant of 3.2×10^{-6} for a reaction means, the equilibrium is [HY. 2018]

(a) largely towards forward direction
(b) largely towards reverse direction
(c) never established
(d) none of these

[Ans. (b) largely towards reverse direction]

10. $\frac{K_C}{K_p}$ for the reaction,

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ is

(a) $\frac{1}{RT}$ (b) $\sqrt{RT}$ (c) RT (d) $(RT)^2$

[Ans. (d) $(RT)^2$]

Hint: K_P and K_C is the relationship between k_p is equal to $K_c . (RT) \Delta n_g$.

11. For the reaction $AB(g) \rightleftharpoons A(g) + B(g)$, at equilibrium, AB is 20% dissociated at a total pressure of P, The equilibrium constant K_P is related to the total pressure by the expression

(a) $P = 24\ K_P$ (b) $P = 8\ K_P$
(c) $24\ P = K_P$ (d) none of these

[Ans. (a) $P = 24\ K_P$]

12. In which of the following equilibrium, K_P and K_C are not equal?

(a) $2\ NO(g) \rightleftharpoons N_2(g) + O_2(g)$
(b) $SO_2(g) + NO_2 \rightleftharpoons SO_3(g) + NO(g)$
(c) $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$
(d) $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

[Ans. (d) $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$]

13. If x is the fraction of PCl_5 dissociated at equilibrium in the reaction

$$PCl_5 \rightleftharpoons PCl_3 + Cl_2$$

then starting with 0.5 mole of PCl_5, the total number of moles of reactants and products at equilibrium is

(a) 0.5 – x (b) x + 0.5
(c) 2x + 0.5 (d) x + 1

[Ans. (b) x + 0.5]

14. The values of K_{P_1} and K_{P_2} for the reactions $X \rightleftharpoons Y + Z$ $A \rightleftharpoons 2B$ are in the ratio 9 : 1 if degree of dissociation and initial concentration of X and A be equal then total pressure at equilibrium P_1, and P_2 are in the ratio

(a) 36 : 1 (b) 1 : 1
(c) 3 : 1 (d) 1 : 9 **[Ans. (a) 36 : 1]**

15. In the reaction,

$Fe(OH)_3(s) \rightleftharpoons Fe^{3+}(aq) + 3OH^-(aq)$,

if the concentration of OH^- ions is decreased by ¼ times, then the equilibrium concentration of Fe^{3+} will

(a) not changed
(b) also decreased by ¼ times
(c) increase by 4 times (d) increase by 64 times

[Ans. (d) increase by 64 times]

16. Consider the reaction where $K_P = 0.5$ at a particular temperature

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

if the three gases are mixed in a container so that the partial pressure of each gas is initially 1 atm, then which one of the following is true

(a) more PCl_3 will be produced
(b) more Cl_2 will be produced
(c) more PCl_5 will be produced
(d) none of these

[Ans. (c) More PCl_5 will be produced]

17. Equimolar concentrations of H_2 and I_2 are heated to equilibrium in a 1 litre flask. What percentage of initial concentration of H_2 has reacted at equilibrium if rate constant for both forward and reverse reactions are equal

(a) 33% (b) 66% (c) $(33)^2$ % (d) 16.5 %

[Ans. (a) 33%]

18. In a chemical equilibrium, the rate constant for the forward reaction is 2.5×10^2 and the equilibrium constant is 50. The rate constant for the reverse reaction is,

(a) 11.5 (b) 5 (c) 2×10^2 (d) 2×10^{-3}

[Ans. (b) 5]

19. Which of the following is not a general characteristic of equilibrium involving physical process

(a) Equilibrium is possible only in a closed system at a given temperature.
(b) The opposing processes occur at the same rate and there is a dynamic but stable condition.
(c) All the physical processes stop at equilibrium.
(d) All measurable properties of the system remains constant.

[Ans. (c) All the physical processes stop at equilibrium.]

20. For the formation of Two moles of $SO_3(g)$ from SO_2 and O_2, the equilibrium constant is K_1. The equilibrium constant for the dissociation of one mole of SO_3 into SO_2 and O_2 is

(a) $\frac{1}{K_1}$ (b) K_1^2 (c) $\left(\frac{1}{K_1}\right)^{1/2}$ (d) $\frac{K_1}{2}$

[Ans. (c) $\left(\frac{1}{K_1}\right)^{1/2}$]

21. Match the equilibria with the corresponding conditions,

i) Liquid $\rightleftharpoons$ Vapour
ii) Solid $\rightleftharpoons$ Liquid
iii) Solid $\rightleftharpoons$ Vapour
iv) Solute(s) $\rightleftharpoons$ Solute (Solution)
1) Melting point
2) Saturated solution
3) Boiling point
4) Sublimation point
5) Unsaturated solution

	(i)	(ii)	(iii)	(iv)
(a)	1	2	3	4
(b)	3	1	4	2
(c)	2	1	3	4
(d)	3	2	4	5

[Ans. (b) 3 1 4 2]

22. Consider the following reversible reaction at equilibrium, A + B $\rightleftharpoons$ C. If the concentration of the reactants A and B are doubled, then the equilibrium constant will

(a) be doubled (b) become one fourth
(c) be halved (d) remain the same

[Ans. (d) remain the same]

23. $[Co(H_2O)_6]^{2+}$ (aq) (pink) + $4Cl^-$ (aq) $\rightleftharpoons$ $[CoCl_4]^{2-}$ (aq) (blue) + $6H_2O$ (*l*)

In the above reaction at equilibrium, the reaction mixture is blue in colour at room temperature. On cooling this mixture, it becomes pink in colour. On the basis of this information, which one of the following is true ?

(a) $\Delta H > 0$ for the forward reaction
(b) $\Delta H = 0$ for the reverse reaction
(c) $\Delta H < 0$ for the forward reaction
(d) Sign of the ΔH cannot be predicted based on this information.

[Ans. (a) $\Delta H > 0$ for the forward reaction]

24. The equilibrium constants of the following reactions are :

$N_2 + 3H_2 \rightleftharpoons 2NH_3$; K_1
$N_2 + O_2 \rightleftharpoons 2NO$; K_2
$H_2 + ½O_2 \rightleftharpoons H_2O$; K_3

The equilibrium constant (K) for the reaction ;

$$2NH_3 + \frac{5}{2}O_2 \overset{K}{\rightleftharpoons} 2NO + 3H_2O, \text{ will be}$$

(a) $K_2^3\frac{K_3}{K_1}$ (b) $K_1\frac{K_3^3}{K_2}$ (c) $K_2\frac{K_3^3}{K_1}$ (d) $K_2\frac{K_3}{K_1}$

[Ans. (c) $K_2\frac{K_3^3}{K_1}$]

Hint: K_C is equal to [c][D]/ [A][B].

25. A 20 litre container at 400 K contains $CO_2(g)$ at pressure 0.4 atm and an excess of SrO (neglect the volume of solid SrO). The volume of the container is now decreased by moving the movable piston fitted in the container. The maximum volume of the container, when pressure of CO_2 attains its maximum value will be :

Given that : $SrCO_3(S) \rightleftharpoons SrO\ (S) + CO_2(g)$
K_P = 1.6 atm (NEET 2017)

(a) 2 litre (b) 5 litre
(c) 10 litre (d) 4 litre

[Ans. (b) 5 litre]

II. WRITE BRIEF ANSWER TO THE FOLLOWING QUESTIONS

26. If there is no change in concentration, why is the equilibrium state considered dynamic ?

Ans. Chemical reactions which are reversible do not cease, when equilibrium is attained. At equilibrium the forward and the backward reactions are proceeding at the same rate and no macroscopic change is observed. So chemical equilibrium is in a state of dynamic equilibrium.

27. For a given reaction at a particular temperature, the equilibrium constant has constant value. Is the value of Q also constant ? Explain.

Ans. In the chemical reaction, as the reaction proceeds, there is a continuous change in the concentration of reactants and products and also the Q value until the reaction reaches the equilibrium. So, even at particular temperature, Q is not constant.

28. What is the relation between K_P and K_C. Give one example for which K_P is equal to K_C.

Ans. The relation between K_P and K_C is $K_P = K_C\,(RT)^{(\Delta n_g)}$

K_p = equilibrium constant is terms of partial pressure

K_c = equilibrium constant is terms of concentration

R = gas constant

T = Temperature

Δn_g = Difference between the sum of the number of moles of products and the sum of number of moles of reactants in the gas phase

When $\Delta n_g = 0$

$K_P = K_C\,(RT)^0 = K_C$ ie., $K_P = K_C$

Example : $H_2(g) + I_2(g) \rightleftharpoons 2HI\,(g)$

$\Delta n_g = 2 - 2 = 0$

$\therefore\ K_P = K_C$ for the synthesis of HI

29. For a gaseous homogeneous reaction at equilibrium, number of moles of products are greater than the number of moles of reactants. Is K_C is larger or smaller than K_P.

Ans. $PCl_5(g) \rightleftharpoons PCl_3\,(g) + Cl_2(g)$

Δn_g = No. of moles of product – No. of moles of reactant

$\Delta n_g = 2 - 1 = 1$

When Δn_g = +ve

$K_P = K_C\,(RT)^{+ve}$

$K_P > K_C$.

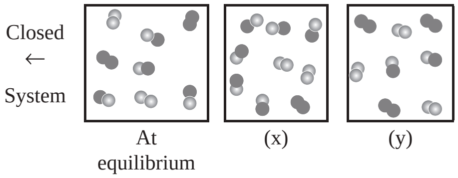
30. When the numerical value of the reaction quotient (Q) is greater than the equilibrium constant (K), in which direction does the reaction proceed to reach equilibrium?

Ans. If $Q > K_C$, the reaction will proceed in the reverse direction i.e., formation of reactants.

31. For the reaction,

$A_2(g) + B_2(g) \rightleftharpoons 2AB(g)$; ΔH is –ve.

the following molecular scenes represent different reaction mixture (A – green, B – blue)



At equilibrium (x) (y)

i) **Calculate the equilibrium constant K_P and (K_C).**

ii) **For the reaction mixture represented by scene (x), (y) the reaction proceed in which directions ?**

iii) **What is the effect of increase in pressure for the mixture at equilibrium?**

Ans. $K_C = \dfrac{[AB]^2}{[A_2][B_2]}$ A – green B – blue

Given that 'V' is constant (closed system)

At equilibrium,

$$K_C = \frac{\left(\frac{4}{V}\right)^2}{\left(\frac{2}{V}\right)\left(\frac{2}{V}\right)} = \frac{16}{4} = 4$$

$K_P = K_C\,(RT)^{\Delta n}$

$K_P = 4(RT)^\circ = 4$

At Stage 'x'

$$Q = \frac{\left(\frac{6}{V}\right)^2}{\left(\frac{2}{V}\right)\left(\frac{1}{V}\right)} = \frac{36}{2} = 18$$

$Q > K_C$ (ie.), reverse reaction is favoured At Stage 'y'

$$Q = \frac{\left(\frac{3}{V}\right)^2}{\left(\frac{3}{V}\right)\left(\frac{3}{V}\right)} = \frac{9}{3\times 3} = 1$$

$K_C > Q$ (ie.), forward reaction is favoured.

32. State Le-Chatelier principle.

Ans. It states that "If a system at equilibrium is disturbed, then the system shifts itself in a direction that nullfiies the effect of that disturbance."

33. Consider the following reactions,

a) $H_2(g) + I_2(g) \rightleftharpoons 2\,HI(g)$

b) $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$

c) $S(s) + 3F_2(g) \rightleftharpoons SF_6(g)$

In each of the above reaction find out whether you have to increase (or) decrease the volume to increase the yield of the product.

Ans. (a) **$H_2(g) + I_2(g) \rightleftharpoons 2\,HI(g)$**

According to Le Chateliers princple increase in pressure will shift the equilibrium a direction that has lesser number of moles.

In the above equilibrium, pressure and volume has no effect, since no. of moles of product is equal to no. of moles of reactant.

(b) **$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$**

In this equilibrium no. of moles of product is greater than no. of moles of reactant. So increase of pressure will shift the equilibrium towards the backward reaction. To increase the yield of product, pressure should be decrease and hence volume increases.

(c) $S(s) + 3F_2(g) \rightleftharpoons SF_6(g)$

In the above equilibrium increase in pressure favours formation of product hence volume should be decreased.

34. State law of mass action.

Ans. The law states that, "At any instant, the rate of a chemical reaction at a given temperature is directly proportional to the product of the active masses of the reactants at that instant".

$$\text{Rate } \alpha \, [\text{Reactant}]^x$$

where, x is the stoichiometric coefficient of the reactant.

35. Explain how will you predict the direction of a equilibrium reaction.

Ans. **(i)** A large value of K_C indicates that the reaction reaches equilibrium with high product yield.

(ii) A low value of K_C indicate that the reaction reaches equilibrium with low product formed.

(iii) In general if the K_C is greater than 10^3, the reaction proceeds nearly to completion. If it is less than 10^{-3} the reaction rarely proceeds.

(iv) If $K_C < 10^{-3}$, reverse reaction is favoured.

If $K_C < 10^3$, forward reaction is favoured.

36. Derive a general expression for the equilibrium constant K_P and K_C for the reaction.

$$3H_2(g) + N_2(g) \rightleftharpoons 2NH_3(g)$$

Ans. **Synthesis of ammonia :**

- Let us consider the formation of ammonia in which, 'a' moles nitrogen and 'b' moles hydrogen gas are allowed to react in a container of volume V. Let 'x' moles of nitrogen react with 3x moles of hydrogen to give 2x moles of ammonia.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

	N_2	H_2	NH_3
Initial number of moles	a	b	0
number of moles reacted	x	3x	0
Number of moles at equilibrium	a – x	b – 3x	2x
Active mass or molar concentration at equilibrium	$\frac{a-x}{V}$	$\frac{b-3x}{V}$	$\frac{2x}{V}$

- Applying law of mass action,

$$K_C = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

$$= \frac{\left(\frac{2x}{V}\right)^2}{\left(\frac{a-x}{V}\right)\left(\frac{b-3x}{V}\right)^3}$$

$$= \frac{\left(\frac{4x^2}{V^2}\right)}{\left(\frac{a-x}{V}\right)\left(\frac{b-3x}{V}\right)^3}$$

$$K_C = \frac{4x^2V^2}{(a-x)(b-3x)^2}$$

The equilibrium constant K_p can also be calculated as follows:

$$K_P = K_C\,(RT)^{(\Delta n_g)}$$

$$\Delta n_g = n_P - n_r = 2 - 4 = -2$$

$$K_P = \frac{4x^2V^2}{(a-x)(b-3x)^3}(RT)^{-2}$$

Total number of moles at equilibrium,

n = a – x + b – 3x + 2x = a + b – 2x

$$K_P = \frac{4x^2V^2}{(a-x)(b-3x)^3} \times \left[\frac{PV}{n}\right]^{-2}$$

$$K_P = \frac{4x^2V^2}{(a-x)(b-3x)^3} \times \left[\frac{n}{PV}\right]^{2}$$

$$K_P = \frac{4x^2V^2}{(a-x)(b-3x)^3} \times \left[\frac{a+b-2x}{PV}\right]^{2}$$

$$K_P = \frac{4x^2(a+b-2x)^2}{P^2(a-x)(b-3x)^3}$$

37. Write a balanced chemical equation for a equilibrium reaction for which the equilibrium constant is given by expression.

$$K_C = \frac{[NH_3]^4[O_2]^5}{[NO]^4[H_2O]^6}$$

Ans. $K_C = \frac{[NH_3]^4[O_2]^5}{[NO]^4[H_2O]^6}$

Chemical equation is,

$$4\,NO + 6H_2O \rightleftharpoons 4NH_3 + 5O_2$$

38. What is the effect of added inert gas on the reaction at equilibrium at constant volume.

Ans. When an inert gas (i.e, a gas which does not react with any other species involved in equilibrium) is added to an equilibrium system at constant volume, the total number of moles of gases present in the container increases, that is, the total pressure of gases increases. The partial pressure of the reactants and the products or the molar concentration of the substance involved in the reaction remains unchanged. Hence at constant volume, addition of inert gas has no effect on equilibrium.

39. Derive the relation between K_P and K_C.

Ans. Let us consider the general reaction in which all reactants and products are ideal gases.

$$xA + yB \rightleftharpoons lC + mD$$

The equilibrium constant, K_C is

$$K_C = \frac{[C]^l[D]^m}{[A]^x[B]^y} \qquad .....(1)$$

and K_P is,

$$K_P = \frac{p_C^l \times p_D^m}{p_A^x \times p_B^y} \qquad .....(2)$$

The ideal gas equation is

$$PV = nRT$$

or

$$P = \frac{n}{V}RT$$

Since Active mass = molar concentration = n/V

p = active mass × RT

Based on the above expression the partial pressure of the reactants and products can be expressed as,

$p_A^x = [A]^x[RT]^x$

$p_B^y = [B]^y[RT]^y$

$p_C^l = [C]^l[RT]^l$

$p_D^m = [D]^m[RT]^m$

On substitution in eqn. 2,

$$K_p = \frac{[C]^l[RT]^l[D]^m[RT]^m}{[A]^x[RT]^x[B]^y[RT]^y} \qquad .....(3)$$

$$K_p = \frac{[C]^l[D]^m[RT]^{l+m}}{[A]^x[B]^y[RT]^{x+y}}$$

$$K_p = \frac{[C]^l[D]^m}{[A]^x[B]^y}[RT]^{(l+m)-(x+y)} \qquad .....(4)$$

By comparing equation (1) and (4), we get

$$K_p = K_C(RT)^{(\Delta n_g)} \qquad .....(5)$$

where,

Δn_g is the difference between the sum of number of moles of products and the sum of number of moles of reactants in the gas phase.

40. One mole of PCl_5 is heated in one litre closed container. If 0.6 mole of chlorine is found at equilibrium, calculate the value of equilibrium constant.

Ans. Given that $[PCl_5]_{Initial} = \frac{1\text{ mole}}{1\text{ dm}^3}$

$$[Cl_2]_{eq} = 0.6\text{ mole dm}^{-3}$$

$$PCl_5 \rightleftharpoons PCl_3 + Cl_2$$

$[PCl_3]_{eq} = 0.6\text{ mole dm}^{-3}$

$[PCl_5]_{eq} = 0.4\text{ mole dm}^{-3}$

$$\therefore K_C = \frac{[PCl_3][Cl_2]}{[PCl_5]} = \frac{0.6 \times 0.6}{0.4}$$

$K_c = 0.9.$

41. For the reaction

$SrCO_3(s) \rightleftharpoons SrO(s) + CO_2(g)$,

the value of equilibrium constant $K_P = 2.2 \times 10^{-4}$ at 1002 K. Calculate K_C for the reaction.

Ans. For the reaction,

$SrCO_3(s) \rightleftharpoons SrO(s) + CO_2(g)$

$\Delta n_g = 1 - 0 = 1$

$\therefore K_P = K_C(RT)$

$2.2 \times 10^{-4} = K_C(0.0821)(1002)$

$$K_C = \frac{2.2 \times 10^{-4}}{0.0821 \times 1002}$$

$K_C = 2.674\ 10^{-6}$

42. To study the decomposition of hydrogen iodide, a student fills an evacuated 3 litre flask with 0.3 mol of HI gas and allows the reaction to proceed at 500°C. At equilibrium he found the concentration of HI which is equal to 0.05 M. Calculate K_C and K_P for this reaction.

Ans. V = 3L

$$[HI]_{initial} = \frac{0.3\text{ mol}}{3L} = 0.1M$$

$$[HI]_{eq} = 0.05\text{ M}$$

$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$

	HI(g)	H_2(g)	I_2(g)
Initial Concentration	0.1	–	–
Reacted	0.05	–	–
Equilibrium concentration	0.05	0.025	0.025

$$K_C = \frac{[H_2][I_2]}{[HI]^2}$$

$$= \frac{0.025 \times 0.025}{0.05 \times 0.05}$$

$$K_C = 0.25$$

$K_P = K_C\,(RT)^{\Delta ng}$

$\Delta n_g = 2 - 2 = 0$

$K_P = 0.25\,(RT)^0$ = **0.25**

43. Oxidation of nitrogen monoxide was studied at 200°C with initial pressures of 1 atm NO and 1 atm of O_2. At equilibrium partial pressure of oxygen is found to be 0.52 atm calculate K_P value.

Ans. $2NO\,(g) + O_2(g) \rightleftharpoons 2NO_2(g)$

	NO	O_2	NO_2
Initial pressure	1	1	–
Reacted	0.96	0.48	–
Equilibrium partial pressure	0.04	0.52	0.96

$$K_p = \frac{\left(p_{NO_2}\right)^2}{\left(p_{NO}\right)^2\left(p_O\right)} = \frac{0.96 \times 0.96}{0.04 \times 0.04 \times 0.52}$$

$$\mathbf{K_p = 1.017 \times 10^3}$$

44. 1 mol of CH_4, 1 mole of CS_2 and 2 mol of H_2S are 2 mol of H_2 are mixed in a 500 ml flask. The equilibrium constant for the reaction $K_C = 4 \times 10^{-2}$ mol² lit⁻². In which direction will the reaction proceed to reach equilibrium ?

Ans. $CH_4(g) + 2H_2S(g) \rightleftharpoons CS_2(g) + 4H_2(g)$

$K_C = 4 \times 10^{-2}$ mol lit^{-2}

Volume = 500 ml = $\frac{1}{2}$ L

$$[CH_4]_{in} = \frac{1\text{ mol}}{\frac{1}{2}L} = 2\text{ mol L}^{-1} \qquad [CS_2]_{in} = \frac{1\text{ mol}}{\frac{1}{2}L} = 2\text{ mol L}^{-1}$$

$$[H_2S]_{in} = \frac{2\text{ mol}}{\frac{1}{2}L} = 4\text{ mol L}^{-1} \qquad [H_2] = \frac{2\text{ mol}}{\frac{1}{2}L} = 4\text{ mol L}^{-1}$$

$$Q = \frac{[CS_2][H_2]^4}{[CH_4][H_2S]^2}$$

$$\therefore Q = \frac{2 \times (4)^4}{(2) \times (2)^2} = 64$$

Q > KC

The reaction will proceed in the reverse direaction to reach the equilibrium.

45. At particular temperature $K_C = 4 \times 10^{-2}$ for the reaction

$$\mathbf{H_2S(g) \rightleftharpoons H_2(g) + ½\,S_2(g)}$$

Calculate K_C for each of the following reaction.

i) $2H_2S\,(g) \rightleftharpoons 2H_2\,(g) + S_2\,(g)$

ii) $3H_2S\,(g) \rightleftharpoons 3H_2\,(g) + \frac{3}{2}\,S_2(g)$

Ans. $K_C = 4 \times 10^{-2}$ for the reaction,

$H_2S(g) \rightleftharpoons H_2(g) + \frac{1}{2}S_2(g)$

$$K_C = \frac{[H_2][S_2]^{1/2}}{[H_2S]}$$

$$\Rightarrow 4 \times 10^{-2} = \frac{[H_2][S_2]^{1/2}}{[H_2S]}$$

For the reaction,

$2H_2S(g) \rightleftharpoons 2H_2(g) + S_2(g)$

$$K_C = \frac{[H_2]^2[S_2]}{[H_2S]^2} = \left(4 \times 10^{-2}\right)^2 = 16 \times 10^{-4}$$

For the reaction,

$3H_2S(g) \rightleftharpoons 3H_2(g) + \frac{3}{2}S_2(g)$

$$K_C = \frac{[H_2]^3[S_2]^{3/2}}{[H_2S]^3} = \left(4 \times 10^{-2}\right)^3 = \mathbf{64 \times 10^{-6}}$$

46. 28 g of nitrogen and 6 g of hydrogen were mixed in a 1 litre closed container. At equilibrium 17 g NH_3 was produced. Calculate the weight of nitrogen, hydrogen at equilibrium.

Ans. Given m_{N_2} = 28 g; m_{H_2} = 6g;

V = 1 L

$$\left(n_{N_2}\right)_{Initial} = \frac{28}{28} = 1\text{ mol}$$

$$\left(n_{H_2}\right)_{Initial} = \frac{6}{2} = 3\text{ mol}$$

$N_2(g) + 3H_2(g) \rightleftharpoons 2\,NH_3(g)$

	$N_2(g)$	$H_2(g)$	$NH_3(g)$
Initial Concentration	1	3	–
Reacted	0.5	1.5	–
Equilibrium concentration	0.5	1.5	1

$$[NH_3] = \left(\frac{17}{17}\right) = 1\text{ mol}$$

Weight of N_2 = (no. of moles of N_2) × molar mass of N_2

= 0.5 × 28 = **14 g**

Weight of H_2 = (no. of moles of H_2) × molar mass of H_2

= 1.5 × 2 = **3g**

47. The equilibrium for the dissociation of XY_2 is given as,

$$2XY_2(g) \rightleftharpoons 2XY\,(g) + Y_2(g)$$

if the degree of dissociation x is so small compared to one. Show that

$2\,K_p = PX^3$ where P is the total pressure and K_p is the dissociation equilibrium constant of XY_2.

Ans. The equilibrium for the dissociation of XY_2 is given as,

$$2XY_2(g) \rightleftharpoons 2XY\,(g) + Y_2(g)$$

	XY_2	XY	Y_2
Intial no. of moles	1	–	–
No. of moles dissociated	x	–	–
No. of moles at equilibrium	$(1-x) \cong 1$	x	$X/2$

Total no. of moles = $1 - x + x + X/2$

= $1 + X/2 \cong 1$

[∵ Given that x < < 1 ; $1 - x \cong 1$ and $1 + X/2 \cong 1$]

$$K_p = \frac{(p_{XY})^2 (p_{Y_2})}{(p_{XY_2})^2} = \frac{\left(\frac{X}{1}\times P\right)^2 \left(\frac{X/2}{1}\times P\right)}{\left(\frac{1}{1}\times P\right)^2}$$

$$K_p = \frac{X^3P}{2}$$

$$\Rightarrow \boxed{2K_P = X^3P}$$

48. A sealed container was filled with 1 mol of $A_2(g)$, 1 mol $B_2(g)$ at 800 K and total pressure 1.00 bar. Calculate the amounts of the components in the mixture at equilibrium given that K = 1 for the reaction

$$A_2(g) + B_2(g) \rightleftharpoons 2AB(g)$$

Ans. $A_2(g) + B_2(g) \rightleftharpoons 2AB(g)$

	A_2	B_2	AB
Initial Concentration	1	1	–
No. of moles dissociated	x	x	–
No. of moles at equilibrium	1 – x	1 – x	2x

Total no. of moles = 1 – x + 1 – x + 2x = 2

$$K_P = \frac{(p_{AB})^2}{(p_{A_2})(p_{B_2})} = \frac{\left(\frac{2x}{2}\times P\right)^2}{\left(\frac{(1-x)}{2}\times P\right)\left(\frac{1-x}{2}\times P\right)}$$

$$K_p = \frac{4x^2}{(1-x)^2}$$

Given that $K_p = 1$; $\frac{4x^2}{(1-x)^2} = 1$

$\Rightarrow \quad 4x^2 = (1 - x)^2$

$\Rightarrow \quad 4x^2 = 1 + x^2 - 2x$

$3x^2 + 2x - 1 = 0$

$$x = \frac{-2 \pm \sqrt{4-(4\times 3\times -1)}}{2(3)}$$

$$x = \frac{-2 \pm \sqrt{4+12}}{6}$$

$$= \frac{-2 \pm \sqrt{16}}{6}$$

$$= \frac{-2+4}{6};\frac{-2-4}{6}$$

$$= \frac{2}{6};\frac{-6}{6}$$

x = 0.33; –1 (not possible)

$\therefore [A_2]_{eq}$ = 1 – x = 1 – 0.33 = 0.67

$[B_2]_{eq}$ = 1 – x = 1 – 0.33 = 0.67

$[AB]_{eq}$ = 2x = 2 × 0.33 = 0.66.

49. Deduce the Vant Hoff equation.

Ans. This equation gives the quantitative temperature dependence of equilibrium constant (K). The relation between standard free energy change (ΔG°) and equilibrium constant is

$\Delta G° = -RT\ln K$ .....(1)

We know that

$\Delta G° = \Delta H° - T\Delta S°$ .....(2)

Substituting (1) in equation (2)

$-RT\ln K = \Delta H° - T\Delta S°$

Rearranging

$$\text{In } K = \frac{-\Delta H°}{RT} + \frac{\Delta S°}{R} \quad .....(3)$$

Differentiating equation (3) with respect to temperature,

$$\frac{d(\text{In } K)}{dT} = \frac{\Delta H°}{RT^2} \quad .....(4)$$

Equation 4 is known as differential form of Van't Hoff equation.

On integrating the equation 4, between T_1 and T_2 with their respective equilibrium constants K_1 and K_2.

$$\int_{K_1}^{K_2} d(\text{In } K) = \frac{\Delta H°}{R}\int_{T_1}^{T_2}\frac{dT}{T^2}$$

$$[\text{In } K]_{K_1}^{K_2} = \frac{\Delta H°}{R}\left[-\frac{1}{T}\right]_{T_1}^{T_2}$$

$$\text{In } K_2 - \text{In } K_1 = \frac{\Delta H°}{R} - \left[\frac{1}{T_2} + \frac{1}{T_1}\right]$$

$$\text{In}\frac{K_2}{K_1} = \frac{\Delta H°}{R}\left[\frac{T_2 - T_1}{T_2T_1}\right]$$

$$\mathbf{\log\frac{K_2}{K_1} = \frac{\Delta H°}{2.303R}\left[\frac{T_2 - T_1}{T_2T_1}\right]} \quad .....(5)$$

Equation 5 is known as integrated form of Van't Hoff equation.

50. The equilibrium constant K_p for the reaction $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ is 8.19 × 10^2 at 298K and 4.6 × 10^{-1} at 498 K. Calculate ΔH° for the reaction.

Ans. $K_{p_1} = 8.19 \times 10^2$ $T_1 = 298$ K

$K_{p_2} = 4.6 \times 10^{-1}$ $T_2 = 498$ K

$$\log\left(\frac{K_{p_2}}{K_{p_1}}\right) = \frac{\Delta H°}{2.303R}\left(\frac{T_2 - T_1}{T_1T_2}\right)$$

$$\log\left(\frac{4.6\times10^{-1}}{8.19\times10^2}\right) = \frac{\Delta H°}{2.303\times8.314}\left(\frac{498-298}{498\times298}\right)$$

$$\frac{-3.2505\times2.303\times8.314\times498\times298}{200} = \Delta H°$$

$\Delta H° = -46181$ J mol^{-1}

$\Delta H° = -46.18$ kJ mol^{-1}

51. The partial pressure of carbon dioxide in the reaction $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$ is 1.017 × 10^{-3} atm at 500°C. Calculate K_p at 600°c C for the reaction. ΔH for the reaction is 181 kJ mol^{-1} and does not change in the given range of temperature.

Ans. $p_{CO_2} = 1.017 \times 10^{-3}$ atm T = 500°C

$K_p = p_{CO_2}$

$\therefore K_{p_1} = 1.017 \times 10^{-3}$;T = 500 + 273 = 773 K

K_{p_1} = ? T = 600 + 273 = 873 K

$\Delta H° = 181$ kJ mol^{-1}

$$\log\left(\frac{K_{p_2}}{K_{p_1}}\right) = \frac{\Delta H°}{2.303R}\left(\frac{T_2 - T_1}{T_1T_2}\right)$$

$$\log\left(\frac{K_{p_2}}{1.017\times10^{-3}}\right) = \frac{181\times10^3}{2.303\times8.314}\left(\frac{873-773}{873\times773}\right)$$

$$\log\left(\frac{K_{p_2}}{1.017\times10^{-3}}\right) = \frac{181\times10^3\times100}{2.303\times8.314\times873\times773}$$

$$\frac{K_{p_2}}{1.017\times10^{-3}} = \text{anti log of } (1.40)$$

$$\frac{K_{p_2}}{1.017\times10^{-3}} = 25.12$$

$\Rightarrow K_{p_2} = 25.12 \times 1.017 \times 10^{-3}$

$\mathbf{K_{p_2} = 25.54 \times 10^{-3}}$

ADDITIONAL QUESTIONS

Choose the Correct Answers **1 MARK**

1. The K_c for given reaction will be
$A_{2(g)} + 2B_{(g)} \rightleftharpoons C_{(g)} + 2D_{(g)}$

(a) $K_c = \frac{[C][D]^2}{[A_2][B]^2}$ (b) $K_c = \frac{[C]}{[A_2][B]^2}$

(c) $K_c = \frac{[A_2][B]^2}{[C][D]^2}$ (d) $K_c = \frac{[A_2][B]^2}{[C]}$

[Ans. (b)]

2. For which of the following reaction, the degree of dissociation (α) and equilibrium constant (K_p) are related as $K_p = \frac{4\alpha^2 P}{(1-\alpha^2)}$?

(a) $N_2O_{4(g)} \rightleftharpoons 2NO_2(g)$
(b) $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI(g)$
(c) $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$
(d) $PCl_{3(g)} + Cl_{2(g)} \rightleftharpoons PCl_{5(g)}$

[Ans. (a) $N_2O_{4(g)} \rightleftharpoons 2NO_2(g)$]

3. In which of the following does the reaction go almost to completion?

(a) $K_c = 10^3$ (b) $K_c = 10^2$
(c) $K_c = 10^{-2}$ (d) $K_c = 10^{-3}$

[Ans. (a) $K_c = 10^3$]

4. Hydrogen (a moles) and iodine (b moles) react to give 2*x* moles of the HI at equilibrium. The total number of moles at equilibrium is

(a) a + b + 2*x* (b) (a – b) + (6 – 2*x*)
(c) (a + b) (d) a + b – *x*

[Ans. (c) (a + b)]

5. K_p is how many times equal to K_c for the given reaction? $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

(a) $\frac{1}{R^2T^2}$ (b) R^2T^2 (c) $\frac{R}{T}$ (d) RT

[Ans. (a) $\frac{1}{R^2T^2}$]

Hint:
$$K_p = K_c (RT)^{\Delta ng}$$
$$K_p = K_c (RT)^{-2}$$
$$\therefore K_p = \frac{K_c}{R^2T^2}$$

6. A + B $\rightleftharpoons$ C + D, K_c for this reaction is 10. If 1, 2, 3, 4 mole/litre of A, B, C and D respectively are present in a container at 25°C, the direction of reaction will be

(a) From left to right (b) From right to left
(c) Reaction is at equilibrium
(d) Unpredictable

[Ans. (a) From left to right]

7. 4*g* H_2, 32*g* O_2, 14*g* N_2 and 11*g* CO_2 are taken in a bulb of 500*ml*. Which one of these has maximum active mass?

(a) H_2 (b) O_2 (c) N_2 (d) CO_2

[Ans. (a) H_2]

8. For reaction, $2A + B \rightleftharpoons 2C$, K = *x*. Equilibrium constant for C $\rightleftharpoons$ A + ½B will be

(a) x (b) $\frac{x}{2}$ (c) $\frac{1}{\sqrt{x}}$ (d) $\sqrt{x}$

[Ans. (c) $\frac{1}{\sqrt{x}}$]

9. XY_2 dissociates as, $XY_{2(g)} \rightleftharpoons XY_{(g)} + Y_{(g)}$ Initial pressure of XY_2 is 600*mm* Hg. The total pressure at equilibrium is 800*mm* Hg. Assuming volume of system to remain constant, the value of K_p is

(a) 50 (b) 100 (c) 400 (d) 20

[Ans. (b) 100]

10. In which of the following equilibrium, change in pressure will not affect the equilibrium ?

(a) $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$
(b) $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$
(c) $PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$
(d) $N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$

[Ans. (b) $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$]

11. In melting of ice, which one of the conditions will be more favorable?

(a) high temperature and high pressure
(b) low temperature and low pressure
(c) low temperature and high pressure
(d) high temperature and low pressure

[Ans. (a) high temperature and high pressure]

12. Two moles of N_2 and two moles of H_2 are taken in a closed vessel of 5 litre capacity and suitable conditions are provided for the reaction. When the equilibrium is reached, it is found that a half mole of N_2 is used up. The equilibrium concentration of NH_3 is

(a) 0.2 (b) 0.4 (c) 0.3 (d) 0.1

[Ans. (a) 0.2]

Sol : Equilibrium concentration

$$= \frac{\text{No. of moles at equilibrium}}{\text{Volume}} = \frac{1}{5} = 0.2$$

13. The active mass of 7.0 g of nitrogen in a 2.0 L container would be

(a) 0.25 (b) 0.125 (c) 0.5 (d) 14.0

[Ans. (b) 0.125]

14. At 700K, the equilibrium constant K_p, for the reaction $2SO_{3(g)} \rightleftharpoons 2SO_{2(g)} + O_{2(g)}$ is 1.8×10^{-3} atm. The value of K_c for the above reaction at the same temperature in moles per litre would be

(a) 1.1×10^7 (b) 6.2×10^{-7}

(c) 3.1×10^{-5} (d) 9.3×10^{-7}

[Ans. (c) 3.1×10^{-5}]

Sol : $K_p = K_c\,(RT)^{\Delta n}$; $\Delta n = 3 - 2 = 1$

$1.8 \times 10^{-3} = K_c\,(0.0832 \times 700)^1$;

$$K_c = \frac{1.8 \times 10^{-3}}{0.0832 \times 700} = 3.09 \times 10^{-5}$$

15. $C_{(s)} + H_2O_{(g)} \rightleftharpoons CO_{(g)} + H_{2(g)}$: $\Delta H < O$
The above equilibrium will proceed in forward direction when

(a) It is subjected to high pressure

(b) It is subjected to high temperature

(c) Inert gas (argon) is added at constant pressure

(d) Carbon (solid) is added

[Ans. (c) Inert gas (argon) is added at constant pressure]

16. A state of equilibrium is reached when

(a) The rate of forward reaction is greater than the rate of the reverse reaction

(b) The concentration of the products and reactants are equal

(c) More product is present than reactant

(d) The concentration of the products and reactants have reached constant value

[Ans. (d) The concentration of the products and reactants have reached constant value]

17. Le-Chatelier's principle is not applicable to

(a) $Fe_{(s)} + S_{(s)} \rightleftharpoons FeS_{(s)}$

(b) $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$

(c) $N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$

(d) $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NN_{3(g)}$

[Ans. (a) $Fe_{(s)} + S_{(s)} \rightleftharpoons FeS_{(s)}$]

Hint : Le-Chatelier's principle is applicable only for gas-phase equilibrium.

18. Following three gaseous equilibrium reactions are occurring at 27°C.

(A) $2CO + O_2 \rightleftharpoons 2CO_2$

(B) $PCl_5 \rightleftharpoons PCl_3 + Cl_2$

(C) $2HI \rightleftharpoons H_2 + I_2$

The correct order of K_p/K_c for the following reaction is

(a) A < B < C (b) C < B < A

(c) A < C < B (d) B < A < C

[Ans. (c) A < C < B]

Sol : (A) $\Delta n = 2 - 3 = -1$; $K_p = K_c(RT)^{-1}$; $K_p/K_c = \frac{1}{RT}$

(B) $\Delta n = 2 - 1 = 1$; $K_p = K_c(RT)$; $K_p/K_c = RT$

(C) $\Delta n = 2 - 2 = 0$; $K_p = K_c$; $K_p/K_c = 0$

19. If the equilibrium constant for $N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$ is K, the equilibrium constant for $\frac{1}{2}N_{2(g)} + \frac{1}{2}O_{2(g)} \rightleftharpoons NO_{(g)}$ will be

(a) K (b) K^2 (c) $K^{½}$ (d) $\frac{1}{2}K$

[Ans. (c) $K^{½}$]

Hint : Since reactants and produced are reduced to half of its value, therefore K also becomes $K^{½}$.

20. In a closed system: $A_{(s)} \rightleftharpoons 2B_{(g)} + 3C_{(g)}$ if the partial pressure of C is doubled then partial pressure of B will be

(a) Twice the orignal pressure

(b) Half of its orignal pressure

(c) $\frac{1}{2\sqrt{2}}$ times, the original pressure

(d) $2\sqrt{2}$ times its original pressure

[Ans. (c) $\frac{1}{2\sqrt{2}}$ times, the original pressure]

21. In which of the following cases, the reaction goes farthest to completion?

(a) $A \rightleftharpoons B\ (K = 10^3)$

(b) $P \rightleftharpoons Q\ (K = 10^{-2})$

(c) $A + B \rightleftharpoons C + D\ (K = 10)$

(d) $X + Y \rightleftharpoons XY_2\ (K = 10^{-1})$

[Ans. (a) $A \rightleftharpoons B\ (K = 10^3)$]

22. The ratio of K_p/K_c for reaction

$$CO_{(g)} + \frac{1}{2}O_{2(g)} \rightleftharpoons CO_{2(g)}$$ **is**

(a) $\frac{R}{T}$ (b) RT (c) $(RT)^{½}$ (d) $(RT)^{-½}$

[Ans. (d) $(RT)^{-½}$]

23. For the reversible reaction

$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ + Heat.

The equilibrium shifts in forward direction.

(a) by increasing the concentration of $NH_{3(g)}$.

(b) by increasing the pressure and decreasing the temperature.

(c) by decreasing the pressure and decreasing the temperature.

(d) by decreasing the concentration of $N_{2(g)}$ and $H_{2(g)}$.

[Ans. (b) by increasing the pressure and decreasing the temperature.]

24. The value of ΔH for the reaction $X_{2(g)} + 4Y_{2(g)} \rightleftharpoons 2XY_{4(g)}$ is less than zero. Formation of $XY_{4(g)}$ will be favoured at :

(a) High pressure and low temperature.

(b) Low pressure and low temperature.

(c) High temperature and high pressure.

(d) High temperature and low pressure.

[Ans. (a) High pressure and low temperature]

25. Ice and water are placed in a closed container at a pressure of 1 atm and 273.15 K temperature. If pressure of the system is increased by 2 atm keeping temperature constant the correct observation would be

(a) The amount of ice increases

(b) Volume of the system increases

(c) The liquid phase disappears completely

(d) The solid phase (ice) disappears completely

[Ans. (d) The solid phase (ice) disappears completely]

26. $2H_{2(g)} + CO_{2(g)} \rightleftharpoons CH_3OH_{(g)}$, ΔH = –92.2 kJ. Which of the following condition will shift the equilibrium in the forward direction?

(a) Temperature of the system is increased

(b) CO is removed (c) CH_3OH is added

(d) The pressure of the system is increased

[Ans. (d)]

27. The value of equilibrium constant of the reaction, $HI_{(g)} \rightleftharpoons \frac{1}{2}H_{2(g)} + \frac{1}{2}I_{2(g)}$ is 8.0. The equilibrium constant of the reaction; $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$ will be

(a) $\frac{1}{8}$ (b) $\frac{1}{16}$ (c) 16 (d) $\frac{1}{64}$

[Ans. (d) $\frac{1}{64}$]

Sol : Formation α $\frac{1}{\text{Dissociation}}$

Then when the reactants & products concentration are doubled, hence equilibrium constant is also doubled.

28. For the reaction, $CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$ K_p is equal to

(a) K_c (b) K_cRT

(c) $K_c(RT)^2$ (d) $K_c(RT)^-$

[Ans. (b) K_cRT]

29. The favourable conditions for melting of ice is

(a) Low pressure (b) High pressure

(c) Low temperature (d) Absence of catalyst

[Ans. (b) High pressure]

30. In the manufacture of NH_3 by Haber's process involving the reaction.

$$N_{2(g)} + 3H_{2(g)} \xrightarrow{[Fe_2O_2]} 2NH_{3(g)};$$

ΔH = –22.08 kcal. The favourable conditions are

(a) High pressure and low temperature

(b) High pressure and high temperature

(c) Low pressure and high temperature

(d) Low pressure and low temperature

[Ans. (a) High pressure and low temperature]

31. If K_1 is the equilibrium constant at temperature T_1 and K_2 is the equilibrium constant at temperature T_2, and if $T_2 > T_1$ and reaction is endothermic then

(a) $K_2 > K_1$ (b) $K_2 < K_1$

(d) $K_2 = K_1$ (c) All of these

[Ans. (a) $K_2 > K_1$]

32. Sulphide ion reacts with solid sulphur

$S^{2-}_{(aq)} + S_{(s)} \rightleftharpoons S^{2-}_{2(aq)}$; $K_1 = 10$

$S^{2-}_{(aq)} + 2S_{(s)} \rightleftharpoons S^{2-}_{3(aq)}$; $K_2 = 130$

The equilibrium constant for the formation of $S_3^{2-}(aq)$ from $S_2^{2-}(aq)$ and sulphur is

(a) 10 (b) 13 (c) 130 (d) 1300

[Ans. (b) 13]

33. For the reaction

$CH_{4(g)} + 2O_{2(g)} \rightleftharpoons CO_{2(g)} + 2H_2O_{(l)}$

$\Delta H = -170.8$ kJ mol^{-1} which of the following statement is not true?

(a) At equilibrium, the concentration of $CO_{2(g)}$ and $H_2O_{(l)}$ are not equal

(b) The equilibrium constant for the reaction is given by $K_p = \dfrac{[CO_2]}{[CH_4][O_2]}$

(c) Addition of $CH_{4(g)}$ or $O_{2(g)}$ at equilibrium will cause a shift to the right.

(d) The reaction is exothermic. **[Ans. (b)]**

34. For the system $3A + 2B \rightleftharpoons C$, the expression for equilibrium constant K is

(a) $\dfrac{[3A]\times[2B]}{[C]}$ (b) $\dfrac{[A]^3\times[B]}{[C]}$

(c) $\dfrac{[C]}{[A]^3\times[B]^2}$ (d) $\dfrac{[C]}{[3A]\times[2B]}$

[Ans. (c) $\dfrac{[C]}{[A]^3\times[B]^2}$ **]**

35. Equilibrium constant K_p for following reaction

$MgCO_{3(s)} \rightleftharpoons MgO_{(s)} + CO_{2(g)}$

(a) $K_p = p_{CO_2}$

(b) $K_p = \dfrac{p_{CO_2}\times p_{CO_2}\times p_{Mgo}}{p_{Mg\,CO_3}}$

(c) $K_p = \dfrac{p_{Mg\,CO_3}}{p_{CO_2}\cdot p_{MgO}}$

(d) $K_p = \dfrac{p_{CO_2}\cdot p_{MgO}}{p_{Mg\,CO_3}}$ **[Ans. (a) $K_p = p_{CO_2}$]**

Hint : Partial pressure of pure solid is unity.

36. A cylinder filled with a movable piston contains liquid water in equilibrium with water vapour at 25°C. Which one of the following operations results in a decrease in the equilibrium vapour pressure?

(a) Moving piston downward a short distance

(b) Removing a small amount of the liquid water

(c) Dissolving salt in the water

(d) Removing a small amount of vapour

[Ans. (c) Dissolving salt in the water]

37. The oxidation of SO_2 and O_2 to SO_3 is an exothermic reaction. The yield of SO_3 will be maximum if

(a) Temperature and pressure both are increased

(b) Temperature decreased, pressure increased

(c) Temperature increased, pressure constant

(d) Temperature and pressure both decreased

[Ans. (b) Temperature decreased, pressure increased]

38. For the reaction $CO_{(g)} + 2H_{2(g)} \rightleftharpoons CH_3OH_{(g)}$. If active mass of CO is kept constant and active mass of H_2 is tripled, the rate of forward reaction will become

(a) Three times (b) Six times

(c) Eight times (d) Nine times

[Ans. (d) Nine times]

39. For the homogeneous gas reaction at 600K, $4NH_{3(g)} + 5O_{2(g)} \rightleftharpoons 4NO_{(g)} + 6H_2O_{(g)}$. The equilibrium K_c has the unit.

(a) (mol $dm^{-3})^{-1}$ (b) (mol $dm^{-3})^{1}$

(c) (mol $dm^{-3})^{10}$ (d) (mol $dm^{-3})^{-9}$

[Ans. (b) (mol $dm^{-3})^{1}$]

Sol : $4NH_{3(g)} + 5O_{2(g)} \rightleftharpoons 4NO_{(g)} + 6H_2O_{(g)}$

$\Delta n_g = 10 - 9 = 1$

Unit of K_c = (mol $dm^{-3})^{\Delta n_g}$

∴ **Unit = (mol $dm^{-3})^{1}$**

40. The equilibrium $A_{(g)} + 4B_{(g)} \rightleftharpoons AB_{4(g)}$ is attained by mixing equal moles of A and B in a one litre vessel. Then at equilibrium

(a) [A] = [B] (b) [A] > [B]

(c) [A] < [B] (d) $[AB_4]$ > [A]

[Ans. (b) [A] > [B]]

41. **If Ar is added to the equilibrium $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_3$ at constant volume, then equilibrium will**

(a) Shift in forward direction
(b) Not shift in any direction
(c) Shift in reverse direction
(d) All are incorrect

[Ans. (b) Not shift in any direction]

42. **The transport of oxygen by hemoglobin in our body as an illustration for a ________ change.**

(a) Reversible (b) Irreversible
(c) Thermodynamic (d) Kinetic

[Ans. (a) Reversible]

43. **In reversible reactions, initially the reaction proceeds towards the _________.**

(a) Formation of the product
(b) Formation of reactions
(c) Decompose of product
(d) Equilibrium state

[Ans. (a) Formation of the product]

44. **What is the temperature and pressure in a thermos flask?**

(a) 298 k, 1 atm (b) 273 k, 2 atm
(c) 298 k, 2 atm (d) 273 k, 2 atm

[Ans. (b) 273 k, 2 atm]

45. **Rate of melting of ice is equal to ____________.**

(a) rate of freezing of ice
(b) rate of melting of ice
(c) rate of freezing water
(d) rate of melting of water

[Ans. (c) rate of freezing water]

46. **Assertion (A) : A pure solid always has the same concentration at a given temperature.**
Reason (R) : It does not expand to fill its container.

(a) Both (A) and (R) are true and (R) is the correct explanation of (A).
(b) Both (A) and (R) are true and (R) is not the correct explanation of (A).
(c) (A) true but (R) false.
(d) Both (A) and (R) are false.

[Ans. (a) Both (A) and (R) are true and (R) is the correct explanation of (A)]

47. **Assertion (A) : The concentration terms of pure liquids can also be excluded from the expression of the equilibrium constant.**
Reason (R) : The active mass concentration of the pure liquid does not charge at a given temperature.

(a) Both (A) and (R) are true and (R) is the correct explanation of (A).
(b) Both (A) and (R) are true and (R) is not the correct explanation of (A).
(c) (A) true but (R) false.
(d) Both (A) and (R) are false.

[Ans. (a) Both (A) and (R) are true and (R) is the correct explanation of (A)]

48. **Match**

A	$H_2 + I_2 \rightleftharpoons 2HI$	**1**	Kp > Kc
B	$PCl_5 \rightleftharpoons PCl_3 + Cl_2$	**2**	Kp < Kc
C	$2SO_2 + O_2 \rightleftharpoons 2SO_2$	**3**	Kp = Kc

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

[Ans. (c) 3 1 2]

49. **Equilibrium constant value depends on ________.**

(a) Temperature (b) Volume
(c) Pressure (d) Catalyst

[Ans. (a) Temperature]

50. **Which of the following is correct about equilibrium constant?**

(a) Unpredict the direction in which the net reaction will take place.
(b) Unpredict the extent of the reaction.
(c) Cannot calculate the equilibrium concentrations of the reactants and products.
(d) These constants do not provide any information regrading the rates of the forward or reverse reaction.

[Ans. (d) These constant do not provide any information regrading the rates of the forward or reverse reaction]

51. **Which equation gives the quantitative temperature dependence of equilibrium constant?**

(a) Hess law (b) Graham's diffusion
(c) Van't Hoff (d) Van dar Waals

[Ans. (c) Van't Hoff]

52. Which of the following is incorrect?

(a) Kc indicates how far the reaction has proceeded.

(b) A large value of Kc indicates that the reaction reaches equilibrium with high product yield.

(c) A low value of Kc indicates that the reaction reaches equilibrium with low product form.

(d) Unpreidt the direction in which the net reaction will take place.**[Ans. (d) Unpreidt the direction in which the net reaction will take place]**

53. What is the relation between standard free energy change and equilibrium constant?

(a) $\Delta G° = + RT \ln k$ (b) $k = -\Delta G°RT$

(c) $\Delta G° = - \ln k$ (d) $k = RT \Delta G$

[Ans. (a) $\Delta G° = - RT \ln k$]

54. Catalyst speeds up the attainment of equilibrium by providing a new pathway having a _______.

(a) lower activation energy

(b) higher activation energy

(c) more activation energy

(d) no activation energy

[Ans. (a) lower activation energy]

VERY SHORT ANSWERS QUESTIONS: 2 MARKS

1. Ice melts slowly at higher altitudes. Explain why?

Ans. $Ice_{(s)} \longrightarrow Water$ ***[HOTS]***

The melting of ice is favoured at high pressure because there is decrease in volume in the forward reaction. Since at high altitudes, atmospheric pressure is low and therefore, ice melts slowly.

2. Predict which of the following reaction will have appreciable concentration of reactants and products?

(i) $Cl_{2(g)} \rightleftharpoons 2Cl_{(g)}; K_c = 5 \times 10^{-39}$

(ii) $Cl_{2(g)} + 2NO_{(g)} \rightleftharpoons 2NOCl_{(g)}; K_c = 3.7 \times 10^{-8}$

(iii) $Cl_{2(g)} + 2NO_{2(g)} \rightleftharpoons 2NO_2Cl_{(g)}; K_c = 1.8$

Ans. The reaction (iii) has an appreciable concentration of reactants and products because its K_c is neither too low nor very high.

3. The following concentration were obtained for the formation of NH_3 from N_2 and H_2 at equilibrium for the reaction $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ $[N_2] = 1.5 \times 10^{-2}M; [H_2] = 3.0 \times 10^{-2}M;$ $[NH_3] = 1.2 \times 10^{-2}M$

Calculate the equilibrium constant.

Sol : $$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3} = \frac{1.2\times10^{-2}}{1.5\times10^{-2}\times(3\times10^{-2})^3}$$

$K_c = 355.55$

4. Which of the following reactions involve homogeneous equilibrium and which involve heterogeneous equilibrium?

(i) $Ag_2O_{(s)} + 2HNO_{3(aq)} \rightleftharpoons 2AgNO_{3(aq)} + H_2O_{(l)}$

(ii) $C_{(s)} + CO_{2(g)} \rightleftharpoons 2CO_{(g)}$

(iii) $CH_3COOC_2H_{5(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COOH_{(aq)} + C_2H_5OH_{(aq)}$

(iv) $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$

Ans. **(i)** Heterogeneous equilibrium

(ii) Heterogeneous equilibrium

(iii) Homogeneous equilibrium

(iv) Homogeneous equilibrium.

5. Write the relationship between equilibrium constant and enthalpy.

Ans. The value of equilibrium constant changes with change in temperature.

If K_1 and K_2 are equilibrium constants at temperatures T_1 and T_2.

ΔH - Heat of reaction at constant pressure.

Then,

$$\log\frac{K_2}{K_1} = \frac{\Delta H}{2.303\ R}\left[\frac{T_2 - T_1}{T_1T_2}\right]$$

6. Explain the state of equilibrium based on the following illustrations.

(i) See-saw (ii) Tug of war

Ans. **(i) See-saw :**

There are different types of equilibrium. For example, if two persons with same weight sit on opposite sides of a see-saw at equal distance from the fulcrum, then the see-saw will be stationary and straight and it is said to be in equilibrium.

(ii) Tug of war :

Another example of a state of equilibrium is the game of "tug-of-war." In this game a rope is pulled taut between two teams. There may be a situation when both the teams are pulling the rope with equal force and the rope is not moving in either direction. This state is said to be in equilibrium.

7. Why are reversible processes non-static?

Ans. In reversible processes, the rate of two opposing reactions equals at a particular stage. At this stage the concentration of reactants and products do not change with time. This condition is not static and is dynamic, because both the forward and reverse reactions are still occurring with the same rate.

8. "Rate of Melting = Rate of freezing" When is the above condition achieved? Explain with an example.

Ans. Let us consider the melting of ice in a closed container at 273 K. In the process the total number of water molecules leaving from and returning to the solid phase at any instant are equal.

If some ice-cubes and water are placed in a thermos flask (at 273K and 1 atm pressure), then there will be no change in the mass of ice and water.

At equilibrium,

$$\text{Rate of melting of ice} = \text{Rate of freezing of water}$$

$$H_2O\ (s) \rightleftharpoons H_2O\ (l)$$

The temperature at which the solid and liquid phases of a substance are at equilibrium is called the melting point or freezing point of that substance.

9. When does the rate of backward reaction increase? What is its consequence?

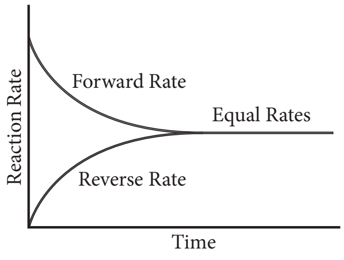
Ans. $$A+B \rightleftharpoons C+D$$

(i) Initially only A and B are present. Soon, a few molecules of the products C and D are formed by the forward reaction.

(ii) As the concentration of the products increases, more products collide and react in the backward direction.

(iii) This leads to an increase in the rate of backward reaction. As the rate of reverse reaction increases, the rate of the forward reaction decreases.

(iv) Eventually, the rate of both reactions becomes equal.



10. Distinguish between homogeneous and heterogeneous equilibrium reaction.

Ans.

S. No.	Homegeneous equilibrium	Heterogeneous equilibrium
(i)	In a homogeneous equilibrium, all the reactants and products are in the same phase.	If the reactants and products of a reaction in equilibrium, are in different phases, then it is called as heterogeneous equilibrium.
(ii)	$H_2(g)+I_2(g) \rightleftharpoons 2HI(g)$	$CaCO_3(s) \rightleftharpoons CaO(s)+CO_2(g)$

11. Define equilibrium constant.

Ans. At a given temperature, the ratio of the product of active masses of reaction products raised to the respective stoichiometric coefficients in the balanced chemical equation to that of the reactants is a constant, known as equilibrium constant.

12. Write the expressions of equilibrium constants in terms of partial pressure and active masses for $2BrCl_{(g)} \rightleftharpoons Br_{2(g)} + Cl_{2(g)}$

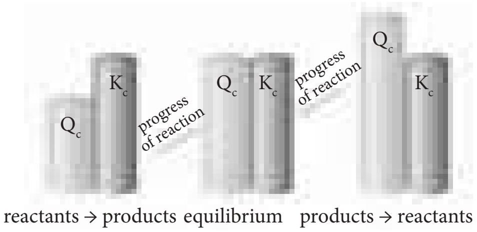
Ans. $K_p = \dfrac{(p_{Br_2})(p_{Cl_2})}{(p_{BrCl})^2}$; $K_c = \dfrac{[Br_2][Cl_2]}{[BrCl]^2}$

13. Define reaction quotient.

Ans. Under non-equilibrium conditions, reaction quotient 'Q' is defined as the ratio of the product of active masses of reaction products raised to the respective stoichiometric coefficients in the balanced chemical equation to that of the reactants.

$$Q = \frac{[C]^l\ [D]^m}{[A]^x\ [B]^y}$$

14. Explain the diagrammatic expression about the direction of reaction.



Ans.

- If $Q < K_c$, the reaction will proceed in the forward direction

- If $Q = K_c$, the reaction is in equilibrium state.
- If $Q > K_c$, the reaction will proceed in the reverse direction.

SHORT ANSWERS QUESTIONS: 3 MARKS

1. Find out the Δng values and write the K_c and K_p relation for the equilibrium reactions

(i) Decomposition of ammonia

(ii) Formation of NO ***[HY-2018]***

Ans. (i) $2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)$

$\Delta ng = 4 - 2 = 2$

$K_p = K_c\,(RT)^{\Delta ng}$

$K_p = K_c\,(RT)^2,\ K_p > K_c$

(ii) $N_2 + O_2 \rightleftharpoons 2NO$

$\Delta ng = 2 - 2 = 0$

$K_p = K_c\,(RT)^{\Delta ng}$

$K_p = K_c\,(RT)^0,\ K_p = K_c$

2. A liquid is in equilibrium with its vapour in a sealed container at a fixed temperature. The volume of the container is suddenly increased.

(i) What is the initial effect of change on vapour pressure?

(ii) How do rates of evaporation and condensation change initially?

(iii) What happens when equilibrium is restored finally and what will be the final vapour pressure?

Ans. $A_{(l)} \longrightarrow A_{(g)}$

Low pressure High pressure

If volume is increased at constant temperature, pressure decreases, since, $p \propto 1/V$ at constant temperature.

(i) Decrease in pressure shift the equilibrium in the direction of high pressure i.e. more vapours are formed hence vapour pressure increases.

(ii) Rate of evaporation increases and rate of condensation decreases.

(iii) When equilibrium is restored finally the rate of evaporation again becomes equal to the rate of condensation and the final vapour pressure becomes equal to the vapour pressure that was before the sudden increase in the volume of the container.

3. Find out the value of K_c for each of the following equilibria from the value of K_p

(i) $2NOC1_{(g)} \rightleftharpoons 2NO_{(g)} + Cl_{2(g)}$;

$K_p = 2.1 \times 10^{-2}$ at 500 K

(ii) $CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$;

$K_p = 165$ at 1073 K.

Ans. (i) $2NOC1_{(g)} \rightleftharpoons 2NO_{(g)} + Cl_{2(g)}$

$$K_p = 2.1 \times 10^{-2} \text{ at } 500 \text{ K}$$

$$\Delta n_g = n_p - n_R = 3 - 2 = 1$$

$$K_c = \frac{K_P}{(RT)^{\Delta n_g}}$$

$$= \frac{2.1 \times 10^{-2}}{0.0821 \times 500} = 5.12 \times 10^{-4}$$

(ii) $CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$

$$K_p = 165 \text{ at } 1073 \text{ K}$$

$$\Delta n_g = n_p - n_R = 1$$

$$K_c = \frac{K_P}{(RT)^{\Delta n_g}} = \frac{165}{0.0821 \times 1073} = 1.87.$$

4. List out few examples of irreversible reactions (changes) taking place in our daily life activity.

Ans. (i) Ripening of fruits and vegetables in few days.

(ii) Tarnishing of silver in few months.

(iii) Rusting of iron slowly.

5. (i) Write a note on biochemical reversible change

(ii) State whether the existence of equilibrium is possible in our lungs or not. Give reason.

Ans. (i) The transport of oxygen by haemoglobin in our body as an illustration for a reversible change. The haemoglobin combines with oxygen in lungs to form oxyhaemoglobin. The oxy-haemoglobin has a tendency to form haemoglobin by releasing oxygen. In fact, in our lungs all the three species coexist.

(ii) The state of equilibrium exist in our lungs because, the three species namely haemoglobin, oxygen (reactants) and oxyhaemoglobin (product) are said to co-exist in our lungs.

6. Discuss the equilibrium involving dissolution of solids or gases in liquids.

Ans. **Solid in liquids :**

- When you add sugar to water at a particular temperature, it dissolves to form sugar solution. If you continue to which the added sugar remains as solid and the resulting solution is called a saturated solution. Here, as in the previous cases a dynamic equilibrium is established between the solute molecules in the solid phase and in the solution phase.

$$\text{Sugar (Solid)} \rightleftharpoons \text{Sugar (Solution)}$$

In this process

$$\begin{array}{c}\text{Rate of dissolution}\\\text{of solute}\end{array} = \begin{array}{c}\text{Rate of}\\\text{crystallisation of solute}\end{array}$$

Gas in liquids :

- When a gas dissolves in a liquid under a given pressure, there will be an equilibrium between gas molecules in the gaseous state and those dissolved in the liquid.
- In carbonated beverages the following equilibrium exists.

  $$CO_2\ (g) \rightleftharpoons CO_2\ (s)$$

- Henry's law is used to explain such gas-solution equilibrium processes.

7. Give the relationship between K_p and K_c for the following cases with example.
(i) Δn_g = +ve (ii) Δn_g = –ve (iii) Δn_g = 0

Ans. (i) **When Δn_g = +ve**

$K_p = K_c\ (RT)^{+ve}$
$K_p > K_c$

Example :

$2NH_3(g) \rightleftharpoons N_2\ (g) + 3H_2\ (g)$
$PCI_5\ (g) \rightleftharpoons PCl_3\ (g) + Cl_2\ (g)$

(ii) **When Δn_g = –ve**

$K_p = K_c\ (RT)^{-ve}$
$K_p < K_c$

Example:

$2H_2(g) + O_2(g) \rightleftharpoons 2H_2O\ (g)$
$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3\ (g)$

(iii) **When Δn_g = 0**

$K_p = K_c\ (RT)^0 = K_c$

Example :

$H_2(g) + I_2(g) \rightleftharpoons 2HI\ (g)$
$N_2\ (g) + O_2\ (g) \rightleftharpoons 2NO(g)$

8. Consider the equations given below
$CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$
$CO_{2(g)} + H_2O_{(e)} \rightleftharpoons H^+_{(aq)} + HCO^-_{3(aq)}$
Write the equilibrium constants for these equations and give reason for the exception of concentration of specific compounds.

Ans. A pure solid always has the same concentration at a given temperature, as it does not expand to fill its container. (i.e.) it has same number of moles L^{-1} of its volume. Therefore, the concentration of a pure solid is a constant. The above expression can be modfied as follows

$$K_c = [CO_2\ (g)] \text{ or } K_p = p_{CO_2}$$

The equilibrium constant for the above reaction depends only the concentration of carbon dioxide and not the calcium carbonate or calcium oxide. Similarly, the active mass (concentration) of the pure liquid does not change at a given temperature. Consequently, the concentration terms of pure liquids can also be excluded from the expression of the equilibrium constant.

For example,

$$CO_2(g) + H_2O\ (l) \rightleftharpoons H+(aq) + HCO^-_3(aq)$$

Since, H_2O (l) is a pure liquid the K_c can be expressed as

$$K_c = \frac{[H^+\ (aq)]\ [HCO^-_3\ (aq)]}{[CO^-_2\ (g)]}$$

9. List down the applications of equilibrium constant.

Ans. (i) Predict the direction in which the net reaction will take place
(ii) Predict the extent of the reaction and
(iii) Calculate the equilibrium concentrations of the reactants and products.

10. What happens when the concentration of H_2 and I_2 are increased in the reaction $H_2 + I_2 \rightleftharpoons 2HI$?

Ans. According to Le Chatelier's principle, the effect of increase in concentration of a substance is to shift the equilibrium in a direction that consumes the added substance.

Let us consider the reaction

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

The addition of H_2 or I_2 to the equilibrium mixture, disturbs the equilibrium. In order to minimize the stress, the system shifts the reaction in a direction where H_2 and I_2 are consumed i.e., the formation of additional HI would balance the effect of added reactant. Hence, the equilibrium shis to the right (forward direction) i.e. the forward reaction takes place until the equilibrium is re-established. Similarly, removal of HI (product) also favours the forward reaction.

11. What inferences do you observe by the values of Q and K_C?

Ans. If Q = K_C, the reaction is in equilibrium state.
If Q > K_C, the reaction will proceed in the reverse direction i.e., formation of reactants.

If $Q < K_C$, the reaction will proceed in the forward direction i.e., formation of products.

12. Discuss the changes you observe in the reaction of synthesis of ammonia with preference to effect of pressure.

Ans. The change in pressure has significant effect only on equilibrium systems with gaseous components. When the pressure on the system is increased, the volume decreases proportionately and the system responds by shifting the equilibrium in a direction that has fewer moles of gaseous molecules.

Let us consider the synthesis of ammonia from nitrogen and hydrogen.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

Effect of pressure on ammonia synthesis

Let the system be allowed to attain equilibrium in a cylinder with a piston. If we press the piston down to increase the pressure, the volume decreases. The system responds to this effect by reducing the number of gas molecules. i.e. it favours the formation of ammonia. If we pull the piston upwards to reduce the pressure, the volume increases. It favours the decomposition of ammonia However, when the total number of the moles of the gaseous reactants and the gaseous products are equal, the change in pressure has no effect on system at equilibrium.

13. Write a note on Haber's process emphasizing the idea of effect of a catalyst in an equilibrium reaction.

Ans. Addition of a catalyst does not affect the state of the equilibrium. The catalyst increases the rate of both the forward and the reverse reactions to the same extent. Hence, it does not change the equilibrium composition of the reaction mixture. However, it speeds up the attainment of equilibrium by providing a new pathway having a lower activation energy.

For example, in the synthesis of NH_3 by the Haber's process iron is used as a catalyst. Similarly, in the contact process of manufacturing SO_3, platinum or V_2O_5 is used as a catalyst.

LONG ANSWERS QUESTIONS: 5 MARKS

1. Explain the following with relevant examples.
- **(i) Solid-liquid equilibrium**
- **(ii) Liquid-vapour equilibrium**
- **(iii) Solid-vapour equilibrium**

Ans. **(i) Solid-liquid equilibrium :**

- ❑ Let us consider the melting of ice in a closed container at 273 K. In the process the total number of water molecules leaving from and returning to the solid phase at any instant are equal.
- ❑ At equilibrium,

  Rate of melting of ice = Rate of freezing of water

$$H_2O\ (s) \rightleftharpoons H_2O\ (l)$$

- ❑ The temperature at which the solid and liquid phases of a substance are at equilibrium is called the melting point or freezing point of that substance.

(ii) Liquid - vapour equilibrium :

- ❑ There exists an equilibrium between the liquid phase and the vapour phase of a substance. For example, liquid water is in equilibrium with its vapour at 373 K and1 atm pressure in a closed vessel.

$$H_2O\ (l) \rightleftharpoons H_2O\ (g)$$

- ❑ Here

  Rate of evaporation = Rate of condensation
- ❑ The temperature at which the liquid and vapour phases are at equilibrium is called the boiling point and condensation point of the liquid.

(iii) Solid - vapour equilibrium :

- ❑ Consider a system in which the solid sublimes to vapour. In this process also, equilibrium can be established between these two phases. When solid iodine is placed in a closed transparent vessel, after sometime,the vessel gets filled up with violet vapour due to sublimation of iodine. The following equilibrium is attained.

$$I_2\ (s) \rightleftharpoons I_2(g)$$

2. Derive the K_p and K_c for the following equilibrium reaction.

$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$

(or)

Derive the value of K_C and K_p for the synthesis of HI.

Ans. Let us consider the formation of HI in which, 'a' moles of hydrogen and 'b' moles of iodine gas are allowed to react in a container of volume V. Let 'x' moles of each of H_2 and I_2 react together to form 2x moles of HI.

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI(g)$$

	H_2	I_2	HI
Initial number of moles	a	b	0
Number of moles reached	x	x	0
Number of moles at equilibrium	a–x	b–x	2x
Active mass or molar concentration at equilibrium	$\frac{a-x}{V}$	$\frac{b-x}{V}$	$\frac{2x}{V}$

Applying law of mass action,

$$K_c = \frac{[HI]^2}{[H_2][I_2]} = \frac{\left(\frac{2x}{V}\right)^2}{\left(\frac{a-x}{V}\right)\left(\frac{b-x}{V}\right)} = \frac{4x^2}{(a-x)(b-x)}$$

The equilibrium constant K_p can also be calculated as follows :

We know the relationship between the K_c and K_p

$$K_p = K_C\,(RT)^{(\Delta n_g)}$$

Here the, $\Delta n_{(g)} = n_p - n_r = 2 - 2 = 0$

Hence $K_p = K_C$; $K_p = \dfrac{4x^2}{(a-x)(b-x)}$

3. Arrive at the expressions of K_p and K_C for the dissociation of $PC1_5$.

Ans. Consider that 'a' moles of $PC1_5$ is taken in a container of volume V. Let 'x' moles of $PC1_5$ be dissociated into x moles of $PC1_3$ and x moles of $C1_2$.

$$PC1_5(g) \rightleftharpoons PC1_3(g) + C1_2(g)$$

	PCl_5	PCl_3	Cl_2
Initial number of moles	a	0	0
Number of moles dissociated	x	0	0
Number of moles at equilibrium	a–x	x	x
Active mass of molar concentration equilibrium	$\frac{a-x}{V}$	$\frac{x}{V}$	$\frac{x}{V}$

Applying law of mass action,

$$K_c = \frac{[PC1_3][C1_2]}{[PC1_5]} = \frac{\left(\frac{x}{V}\right)\left(\frac{x}{V}\right)}{\left(\frac{a-x}{V}\right)} = \frac{x^2}{(a-x)V}$$

The equilibrium constant K_p can also be calculated as follows :

We know the relationship between the K_C and K_p

$$K_p = K_c(RT)^{(\Delta n_g)}$$

Here the

$$\Delta n_g = n_p - n_r = 2 - 1 = 1$$

Hence $K_p = K_C\,(RT)$

We know that PV = nRT

$$RT = \frac{PV}{n}$$

Where n is the total number of moles at equilibrium.

n = (a–x) + x + x = (a+x)

$$K_p = \frac{x^2}{(a-x)V}\,\frac{PV}{n}$$

$$K_p = \frac{x^2}{(a-x)V}\,\frac{PV}{(a+x)} = \frac{x^2P}{(a-x)\,(a+x)}$$

4. Equilibrium constant K_C for the reaction, $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ at 500K is 0.061. At particular time, the analysis shows that the composition of the reaction mixture is 3.0 mol L^{-1} of N_2; 2.0 mol L^{-1} of H_2; 0.50 mol L^{-1} of NH_3. Is the reaction at equilibrium?

Ans. The given reaction is $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

According to available data

N_2 = (3.0) H_2 = (2.0) NH_3 = (0.50)

$$Q_C = \frac{\left(NH_{3(g)}\right)^2}{\left[N_{2(g)}\right]\left[H_{2(g)}\right]^3}$$

$$= \frac{[0.50]^2}{(3.0)(2.0)} = \frac{0.25}{24} = 0.0104$$

5. Explain : How does the extent of reaction depend on K_C?

Ans.

Value of K_C	**$K_C < 10^3$**	**$10^3 < K_C < 10^3$**	**$K_C > 10_3$**
Relative concentrations of reactants and products	[Products << [Reactants]	Significant quantity of Products and Reactants	[Products] >> [Reactants]
Extent of reaction	Reaction makes a little progress in the forward direction	Both the forward and backward reaction reaction make significant progress	Reaction nearly goes to completion
Prediction	Reverse reaction is favoured	Neither forward nor reverse reaction predominates	Forward reaction is favoured
Examples	Decomposition of water at 500 K $2H_2O(g) \rightleftharpoons 2H_2(g) + O_2 (g)$ $K_C = 4.1 \times 10^{-48}$ Oxidation of nitrogen at 1000 K $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ $K_C = 1 \times 10^{-30}$	Dissociation of bromine monochloride at 1000 K $2BrC1(g) \rightleftharpoons Br_2(g) + C1_2(g)$ $K_C = 5$ Formation HI at 700 K $H_2(g) + I(g) \rightleftharpoons 2HI(g)$ $K_C=57.0$	Formation of HCI at 300K $H_2(g) + C1_2(g) \rightleftharpoons 2HC1(g)$ $K_C = 4 \times 10^{31}$ Oxidation of carbon monoxide at 1000 K $2CO(g) + O_2 (g) \rightleftharpoons 2CO_2(g)$ $K_C = 2.2 \times 10^{22}$

6. Explain the effect of concentration, pressure, temperature, catalyst and inert gas on equilibrium.

Ans.

Condition	**Stress**	**Direction in which equilibrium shifts**
Concentration	Addition of reactants (increase in reactant concentration)	Forward reaction
	Removal of products (decrease in product concentration)	
	Addition of products (increase in product concentration)	Reverse reaction
	Removal of reactants (decrease in reactant concentration)	
Pressure	Increase of pressure (Decrease in volume)	Reaction that favours fewer moles of the gaseous molecules
	Decrease of pressure (Increase in volume)	Reaction that favours more moles of the gaseous molecules
Temperature (Alters equilibrium constants)	Increase (High T)	Towards endothermic reaction
	Decrease (Low T)	Towards exothermic reaction
Catalyst (Speeds up the attainment of equilibrium)	Addition of catalyst	No effect
Inert gas	Addition of inert gas at constant volume	No effect

CREATIVE QUESTIONS (HOTS)

2 MARKS

1. How will you arrive at the unit of equilibrium constant?

Ans. (i) The units of K_p and K_c depend on the value of Δn_g

(ii) If number of moles of reactants and products are equal (ie) $\Delta n_g = 0$; Then K_p and K_c have no units.

(iii) If there is increase or decrease in the number of moles of the reaction, then

- Unit of K_p is $(\text{atmosphere})^{\Delta n_g}$
- Unit of K_c is $(\text{mol per litre})^{\Delta n_g}$

2. $\mathbf{2NO_{(g)} + O_{2(g)} \rightleftharpoons 2NO_{2(g)}; \Delta H = -117\ kJ.}$

(i) Predict the effect of an increase in concentration of NO.

(ii) Predict the effect of pressure decrease as a result of increased volume on the equilibrium concentration of NO_2.

Sol : $2NO_{(g)} + O_{2(g)} \rightleftharpoons 2NO_{2(g)}; \Delta H = -117\ kJ$

(i) If we increase the concentration of NO, the rate of forward reaction will increase, i.e. more NO_2 will be formed.

(ii) Decrease in pressure will favour backward reaction, i.e. less NO_2 will be formed.

3. Following data is given for the reason,

$\mathbf{CaCO_{3(s)} \longrightarrow CaO_{(s)} + CO_{2(s)}}$

$\mathbf{\Delta_f H°[CaO_{(s)}] = -650.0\ kJ\ mol^{-1}}$

$\mathbf{\Delta_f H°[CO_{2(g)}] = -395.9\ kJ\ mol^{-1}}$

$\mathbf{\Delta_f H°[CaCO_{3(s)}] = -1206.9\ kJ\ mol^{-1}}$

Predict the effect of temperature on the equilibrium constant of the above reaction.

Sol : $CaCO_{3(s)} \longrightarrow CaO_{(s)} + CO_{2(s)}$

$\Delta_f H° = \Delta_f H°[CaO_{(s)}] + \Delta_f H°[CO_{2(g)}] - \Delta_f H°[CaCO_{3(s)}]$

$\Delta_f H° = -650 + (395.9) - (-1206.9)$

$= +161\ kJ\ mol^{-1}$

Because ΔH value is positive, so the reaction is endothermic. Hence, according to Le-Chatelier's principle, reaction will proceed in forward direction on increasing temperature.

5 MARKS

1. Write a relation between ΔG and Q and define the meaning of each term and answer the following

(i) Why a reaction proceeds forward when Q < K and no net reaction occurs when Q = K?

(ii) Explain the effect of increase in pressure in terms of reaction quotient Q.

For the reaction,

$$\mathbf{CO_{(g)} + 3H_{2(g)} \longrightarrow CH_{4(g)} + H_2O_{(g)}}$$

Ans. The relation between ΔG and Q is

$\Delta G = \Delta G° + RT\ In\ Q$

ΔG = change in free energy as the reaction proceeds

ΔG° = standard free energy

Q = reaction quotient

R = gas constant

T = absolute temperature in K

(i) Since, $\Delta G° = -RT \ln K$

$\therefore \quad \Delta G = -RT \ln K + RT \ln Q;$

$$\Delta G = RT \ln \frac{Q}{K}$$

If Q < K, ΔG will be negative and the reaction proceeds in the forward direction. If Q = K, ΔG = 0 reaction is in equilibrium and there is no net reaction.

(ii) $CO_{(g)} + 3H_{2(g)} \rightleftharpoons CH_{4(g)} + H_2O_{(g)}$

$$K_c = \frac{[CH_4][H_2O]}{[CO][H_2]^3}$$

On increasing pressure, volume decreases. If we doubled the pressure, volume will be halved but the molar concentrations will be doubled. Then,

$$Q_c = \frac{2[CH_4].2[H_2O]}{2[CO]\{2[H_2]\}^3} = \frac{1}{4}\frac{[CH_4][H_2O]}{[CO][H_2]^3} = \frac{1}{4}K_c$$

Therefore, Q_c is less than K_c, so Q_c will tend to increase to re-establish equilibrium and the reaction will go in forward direction.

$$CO_{(g)} + 3H_{2(g)} \rightleftharpoons CH_{4(g)} + H_2O_{(g)}$$

2. **(i) Describe the effect of**

(a) addition of H_2

(b) addition of CH_3OH

(c) removal of CO

(d) removal of CH_3OH on the equilibrium of the reaction, $2H_{2(g)} + CO_{(g)} \rightleftharpoons CH_3OH_{(g)}$

(ii) What happens to an equilibrium in a reversible reaction if a catalyst is added to it?

Ans. **(i)** $2H_{2(g)} + CO_{(g)} \rightleftharpoons CH_3OH_{(g)}$

According to Le-Chatelier's principle,

(a) addition of H_2 (increase in concentration of reactants) shifts the equilibrium in forward direction (more product is formed).

(b) addition of CH_3OH (increase in concentration of product) shifts the equilibrium in backward direction.

(c) removal of CO also shifts the equilibrium in backward direction.

(d) removal of CH_3OH shifts the equilibrium in forward direction.

(ii) When catalyst is added, the state of equilibrium is not disturbed but equilibrium is attained quickly. This is because the catalyst increases the rate of forward and backward reaction to the same extent.

* * *

09

SOLUTIONS

CHAPTER SNAPSHOT

- Types of solutions
- Expressing concentration of solutions
- Solubility of the solutes
- Henry's law
- Vapour pressure of liquid
- Vapour pressure of liquid solutions
    - ✶ Vapour pressure of binary solution of liquid in liquids
    - ✶ Vapour pressure of binary solution of solids in liquids
- Ideal and non-ideal solutions
    - ✶ Ideal solutions
    - ✶ Non-ideal solutions
- Positive deviation from Rauolt's law
- Negative deviation from Rauolt's law
- Colligative properties
    - ✶ Relative lowering of vapour pressure (P)
    - ✶ Elevation of boiling point
    - ✶ Depression in freezing point
    - ✶ Osmosis and osmotic pressure
    - ✶ Isotonic solutions
    - ✶ Reverse osmosis (RO)
    - ✶ Abnormal molar mass

32. State Henry's law.

33. How does classical smog differ from photochemical smog?

PART - D

Answer all five questions : **(5 × 5 = 25)**

34. (a) Enlist the postulates of Bohr's atom model.

(or)

(b) (i) Why rocksalt is harder than metallic sodium?

(ii) Represent the bond formation in $[Fe(CN)_6]^{4-}$ and $BF_3 - NH_3$

35. (a) (i) KCl in water deviates from ideal behaviour - why?

(ii) Define solution. Explain with an example.

(or)

(b) For a gaseous mixture of 2.41g of helium and 2.79gof neon in an evacuated 1.04 dm^3 container at 298 K calculate the partial pressure of each gas and hence find the total pressure of the mixture. Explain how heat absorbed at constant volume is measured using bomb calorimeter with a neat diagram.

36.(a) (i) State the first law of thermodynamics.

(ii) Enthalpy of neutralization is always a constant when a strong acid is neutralized by a strong base: account for the statement.

(or)

(b) Define hydrogen bond and its types.

37. (a) (i) Why does lime water turn milky when CO_2 is bubbled through it?

(ii) Dihydrogen reacts with dioxygen (O_2) to form water. Write the name and formula of the product when the isotope of hydrogen which has one proton and one neutron in its nucleus is treated with oxygen. Will the reactivity of both the isotopes be the same towards oxygen? Justify your answer.

(or)

(b) How is acid rain formed? Explain its effect.

38.(a) (i) What happens when ethylene is passed through cold dilute alkaline potassium permanganate.

(ii) Explain Markow niko's rule with suitable example.

(or)

(b) Write note on decomposition reaction.

★ ★ ★

ANSWERS

PART - A

1. (c) A compound retains the physical properties of its constituent element

2. d) Dries up the blood

3. (d) 2 1 4 3

4. (c) assertion is true but reason is false

5. (d) 0.04 M

6. (d) $O_2^{2-} < C_2^{+} < O_2 < C_2^{2-}$

7. (a) Both assertion and reason are true and reason is the correct explanation of assertion.

8. (c) 3 1 4 2

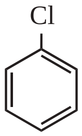
9. (d) stratosphere

10. (a) The forward reaction is exothermic

11. (a) Amongst the isoelectronic species, smaller the positive charge on cation, smaller is the ionic radius

12. (b) 4 3 1 2

13. (b)



14. (b) dimethyl ether

15. (d) free radical

PART - B

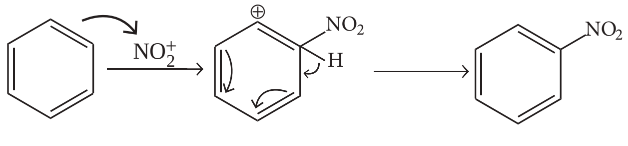
16. **(a)** D_2O retards the growth of living organisms like plants and animals.

(b) Pure heavy water kills small fishes, tadpoles and mice when fed upon it.

17. K_H is a empirical constant with the dimensions of pressure. The value of 'K_H' depends on the nature of the gaseous solute and solvent.

18. The greater hydration enthalpies of Be^{2+} and Mg^{2+} ions overcome the lattice enthalpy factor and therefore their sulphates are soluble in water.

19. Mechanism of nitration of benzene



20. The term periodicity of properties indicates that the elements with similar properties reappear at certain regular intervals of atomic number in the periodic table.

21. **Schrodinger Wave Equation :**

$$\frac{\partial^2\psi}{\partial x^2}+\frac{\partial^2\psi}{\partial y^2}+\frac{\partial^2\psi}{\partial z^2}+\frac{8\pi^2 m}{h^2}(E-V)\psi=0$$

Ψ = amplitude of wave; E = total energy of electron

V = potential energy; m = mass of electron

22. No. The value of Q is determined by the concentration of product and reactants that are not necessarily equilibrium concentration. Thus its value is not a constant. At equilibrium $K_C = Q$.

23. This indicates that the compound contains oxygen. Its percentage is given as 100 – 95 = 5.

24. Compounds having same physical and chemical property but differ only in the rotation of plane of the polarized light are known as optical isomers and the phenomenon is known as optical isomerism.

PART - C

25. $2A + 4B \longrightarrow 3C + 4D$

According to the above equation, 2 mols of 'A' require 4 mols of 'B' for the reaction.

Hence, for 5 mols of 'A', the moles of 'B' required

$$= 5 \text{ mol of A} \times \frac{4 \text{ mol of B}}{2 \text{ mol of A}}$$

$$= 10 \text{ mol B}$$

But we have only 6 mols of 'B'. hence, 'B' is the limiting reagent. So amount of 'C' formed is determined by amount of 'B'.

Since 4 mols of 'B' give 3 mols of 'C'. Hence 6 mols of 'B' will give

$$6 \text{ mol of B} \times \frac{3 \text{ mol of C}}{4 \text{ mol of B}} = 4.5 \text{ mol of C.}$$

26. No. of valence electrons in N-atom = 5 + 1 (negative charge) = 6

One O-atom forms a double bond.

Other two O-atoms shared with two electrons of N-atom.

$\therefore$ No. of bond pairs = 4

No. of lone pairs = No. of valence electron – Bonding pairs

= 4 – 4 = 0

$\therefore$ No. of lone pairs = 0

27. **Characteristics of internal energy (U) :**

The internal energy of a system is an extensive property.

The internal energy of a system is a state function.

The change in internal energy of a system is expressed as $\Delta U = U_f - U_i$

In a cyclic process, there is no internal energy change. $\Delta U_{(cyclic)} = 0$

If the internal energy of the system in the final state (U_f) is less than the internal energy of the system in its initial state (U_i), then ΔU would be negative.

$\Delta U = U_f - U_i = -ve\ (U_f < U_i)$

If the internal energy of the system in the final state (U_f) is greater than the internal energy of the system in its initial state (U_i), then ΔU would be positive.

$\Delta U = U_f - U_i = +ve\ (U_f > U_i)$

28. A small piece of Na dried by pressing between the folds of a filter paper is taken in a fusion tube and it is gently heated. When it melts to a shining globule, put a pinch of the organic compound on it. Heat the tube till reaction ceases and becomes red hot. Plunge it in about 50 mL of distilled water taken in a china dish and break the bottom of the tube by striking against the dish. Boil the contents of the dish for about 10 mts and filter. This filtrate is known as Lassaignes extract or sodium fusion extract and it used for detection of nitrogen, sulfur and halogens present in organic compounds.

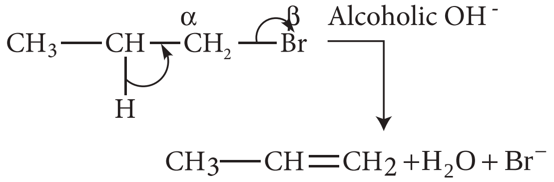
$$Na + \underbrace{C \;+\; N}_{\text{from organic compounds}} \longrightarrow NaCN$$

29. (i) H_2O_2 is used in pollution control treatment of domestic and industrial effluents, oxidation of cyanides, restoration of aerobic conditions to sewage wastes, etc.

(ii) H_2O_2 is stored in wax – coated glass or plastic container in darkness.

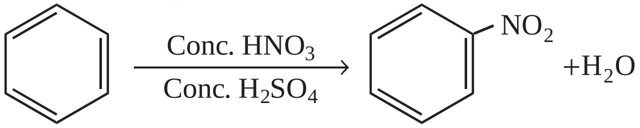
(iii) The presence of dust induces the explosive decomposition of the compound.

30. **(i)** **β - elimination :**



$$CH_3-\underset{H}{\underset{|}{CH}}-\overset{\alpha}{CH_2}-\overset{\beta}{Br} \xrightarrow{\text{Alcoholic OH}^-} CH_3-CH=CH_2 + H_2O + Br^-$$

(ii) **Electrophilic substitution :**



31. (i) **Cu** is largest due to less **effective nuclear charge**. It has 29 electrons, 29 protons. Cu^+ has 28 electrons and 29 protons, Cu^{2+} has 27 electrons and 29 protons. [1]

(ii) **He (helium)** has highest ionisation energy.

(iii) **Mg** is more metallic due to **lower ionisation energy**.

32. According to him, "the partial pressure of the gas in vapour phase (vapour pressure of the solute) is directly proportional to the mole fraction(x) of the gaseous solute in the solution at low concentrations". is statement is known as Henry's law.

Henry's law can be expressed as,

$p_{solute} \propto x_{solute\ in\ solution}$

$p_{solute} = K_H x_{solute\ in\ solution}$

Here, p_{solute} represents the partial pressure of the gas in vapour state which is commonly called as vapour pressure.

33.

S.No	Classical smog	Photochemical smog
1.	It occurs in cool humid climate	It occurs in warm and dry climate
2.	The chemical composition in the mixture of SO_2, SO_3 and humidity	It is formed by the combination of smoke, fog, dust and air pollutants,
3.	It is reducing in nature due to high concentration SO_2 and called reducing smog	It is oxidizing in nature due to high concentration of oxidizing agents like NO_2 and O_3 and is called oxidizing smog.
4.	Classical smog is responsible for acid rain and causes bronchial irritation.	Photo chemical smog causes irritation of eyes skin and lungs.

PART - D

34. **(a) Bohr's atom is based on the following assumptions :**

The energies of electrons are quantised

The electron is revolving around the nucleus in a certain fixed circular path called stationary orbit.

Electron can revolve only in those orbits in which the angular momentum (mvr) of the electron must be equal to an integral multiple of h/2π.

i.e. $mvr = nh/2\pi$

where n = 1,2,3,...etc.,

As long as an electron revolves in the fixed stationary orbit, it doesn't lose its energy. However, when an electron jumps from higher energy state (E_2) to a lower energy state (E_1), the excess energy is emitted as radiation. The frequency of the emitted radiation is

$E_2 - E_1 = h\nu$ and

$$\mathbf{v = \frac{(E_2 - E_1)}{h}}$$

Conversely, when suitable energy is supplied to an electron, it will jump from lower energy orbit to a higher energy orbit.

(or)

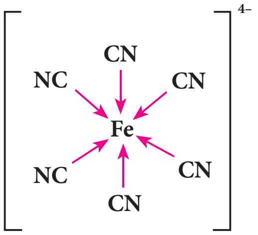
(b)

(i) **(1)** The Na^+ and Cl^- ions are linked by a strong ionic bond.

(2) Due to strong coulombic force of attraction between the oppositely charged ions, the ionic compound exist as hard crystalline solid.

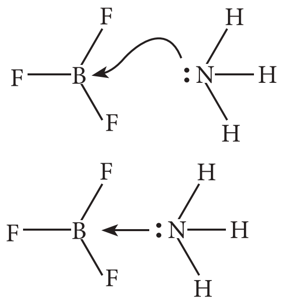
(3) In metallic sodium there exist only a weak metallic bond which makes it softer than rocksalt.

(ii)In ferrocynide ion $[Fe(CN)_6]^{4-}$, each cyanide ion (CN^-) donates a pair of electrons to form a co-ordinate bond with iron (Fe^{2+}) and these electrons are shared by Fe^{2+} and CN^-.



Structure of Ferrocyanide ion

In certain cases, molecules having a lone pair of electrons such as ammonia donates its pair to an electron deficient molecules such as BF_3. to form a co-ordinate bond.



Structure of $BF_3 \rightarrow NH_3$

35. (i) A solution of potassium chloride in water deviates from ideal behavior because the solute dissociates to give K^+ and Cl^- ion which form strong ion-dipole interaction with water molecules.

(ii) A solution is a homogeneous mixture of two or more substances, consisting of atoms, ions or molecules. The compound that is present in largest amount in a homogeneous mixture is called the solvent, and the others are solutes. For example, when a small amount of NaCl is dissolved in water, a homogeneous solution is obtained. In this solution, Na^+ and Cl^- ions are uniformly distributed in water. Here water is the solvent as the amount of water is more compared to the amount of NaCl present in this solution, and the NaCl is the solute.

(or)

(b) Mass of He = 2.41g

No. of moles of He =

$$\frac{\text{Mass}}{\text{Molar Mass}} = \frac{2.41}{4} = 0.6025 \text{ moles}$$

Mass of Ne = 2.79 g

$$\text{No. of moles of Ne} = \frac{\text{Mass}}{\text{Molar Mass}} = \frac{2.79}{20}$$

= 0.1395 moles

Volume of the Total no. of moles of the mixture

= 0.6025 + 0.1395 = 0.7420 moles

Container V = 1.04 dm^3

Temperature T = 298 K

$$\text{Pressure P} = \frac{1}{V}RT$$

According to ideal gas equation PV = nRT

$$P = \frac{0.7420 \times 0.0821 \times 298}{1.04} = 17.45 \text{ atm}$$

Partial pressure P = molefraction × Total pressure

$$= \frac{nA}{nA + nB} \times P$$

$$\text{Partial Pressure of Helium} = p_{He} = \frac{0.6025}{0.7420} \times 17.45$$

According to Dalton's law of partial pressure

= 3.280 atm.

$P = P_1 + P_2 + P_3 \ldots$

$P_{Total} = P_{He} + P_{Ne} = 14.169 + 3.280 = 17.449$ atm

36. (a) (i) The first law of thermodynamics, also known as the law of conservation of energy, states that "The total energy of an isolated system remains constant though it may change from one form to another."

The mathematical statement of the First Law is :

$\Delta U = q + w$

Where q - the amount of heat supplied to the system; w - work done on the system.

(ii) Strong acids and strong bases exist in the fully ionised form in aqueous solutions as below:

$H_3O^+ + Cl^- + Na^+ + OH^- \longrightarrow Na^+ + Cl + 2H_2O$

(or)

$H_3O^+_{(aq)} + OH^-_{(aq)} \longrightarrow 2H_2O(l)°$

$\Delta H° = -57.32$ KJ.

The H^+ ions produced in water by the acid molecules exist as H_3O^+. Thus, enthalpy change of neutralisation is essentially due to enthalpy change per mole of water formed from H_3O^+ and OH– ions. Therefore, irrespective of the chemical nature, the enthalpy of neutralisation of strong acid by strong base is a constant value which is equal to –57.32 KJ.

(or)

(b) **(i) Hydrogen bond :**

When a hydrogen atom (H) is covalently bonded to a highly electronegative atom (F or O or N), the bond is polarized in such a way that the hydrogen atom is able to form a weak bond (electrostatic attraction) between the hydrogen atom of a molecule and the **electronegative** atom a second molecule. The bond thus formed is called a **hydrogen bond**.

(ii) Intermolecular Hydrogen :

Intermolecular hydrogen bonds occur between two separate molecules.

They can occur between any numbers of like or unlike molecules as long as hydrogen donors and acceptors are present an in positions in which they can interact. Eg: Water, HF, etc,.

(iii) Intramolecular Hydrogen :

This type of bond is formed between hydrogen atom and N, O or F atom of the **same molecule**.

This type of hydrogen bonding is commonly called **chelation** and is more frequently found in organic compounds. Eg: o-nitro phenol, salicylic acid, etc,.

37. (a) (i) When carbon dioxide is passed through lime water it turns milky due to the formation of calcium carbonate.

$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

(ii) $2H_2 + O_2 \longrightarrow 2H_2O$

The isotope of hydrogen which has one proton and one neutron in its nucleus is Deuterium.

$2D_2 + O_2 \longrightarrow 2D_2O$

The product is heavy water (Deuterium oxide). H_2O and D_2O has same chemical properties but the reaction velocity of D_2O is slightly less due to the difference in the mass number of the isotopes known as isotopic effect. Deuterium is heavier than protium so reacts slowly.

(or)

(b) Burning of fossil fuels (coal and oil) in power stations, furnaces and petrol, diesel in motor engines produce sulphur dioxide and nitrogen oxides. The main contributors of acid rain are SO_2 and NO_2.They are converted into sulphuric acid and nitric acid respectively by the reaction with oxygen and water.

$2SO_2 + O_2 + 2H_2O \longrightarrow 2H_2SO_4$

$4NO_2 + O_2 + 2H_2O \longrightarrow 4HNO_3$

The pH of rain water drops to 5:6 and hence its is called acid rain.

Harmful effects of acid rain : Some harmful effects are discussed below.

(i) Acid rain causes extensive damage to buildings and structural materials of marbles. This attack on marble is termed as Stone leprosy.

$CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + H_2O + CO2\uparrow$

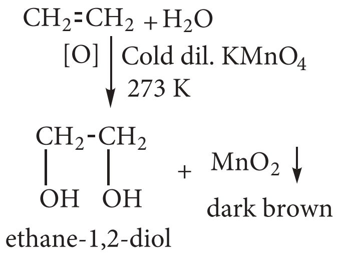
(ii) Acid rain affects plants and animal life in aquatic ecosystem.

(iii) It is harmful for agriculture, trees and plants as it dissolves and removes the nutrients needed for their growth.

(iv) It corrodes water pipes resulting in the leaching of heavy metals such as iron, lead and copper into the drinking water which have toxic effects.

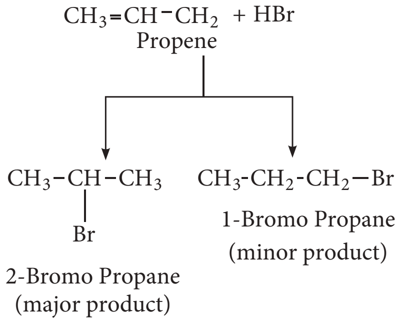
(v) It causes respiratory ailment in humans and animals.

38. **(a)** **(i)** Ethene reacts with cold alk $KMno_4$ (Balyer's regent to give ethane 1,2 - diol



(ii) **Markovnikoff's rule :** "When an unsymmetrical alkene reacts with hydrogen halide, the hydrogen adds to the carbon that has more number of hydrogen and halogen add to the carbon having fewer hydrogen".

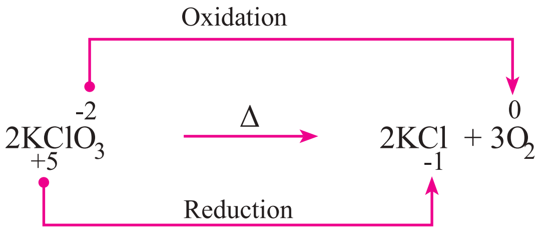
Eg : **Addition HBr to unsymmetrical alkene :** In the addition of hydrogen halide to an unsymmetrical alkene, two products are obtained.



(or)

(b) **Decomposition reaction :** Redox reactions in which a compound breaks down into two or more components are called decomposition reactions. These reactions are opposite to combination reactions. In these reactions, the oxidation number of the different elements in the same substance is changed.

Eg :



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SURA'S. MODEL QUESTION PAPER - 3

11th
STD.

TIME ALLOWED : 2.30 HOURS **CHEMISTRY** MARKS : 70

PART - A

ANSWER ALL THE QUESTIONS: (15 × 1 = 15)

1. The volume occupied by any gas at S.T.P. is _____ .

(a) 22.4 litres (b) 2.24 litres
(c) 224 litres (d) 0.224 litres

2. Assertion : Helium has the highest value of ionisation energy among all the elements known

Reason : Helium has the highest value of electron affinity among all the elements known

(a) Both assertion and reason are true and reason is correct explanation for the assertion
(b) Both assertion and reason are true but the reason is not the correct explanation for the assertion
(c) Assertion is true and the reason is false
(d) Both assertion and the reason are false

3. For alkali metals, which one of the following trends is incorrect ?

(a) Hydration energy : Li > Na > K > Rb
(b) Ionisation energy : Li > Na > K > Rb
(c) Density : Li < Na < K < Rb
(d) Atomic size : Li < Na < K < Rb

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	Chloromycetin	**1**	Malaria
B	Thyroxine	**2**	Typhoid Fever
C	Chloroquine	**3**	Anaesthetic
D	Halothane	**4**	Goitre

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

5. Almost the entire mass of an atom is concentrated in the ___________.

(a) proton (b) electrons
(c) neutrons (d) nucleus

6. The partial pressure of nitrogen in air is 0.76 atm and its Henry's law constant is 7.6×10^4 atm at 300K. What is the molefraction of nitrogen gas in the solution obtained when air is bubbled through water at 300K?

a) 1×10^{-4} b) 1×10^{-6} c) 2×10^{-5} d) 1×10^{-5}

7. Molar heat of vapourisation of a liquid is 4.8 kJ mol^{-1}. If the entropy change is 16 J mol^{-1} K^{-1}, the boiling point of the liquid is __________

(a) 323 K (b) 27° C (c) 164 K (d) 0.3 K

8. Assertion : Oxygen molecule is paramagnetic.

Reason : It has two unpaired electron in its bonding molecular orbital.

a) both assertion and reason are true and reason is the correct explanation of assertion
b) both assertion and reason are true but reason is not the correct explanation of assertion
c) assertion is true but reason is false
d) Both assertion and reason are false

9. Which of the following carbocation will be most stable?

a) $Ph_3C^{+}_{-}$ b) $CH_3{-}\overset{+}{C}H_2{-}$
c) $(CH_3)_2{-}\overset{+}{C}H$ d) $CH_2 = CH - \overset{+}{C}H_2$

10. Which one of the following is incorrect statement ?

a) For a system at equilibrium, Q is always less than the equilibrium constant.
b) Equilibrium can be attained from either side of the reaction.
c) Presence of catalyst affects both the forward reaction and reverse reaction to the same extent.
d) Equilibrium constant varied with temperature.

11. Match the List I with List II and select the correct answer using the code given below the lists

List I		**List II**	
A	Depletion of ozone layer	**1**	CO_2
B	Acid rain	**2**	NO
C	Photochemical smog	**3**	SO_2
D	Green house effect	**4**	CFC

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

12. Rate of diffusion of a gas is
(a) directly proportional to its density
(b) directly proportional to its molecular weight
(c) directly proportional to its square root of its molecular weight
(d) inversely proportional to the square root of its molecular weight

13. Which one of the following statements is incorrect with regard to ortho and para dihydrogen ?
(a) They are nuclear spin isomers
(b) Ortho isomer has zero nuclear spin whereas the para isomer has one nuclear spin
(c) The para isomer is favoured at low temperatures
(d) The thermal conductivity of the para isomer is 50% greater than that of the ortho isomer.

14. The general formula for alkadiene is _______
a) C_nH_{2n} b) C_nH_{2n-1} c) C_nH_{2n-2} d) C_nH_{n-2}

15. Benzene reacts with chlorine in presence of sun light gives a compounds (A). The compound and its use are
(a) C_6Cl_6, insecticide
(b) $C_6H_6Cl_6$, insecticide
(c) C_6H_5Cl, insecticide
(d) $C_6H_6Cl_6$, sterlising agent

PART - B

Answer six questions. Question No. 18 is compulsory. Answer any five from the remaining: **(6 × 2 = 12)**

16. Write the common name for the following compounds.
(i) CH_3OH (ii) C_2H_5OH
(iii) $C_2H_5–O–C_2H_5$ (iv) CH_3COOH

17. An atom of an element contains 29 electrons and 35 neutrons. Deduce
(i) the number of protons.
(ii) the electronic configuration of the element.

18. Define modern periodic law.

19. What is abnormal molar mass?

20. Categorise the redox reactions that occur in our daily life.

21. What are ternary Hydrides? Give examples.

22. What is dead burnt plaster?

23. Define resonance effect.

24. Which bond is stronger σ or π ? Why?

PART - C

Answer six questions. Question No. 27 is compulsory. Answer any Five form the remaining : **(6 × 3 = 18)**

25. List out the uses of alkenes.

26. Among ortho, meta and para substituted diahalobenzenes which has high melting point? Give reason with example.

27. What is the effect of added inert gas on the reaction at equilibrium?

28. What do you understand by stoichiometric co-efficients in a chemical equation?

29. A balloon filled with air at room temperature and cooled to a much lower temperature can be used as a model for Charle's law.

30. What are spontaneous reactions? What are the conditions for the spontaneity of a process?

31. Write the uses of calcium hydroxide.

32. How can domestic waster be used as manure?

33. How will you convert ethyl chloride in to
i) ethane ii) n- butane

PART - D

Answer all five questions : **(5 × 5 = 25)**

34. (a) Calculate the number of atoms/molecules present in the following:
a) 10g of Hg
b) 1.8g of water
c) 100g of sulpurdioxide
d) 1kg of acetic acid

(OR)

b) (i) The effect of uncertainty principle is significant only for motion of microscopic particles and is negligible for the macroscopic particles. Justify the statement with the help of a suitable example.
(ii) How does the Bohr theory of the hydrogen atom differ from that of Schrodinger?

35. (a) Define hydrogen bond and its types.

(or)

(b) (i) State the third law of thermodynamics.
(ii) Orbits are also called as stationary states. Say whether the above statement is true or false. Justify you answer.

36. (a) (i) Radius of a cation is smaller than the parent atom. Account for the following.
(ii) I.E increases as we move across the period but Ionisation enthalpies (I.E) of second period of elements in the order.
L*i* < B < B*e* < C < O < N < F < N*e*
Explain why?
(1) Be has higher I.E and B
(2) O has lower I.E than N & F

(OR)

(b) Explain the following observations
  (a) Aerated water bottles are kept under water during summer
  (b) Liquid ammonia bottle is cooled before opening the seal
  (c) The tyre of an automobile is inflated to slightly lesser pressure in summer than in winter
  (d) The size of a weather balloon becomes larger and larger as it ascends up into larger altitude

37. (a) Give a detailed account on the different mechanisms followed in elimination reaction.

(OR)

(b) (i) Why do you classify mesomeric effect (M-effect) into $^{+}$M and $^{-}$M effect?
  (ii) Why type of mesomeric effect is observed in phenol? Explain.

38. (a) Describe Fajan's rule

(OR)

(b) (i) When does a non-ideal solution is said to show a negative deviation?

  (ii) Analyse the deviation observed in the solution of phenol and aniline.

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ANSWERS

PART - A

1. (a) 22.4 litres
2. (c) Assertion is true and the reason is false
3. (c) Density : Li < Na < K < Rb
4. (b) 3 1 4 2
5. (d) nucleus
6. (d) 1×10^{-5}
7. (b) 27° C
8. (c) assertion is true but reason is false
9. (a) $Ph_3C^{+}_{-}$
10. (a) For a system at equilibrium, Q is always less than the equilibrium constant.
11. (c) 4 3 2 1
12. (d) inversely proportional to the square root of its molecular weight
13. (b) Ortho isomer has zero nuclear spin whereas the para isomer has one nuclear spin
14. (c) C_nH_{2n-2}
15. (b) $C_6H_6Cl_6$, insecticide

PART - B

16. (i) Methyl alcohol
  (ii) Ethyl alcohol
  (iii) Di ethyl ether
  (iv) Acetic acid

17. (i) For a neutral atom,
Number of electrons = number of protons
29 electrons = 29 protons.
(ii) $29Z = 1s^2,2s^2,2p^6,3s^2,3p^6,3d^{10},4s^1$
(The element is copper).

18. The modern periodic law states that, "the physical and chemical properties of the elements are periodic functions of their atomic numbers." Draw the hydrogen bonding existing in the following compounds.

19. The dissociation or association of solute molecules would alter the total number of particles present in the solution and hence affect the results of measured colligative properties. In such solutions, the value of the molar mass of the solute determined using colligative properties would be different from the actual molar mass, and it is called abnormal molar mass.

s the number of solute involved in association.

20. Fading of the colour of the clothes
Burning of cooking gas, fuel, wood, etc.
Rusting of Iron
Extraction of Metals.

21. Ternary hydrides are compounds in which the molecule is constituted by hydrogen and two types of elements, e.g., LiB_4 or $LiA1H_4$.

22. When gypsum is heated above 393 K, no water of crystallisation is left and anhydrous calcium sulphate, $CaSO_4$ is formed. This is known as 'dead burnt plaster'.

23. The resonance is a chemical phenomenon which is observed in certain organic compounds possessing double bonds at a suitable position. Certain organic compounds can be represented by more than one structure and they differ only in the position of bonding and lone pair of electrons. Such structures are called resonance structures (canonical structures) and this phenomenon is called resonance. This phenomenon is also called mesomerism or mesomeric effect.

24. Sigma σ bonds are strong than pi (p) bonds. Sigma bonds are formed by head on over lap of atomic orbitals so extent of overlapping is maximum. Pi bonds are weaker, since according to quantum mechanics, the orbital path are parallel to there is much less overlap between the p orbitals.

PART - C

25. 1) Alkenes find many diverse applications in industry. They are used as starting materials in the synthesis of alcohols, plastics, liquors, detergents and fuels

2) Ethene is the most important organic feed stock in the polymer industry. E.g. PVC, Sarans and polyethylene. These polymer are used in the manufacture of floor tiles, shoe soles, synthetic fibres, raincoats, pipes etc.,

26. The boiling points of isomeric dihalobenzene are nearly the same. The melting point of para isomer is generally higher than the melting points of ortho and meta isomers. The higher melting point of p-isomer is due to its symmetry which leads to more close packing of its molecules in the crystal lattice and consequently strong intermolecular attractive force which requires more energy for melting.

p–Dihalobenzene > o-Dichlorobenzene > m-Dichloro benzene.

27. When an inert gas (i.e, a gas which does not react with any other species involved in equilibrium) is added to an equilibrium system at constant volume, the total number of moles of gases present in the container increases, that is, the total pressure of gases increases. The partial pressure of the reactants and the products or the molar concentration of the substance involved in the reaction remains unchanged. Hence at constant volume, addition of inert gas has no effect on equilibrium.

28. The co-efficients of reactants and products involved in a chemical equation represented by the balanced form are known as stoichiometric co-efficients.

Eg : $N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$

The stoichiometric co-efficients are 1, 3 and 2 respectively.

29. Charles law states that "At constant pressure, the volume of a given mass of an ideal gas is directly proportional to its temperature."

According to Charles Law, if we were to take a balloon filled with air and increase the temperature of the air inside, the volume of air would increase causing the balloon to expand. This is caused by the heating of the molecules of air inside the balloon causing them to move rapidly. In the same manner if we cooled the balloon in a freezer, the volume of air decrease, making the balloon look partially deflated.

30. (i) spontaneous reaction : A reaction that occurs under the given set of conditions without any external driving force is called a spontaneous reaction.

(ii) Criteria for spontaneity of a process : The spontaneity of any process depends on three different factors. $\Delta H = -ve$, $\Delta S = +ve$, $\Delta G = -ve$.

31. (i) in the preparation of mortar, a building material.

(ii) in white wash due to its disinfectant nature.

(iii) in glass making, in tanning industry, for the preparation of bleaching powder and for purification of sugar..

32. (i) Domestic wastes are collected in small dustbins and carried to the disposable site.

(ii) The garbages are sorted out as bio-degradable and non-biodegradable.

(iii) Then, the bio-degradable wastes (Eg: fruits, vegetables, animal waste, etc) are deposited in land fills and are converted into manure.

33. (i) Ethyl Chloride ⟶ Ethane :

$$\underset{\text{Ethyl Chloride}}{CH_3-CH_2-Cl} \xrightarrow[\text{Zn/HCl}]{[H]} \underset{\text{Ethane}}{CH_3-CH_3} + HCl$$

(ii) Ethyl chloride ⟶ n-Butane (Wurtz reaction) :

$$\underset{\text{Ethyl chloride}}{CH_3-CH_2-Cl} + 2Na + Cl-CH_2-CH_3$$

$$\xrightarrow{\text{Dry Ether}} \underset{\text{n - Butane}}{CH_3-CH_2-CH_2-CH_3} + 2NaBr$$

PART - D

34.(a)

(a) 10g of Hg

Atomic mass of Hg = 200 $gmol^{-1}$

200 g of mercury contains 6.023×10^{23} atoms of mercury.

10 g of mercury contains

$$= \frac{10\times6.023\times10^{23}}{200}$$

$$= 0.301 \times 10^{23} = 3.01 \times 10^{24}$$

atoms of mercury.

(b) 1.8g of water

1 mole of water = 18 g mol^{-1}

18 g of water contains 6.023×10^{23} molecules of water

$$\text{1.8g of water contains} = \frac{1.8\times6.023\times10^{23}}{18}$$

$$= 0.602 \times 10^{23}$$

$$= 6.02 \times 10^{24}$$

Molecules of water

(c) 100g of sulphur dioxide

Molecular mass of SO_2 = 64

64g of sulphur dioxide contains = 6.023×10^{23} Molecules of SO_2

$$\therefore 100\text{g of } SO_2 \text{ contains} = \frac{100 \times 6.023 \times 10^{23}}{64}$$

= 9.41 molecules of SO_2

(d) 1Kg of acetic acid

Molecular mass of acetic acid = 60

60g of acetic acid contains = 6.023×10^{23} Molecules of acetic acid

$\therefore$ 1000g of acetic acid contains

$$= \frac{1000 \times 6.023 \times 10}{60}$$

= 100×10^{23}

molecules of acetic acid **Oxidation number :** It is defined as the imaginary charge left on the atom when all other atoms of the compound have been removed in their usual oxidation states that are assigned according to set of rules.

(OR)

(b) (i) If uncertainty principle is applied to an object of mass say about a milligram (10^{-6} kg), then

$$\Delta v . \Delta x = \frac{h}{4\pi m}$$

$$\Delta v.\ \Delta x = \frac{6.626 \times 10^{-34} \text{kg } m^2 s^{-1}}{4 \times 3.14 \times 10^{-6} \text{kg}}$$

$= 0.52 \times 10^{-28}\ m^2\ s^{-1}$

The value of $\Delta v.\ \Delta x$ obtained is extremely small and is insignificant. Therefore, for milligram sized or heavier objects, the associated uncertainties are hardly of any real consequence.

(ii) Bohr's theory does not consider the de-Broglie concept of dual nature of electron and also contradicts with the Heisenberg's uncertainty principle, while the Schrodinger equation is based on quantum mechanics which deals with the microscopic objects having both the particle as well as wave like character.

(or)

35. .(a) (i) **Hydrogen bond :** When a hydrogen atom (H) is covalently bonded to a highly electronegative atom (F or O or N), the bond is polarized in such a way that the hydrogen atom is able to form a weak bond (electrostatic attraction) between the hydrogen atom of a molecule and the **electronegative** atom a second molecule. The bond thus formed is called a **hydrogen bond**.

(ii) Intermolecular Hydrogen :

Intermolecular hydrogen bonds occur between two separate molecules.

They can occur between any numbers of like or unlike molecules as long as hydrogen donors and acceptors are present an in positions in which they can interact. Eg: Water, HF, etc,.

(iii) Intramolecular Hydrogen :

This type of bond is formed between hydrogen atom and N, O or F atom of the **same molecule**.

This type of hydrogen bonding is commonly called **chelation** and is more frequently found in organic compounds. Eg: o-nitro phenol, salicylic acid, etc,.

(or)

b) (i) **(1)** The third law of thermodynamics states that **the entropy of pure crystalline substance at absolute zero is zero**.

(2) It can also be stated as **it is impossible to lower the temperature of an object to absolute zero in a finite number of steps.**

(3) Mathematically,

$\lim_{T \to 0} S = 0$ for a perfectly ordered crystalline state.

(ii) The statement is true. According to Bohr, as long as an electron remains in a particular orbit, it does not lose or gain energy. This means that energy of an electron in a particular path remains constant. Therefore, these orbits are also called stationary states.

36.(a) **(i)** A cation is formed by loss of one or more electrons. The nuclear charge remains the same but the number of electrons becomes less than the parent resulting in the increase in the effective nuclear charge per electron. This causes decrease in size.

(ii) **(1)** $_{4}Be - 1s^2\ 2s^2$; $_{5}B - 1s^2\ 2s^2\ 2p^1$

The I.E. of Be is more than that of B though the nuclear charge of boron atom (Z = 5) is greater than that of beryllium atom (Z = 4). This can be explained as follows:

Boron atom (Z = 5; $1s^2\ 2s^2\ 2p_x^{\ 1}\ 2p_y^{\ 0}\ 2p_z^{\ 0}$) is having one unpaired electron in the 2p-subshell. Be-atom (Z = 4; $1s^2\ 2s^2$) is having paired electrons in the 2s-subshell.

As the fully filled 2s-subshell in Be-atom is more stable than B-atom due to symmetry, more energy would be needed to remove an electron from Be-atom. Hence, Be has high I. E.

Hence I.E of Be > B.

$$_{7}N - 1s^2, 2s^2, 2p_x^1, 2p_y^1, 2p_z^1$$

(2) $$_{8}O - 1s^2, 2s^2, 2p_x^2, 2p_y^1, 2p_z^1$$

∴ O has lower I.E than N.

(OR)

(b) (a) Aerated water bottles are kept under water during summer :

In aerated water bottles, CO_2 gas is passed through the aqueous solution under pressure since solubility of the gas in water is not very high. In summer, the solubility of the gas in water is likely to decrease since rise in temperature decreases solubility. Pressure becomes too high for the glass bottle to with stand and so explodes. To avoid this, bottles are kept under water.

(b) Liquid ammonia bottle is cooled before opening the seal :

At room temperature, vapour pressure of liquid ammonia is very high and so will evaporate. If the bottle is opened, the sudden decrease in pressure will lead to increase in volume of the gas and cause breakage of the bottle. Cooling decreases the vapour pressure and maintains the liquid in the same state. Hence, the bottle is cooled before opening.

(c) The tyre of an automobile is inflated to slightly lesser pressure in summer than in winter :

Air pressure is directly proportional to temperature. During summer, increase in temperature increases pressure of air in the tube which causes the tube to burst. So tyres are inflated to lesser pressure in summers than in winters.

(d) The size of a weather balloon becomes larger and larger as it ascends up into larger altitude :

According to Boyle's law, the volume of a gas is inversely proportional to the pressure at a given temperature. As the weather balloon ascends, atmospheric pressure is less, pressure of the gas tends to decrease and so volume as well as the size of the balloon increases.

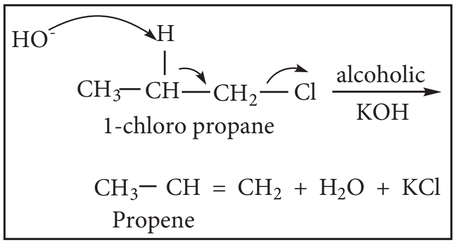
37. (a) Elimination reactions may proceed through two different mechanisms namely E_1 and E_2

$$\begin{tikzcd} & \text{Elimination} \\ E_2 \arrow[r] \arrow[ur] & \text{bimolecular} \\ & \text{(Second order)} \end{tikzcd}$$

(i) The rate of E_2 reaction depends on the concentration of alkyl halide and base

Rate = k [alkyl halide] [base]

(ii) It is therefore, a second order reaction. Generally primary alkyl halide undergoes this reaction in the presence of alcoholic KOH. It is a one step process in which the abstraction of the proton from the β carbon and expulsion of halide from the α carbon occur simultaneously. The mechanism is shown below.

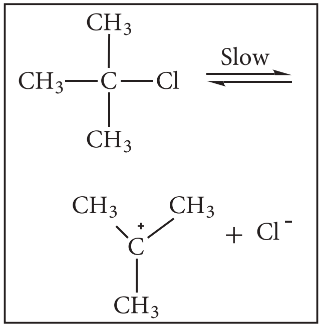


E_1 reaction mechanism

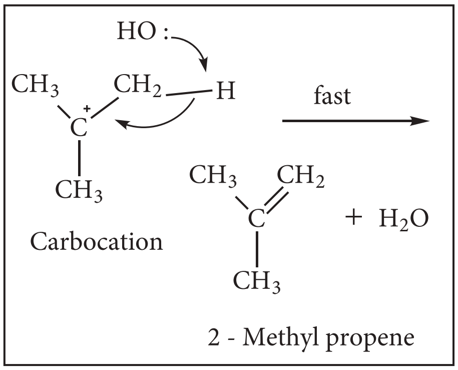
$$\begin{tikzcd} & \text{Elimination} \\ E_1 \arrow[r] \arrow[ur] & \text{Unimolecular} \end{tikzcd}$$

(iii) Generally, tertiary alkyl halide which undergoes elimination reaction by this mechanism in the presence of alcoholic KOH. It follows first order kinetics. Let us consider the following elimination reaction.

Step - 1: Heterolytic fission to yield a carbocation



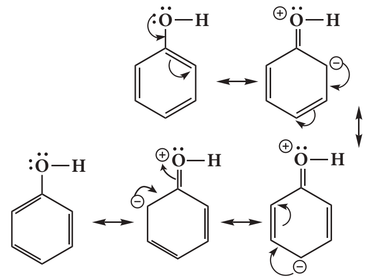
Step - 2 Elimination of a proton from the β - carbon to produce an alkene.

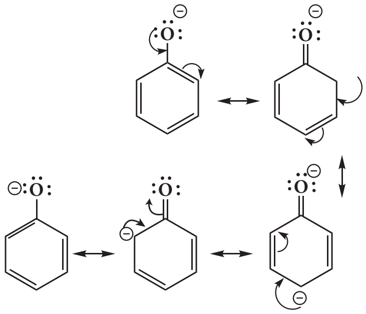


(OR)

(b) (i) Similar to the other electron displacement effect, mesomeric effect is also classified into positive mesomeric effect (+M or +R) and negative mesomeric effect (–M of –R) based on the nature of the functional group present adjacent to the multiple bond.

(ii) Resonance is useful in explaining certain properties such as acidity of phenol. The phenoxide ion is more stabilised than phenol by resonance effect (+M effect) and hence resonance favours ionisation of phenol to form H^+ and shows acidity.





The above structures shows that there is a **charge separation** in the resonance structure of phenol which needs energy, where as there is no such hybrid structures in the case of phenoxide ion. This **increased stability** accounts for the **acidic character of phenol.**

38. (a) The ability of a cation to polarise an anion is called its polarising ability and the tendency of an anion to get polarised is called its polarisability. The extent of polarisation in an ionic compound is given by the Fajans rules

Fajans Rules :

(i) To show greater covalent character, both the cation and anion should have high charge on them. Higher the positive charge on the cation, greater will be the attraction on the electron cloud of the anion. Similarly higher the magnitude of negative charge on the anion, greater is its polarisability. Hence, the increase in charge on cation or in anion increases the covalent character

Let us consider three ionic compounds aluminum chloride, magnesium chloride and sodium chloride. Since the charge of the cation increase in the order $Na^+ < Mg^{2+} < Al^{3+}$, the covalent character also follows the same order $NaCl < MgCl_2 < AlCl_3$.

(ii) The smaller cation and larger anion show greater covalent character due to the greater extent of polarisation.

Lithium chloride is more covalent than sodium chloride. The size of Li^+ is smaller than Na^+ and hence the polarising power of Li^+ is more. Lithium iodide is more covalent than lithium chloride as the size of I^- is larger than the Cl^-. Hence I^- will be more polarised than Cl^- by the cation, Li^+.

(iii) Cations having $ns^2\ np^6\ nd^{10}$ configuration show greater polarising power than the cations with $ns^2\ np^6$ configuration. Hence, they show greater covalent character.

CuCl is more covalent than NaCl. Compared to Na^+ (1.13 Å). Cu^+ (0.6 Å) is small and have $3s^2\ 3p^6\ 3d^{10}$ configuration.

Electronic configuration of Cu^+

$[Ar]\ 3s^2, 3p^6, 3d^{10}$

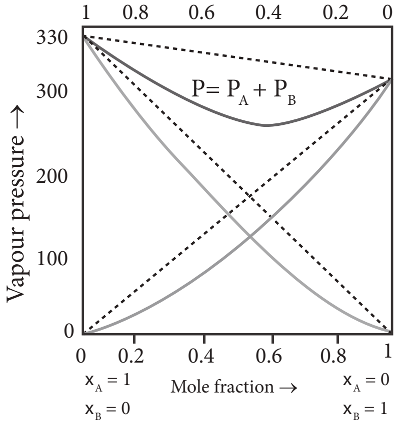
Electronic Configuration of Na^+

$[He]\ 2s^2, p^6$

(b) (i) The escaping tendency of A and B will be lower when compared with an ideal solution formed by A and B. Hence, the vapour pressure of such solutions will be lower than the sum of the vapour pressure of A and B. This type of deviation is called negative deviation. For the negative deviation $pA < p°A\ xA$ and $pB < p°B\ xB$.

(ii) Let us consider a solution of phenol and aniline. Both phenol and aniline form hydrogen bonding interactions amongst themselves. However, when mixed with aniline, the phenol molecule forms hydrogen bonding interactions with aniline, which are stronger than the hydrogen bonds formed amongst themselves. Formation of new hydrogen bonds considerably reduce the escaping tendency of phenol and aniline from the solution. As a result, the vapour pressure of the solution is less and there is a slight decrease in volume (ΔVmixing< 0) on mixing. During this process evolution of heat takes place (i.e.) ΔHmixing< 0 (exothermic)

Examples for non-ideal solutions showing negative deviation : Acetone + chloroform, Chloroform + diethyl ether, Acetone + aniline,Chloroform + Benzene.



Vapour pressure diagram showing negative deviation

Negative deviation from Raoult's law. The dotted line (-----) is ideal behavior and the solid lines (____) is actual behaviour

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PUBLIC EXAMINATION – MARCH 2019

CHEMISTRY

TIME ALLOWED : 2.30 HOURS **MARKS : 70**

PART - I

ANSWER ALL THE QUESTIONS: (15 × 1 = 15)

1. Many of the organic compounds are inflammable because of its :
(a) Vander Waal's force (b) Co-ordinate nature
(c) Covalent nature (d) Ionic nature

2. When Δn_g is negative in chemical equilibrium reaction then :
(a) $K_p < K_c$ (b) $K_p = 1/K_c$
(c) $K_p = K_c\,(RT)^{-ve}$ (d) $K_p > K_c$

3. $CaO + 3C \xrightarrow{3273\text{ K}} \underline{\;A\;} + CO$
(a) CaC_2 (b) CO_2
(c) Ca (d) Ca_2O

4. Splitting of spectral lines in an electric field is called :
(a) Compton effect (b) Stark effect
(c) Zeeman effect (d) Shielding effect

5. Which of the following species does not exert a resonance effect?
(a) $C_6H_5NH_2$ (b) $C_6H_5\overset{+}{N}H_3$
(c) C_6H_5OH (d) C_6H_5CI

6. Match the following :

	Compound		Uses
(1)	Chloro picrin	(i)	Detection of primary amine
(2)	Methyl Isocyanide	(ii)	DDT
(3)	Chloro benzene	(iii)	Paint remover
(4)	Methylene Chloride	(iv)	Soil sterilizer

(a) (1) – (iv), (2) – (iii), (3) – (ii), (4) – (i)
(b) (1) – (iii), (2) – (iv), (3) – (ii), (4) – (i)
(c) (1) – (i), (2) – (ii), (3) – (iv), (4) – (iii)
(d) (1) – (iv), (2) – (i), (3) – (ii), (4) – (iii)

7. Use of hot air balloon in meteorological observatory is an application of :
(a) Kelvin's Law (b) Brown's Law
(c) Boyle's Law (d) Newton's Law

8. What is pH of rain water ?
(a) 5.6 (b) 4.6
(c) 6.5 (d) 7.5

9. Which compound is named as "Blue John" among the following compounds ?
(a) $Ca_3(PO_4)_2$ (b) CaO
(c) CaH_2 (d) CaF_2

10. The element with positive electron gain enthalpy is :
(a) Argon (b) Fluorine
(c) Hydrogen (d) Sodium

11. Which of the following molecule does not contain π bond ?
(a) CO_2 (b) H_2O
(c) SO_2 (d) NO_2

12. Which of the following compound has same percentage of Carbon as that of ethylene (C_2H_4) ?
(a) benzene (b) ethane
(c) propene (d) ethyne

13. The SI unit of Molar heat capacity is :
(a) $JK^{-1}mol^{-1}$ (b) $kJ\ mol^{+1}$
(c) $kJ\ mol^{-1}$ (d) cm

14. What percentage of solution of H_2O_2 is called as "100–Volume" H_2O_2 ?
(a) 15% (b) 50%
(c) 20% (d) 30%

15. Osmotic pressure (π) of a solution is given by the relation :
(a) $\pi RT = n$ (b) $V = \pi nRT$
(c) $\pi = nRT$ (d) $\pi V = nRT$

PART - II

Answer any six of the following questions. Question No. 24 is compulsory. (6 × 2 = 12)

16. State and explain Pauli's Exclusion Principle.

17. Define – Valency.

18. What are ideal gases?

19. State the third law of Thermodynamics.

20. What is called Bond Length? Name the techniques through which the length of a bond can be determined.

21. Describe the reaction involved in the detection of Nitrogen in an organic compound by Lassaigne Method.

22. How is Alkane prepared from Grignard reagent?

23. Define – Acid rain.

24. Which is the suitable method for detection of Nitrogen present in food and fertilizers?

PART - III

Answer any six of the following questions. Question No. 33 is compulsory. (6 × 3 = 18)

25. Calculate the equivalent mass of H_2SO_4.

26. Explain diagonal relationship.

27. How is Tritium prepared?

28. Define – Le–Chatelier principle.

29. State the term "Isotonic solution".

30. Both C_2H_2 and CO_2 have the same structure. Explain why.

31. Write note on Williamson's Synthesis.

32. Explain why $Ca(OH)_2$ is used in white washing.

33. Give the structural formula for the following compounds.

(a) m – dinitrobenzene

(b) p – dichlorobenzene

(c) 1,3,5 Tri–methyl Benzene

PART - IV

Answer all five questions : (5 × 5 = 25)

34. (a) (i) Calculate oxidation number of oxygen in H_2O_2.

(ii) Write the de–Broglie eqution.

OR

(b) (i) State and explain Dobereiner's "Triad".

(ii) Complete the following equation

$Na_2O_2 + \underline{\quad ? \quad} \rightarrow Na_2SO_4 + H_2O_2$

35. (a) (i) Among the alkaline earth metals BeO is insoluble in water but other oxides are soluble. Why?

(ii) State Diffusion Law.

OR

(b) (i) Calculate the entropy change during the melting of one mole of ice into water at 0°C. Enthalpy of fusion of ice is 6008 J mol^{-1}.

(ii) Write the Balance chemical equation for the

$$Kc = \frac{[CaO_{(s)}]\,[CO_{2(g)}]}{[CaCO_{(s)}]}$$

36. (a) (i) NH_3 and HCl do not obey Henry's law. Why?

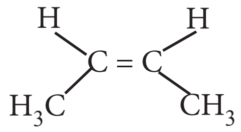
(ii) Write the structure of the following compounds.

(A) NH_3 (B) BF_3

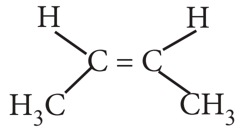
OR

(b) (i) Identify the cis and trans isomers for the following compounds.

(A)



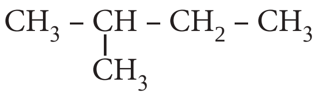
(B)



(ii) Explain with example the Positive Mesomeric Effect.

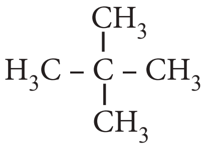
37. (a) (i) Write the IUPAC name for the following compound

(A)



$CH_3 - \underset{\underset{CH_3}{|}}{CH} - CH_2 - CH_3$

(B)



$H_3C - \overset{\overset{CH_3}{|}}{\underset{\underset{CH_3}{|}}{C}} - CH_3$

(ii) What are Nucleophiles and Electrophiles? Give one example each.

OR

(b) (i) How will you get the following products with the given reactants?

(A) Acetylene → Benzene
(B) Phenol → Benzene
(C) Benzene → Toluene

(ii) Write any two different components you get during fractional distillation of Coal Tar at any two different temperature.

38. (a) (i) A Compound having the empirical formula C_6H_6O has the vapour density 47. Find its Molecular formula.

(ii) The Simple Aromatic Hydrocarbon compound (A) reacts with Bromine to give (B). Compound (A) reacts with Raney Ni and gives (C). Identify (A), (B) and (C).

OR

(b) (i) $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$
Calculate the standard entropy change for the above reaction, given the standard entropies of $CO_{2(g)}$, $C_{(s)}$, $O_{2(g)}$ are 213.6, 5.740 and 205 JK^{-1} respectively.

(ii) Identify the compound (A) and (B)

$$R-C\equiv N \xrightarrow{H_2O/H^+} (A) \xrightarrow{H_2O/H^+} (B).$$

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ANSWERS

PART - I

1. (c) Covalent nature
2. (a) $K_p < K_c$
3. (a) CaC_2
4. (d) Shielding effect
5. (b) $C_6H_5NH_3$
6. (d) (1) – (iv), (2) – (i), (3) – (ii), (4) – (iii)
7. (c) Boyle's Law
8. (a) 5.6
9. (d) CaF_2
10. (a) Argon
11. (b) H_2O
12. (c) Propene
13. (a) $JK^{-1}mol^{-1}$
14. (d) 30%
15. (d) $\pi V = nRT$

PART - II

16. Pauli's exclusion principle states that "No two electrons in an atom can have the same set of values of all four quantum numbers. $H(Z = 1)\ 1s^{-1}$.
one electron is present in hydrogen atom, the four quantum numbers are: $n = 1$; $l = 0$; $m = 0$ and $s = +½$.
For helium Z = 2. He : $1s^2$
In this one electron has the quantum number. Same as that of hydrogen $n = 1$, $l = 0$, $m = 0$ and $s = –½$. For other quantum number is different i.e., $n = 1$, $l = 0$, $m = 0$ and $s = –½$.

17. Define valency of an element may be defined as the combining capacities of elements. The electrons present in the outermost shell are called valence electrons and these electrons determine the valency of the atom.

18. An ideal gas is defined as one in which all collisions between atoms or molecules are perfectly eleastic and in which there are no intermolecular attractive forces. An ideal gas is a gas that obeys the ideal gas law, PV = nRT, where n is the number of moles of the gas, R is the ideal gas constant,pressure P, volume V, and temperature T.

19. (i) The third law of thermodynamics states that **the entropy of pure crystalline substance at absolute zero is zero**.

(ii) It can also be stated as **it is impossible to lower the temperature of an object to absolute zero in a finite number of steps**.

(iii) Mathematically,
$\lim_{T\to 0} S = 0$ for a perfectly ordered crystalline state.

20. The distance between the nuclei of the two covalently bonded atoms is called bond length.
The length of a bond can be determined by spectroscopic, x-ray diffraction and electron-diffraction techniques

21. $$Na + \underbrace{C\ +\ N} \longrightarrow NaCN$$

from organic compounds

$$FeSO_4 + 2NaOH \longrightarrow Fe(OH)_2 + Na_2SO_4$$
(from excess of sodium)

$$6NaCN + Fe(OH)_2 \longrightarrow \underset{\text{Sod.ferrocyanide}}{Na_4[Fe(CN)_6]} + 2NaOH$$

$$3Na_4[Fe(CN)_6] + 4FeCl_3 \longrightarrow \underset{\substack{\text{ferric ferrocyanide Prussian} \\ \text{blue or green ppt}}}{Fe_4[Fe(CN)_6]_3} + 12NaCl$$

22. $CH_3MgI + HO - H \longrightarrow CH_4 + MgI(OH)$

(or)

$$CH_3MgI + \underset{\text{Ethyl alcohol}}{C_2H_5OH} \xrightarrow{\Delta} \underset{\text{methane}}{CH_4} + MgI(OC_2H_5)$$

23. Rain water normally has a pH of 5.6 due to dissolution of atmospheric CO_2 into it. Oxides of sulphur and nitrogen in the atmosphere may be absorbed by droplets of water that make up clouds and get chemically converted into sulphuric acid and nitric acid respectively as a results of pH of rain water drops to the level 5.6, hence it is called acid rain.

24. **Kjeldahls method :** This method is carried much more easily than the Dumas method. It is used largely in the analysis of foods and fertilizers. Kjeldahls method is based on the fact that when an organic compound containing nitrogen is heated with conc. H_2SO_4, the nitrogen in it is quantitatively converted to ammonium sulphate.

PART - III

25. H_2SO_4 basicity = $2eq\ mol^{-1}$

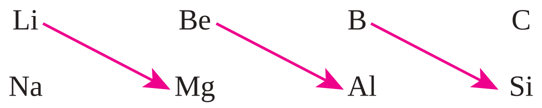
Molar mass of H_2SO_4 = $(2 \times 1) + (1 \times 32) + (4 \times 16)$

= $98\ g\ mol^{-1}$

Gram equivalent of H_2SO_4 = $\dfrac{98}{2}$

= $49\ g\ eq^{-1}$

26. On moving diagonally across the periodic table, the second and third period elements show certain similarities. It is quite pronounced in the following pair of elements.



The similarity in properties existing between the diagonally placed elements is called 'diagonal relationship'.

27. (i) By bombarding lithium with slow neutrons

(ii) ${}_3Li^6 + {}_0n^1 \longrightarrow {}_1T^3 + {}_2He^4$

28. It states that "If a system at equilibrium is disturbed, then the system shifts itself in a direction that nullfies the effect of that disturbance."

29. (i) Two solutions having same osmotic pressure at a given temperature are called isotonic solutions.

(ii) When such solutions are separated by a semipermeable membrane, solvent flow between one to the other on either direction is same, i.e. the net solvent flow between the two isotonic solutions is zero.

30.

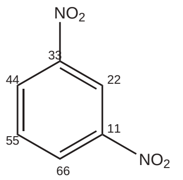
Molecule	concept	Geometry
C_2H_2	Hybridisation (sp)	Linear
CO_2	VSEPR (AB_2)	Linear

31. **Williamson's synthesis :** Halo alkanes when boiled with sodium alkoxide gives the corresponding other.

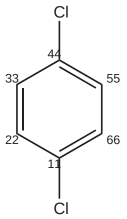
$$\underset{\substack{\text{Bromo}\\\text{ethane}}}{CH_3 - CH_2Br} + \underset{\substack{\text{Sodium}\\\text{ethoxide}}}{CH_3\ CH_2\ ONa} \longrightarrow \underset{\text{Diethyl ether}}{CH_3 - CH_2 - O - CH_2 - CH_3} + NaBr$$

32. White wash due to its disinfectant nature.

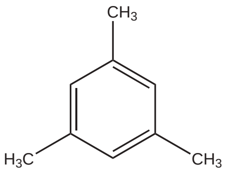
33.



1,3-dinitrobenzene
(i)



p-dichloro benzene
(ii)



1,3,5-trimethylbenzene
(iii)

PART - IV

34. a (i) hydrogen peroxide (H_2O_2)

$2 (+ 1) + 2x = 0; \Rightarrow 2x = -2 ; \Rightarrow x = -1$

(ii) ❑ de-Broglie combined the following two equations of energy of which one represents wave character (hυ) and the other represents the particle nature (mc^2).

(i) **Planck's quantum hypothesis :** $E = h\nu$

(ii) **Einsteins mass-energy relationship :**

$E = mc^2$

From (i) and (ii)

$h\nu = mc^2$

$hc/\lambda = mc^2$

$\lambda = h / mc$

- The equation represents the wavelength of photons whose momentum is given by mc (Photons have zero rest mass)
- For a particle of matter with mass m and moving with a velocity v, the equation can be written as

$$\lambda = h / mv$$

- This is valid only when the particle travels at speeds much less than the speed of light.

(or)

34. b (i) some elements such as chlorine, bromine and iodine with similar chemical properties into the group of three elements called as triads. In triads, the atomic weight of the middle element nearly equal to the arithmetic mean of the atomic weights of the remaining two elements. Any one example

S. No.	Elements in the Triad	Atomic weight of middle element	Average atomic weight of the remaining elements
1	Li, Na, K	23	$\frac{7+39}{2} = 23$
2	Cl, Br, I	80	$\frac{35.5+127}{2} = 81.25$
3	Ca, Sr, Ba	88	$\frac{40+137}{2} = 88.5$

(ii) $Na_2O_2 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O$

35. a (i) BeO is amphoteric, BeO oxide is covalent due to the small size of Be^{2+} ion. So BeO insoluble in water

(ii) When two non-reactive gases are allowed to mix, the gas molecules migrate from region of higher concentration to a region of lower concentration. This property of gas which involves the movement of the gas molecules through another gases is called diffusion.

(or)

b (i) $H_2O(S) \xrightarrow{273\text{ K}} H_2O(l)$

$$\Delta S_{fusion} = \frac{\Delta H_{fusion}}{T_f}$$

$$= \frac{6008}{273}$$

$$\Delta S_{fusion} = 22.007 \text{ J K}^{-1} \text{ mole}^{-1}$$

(ii) $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$

(or)

36. a (i)

(i) Henry's law is applicable at moderate temperature and pressure only.

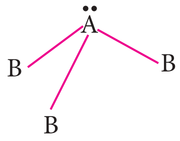
(ii) Only the less soluble gases obeys Henry's law

(iii) The gases reacting with the solvent do not obey Henry's law. For example, ammonia or HCl reacts with water and hence does not obey this law.

$$NH_3 + H_2O \rightleftharpoons NH^+_4 + OH^-$$

(iv) The gases obeying Henry's law should not associate or dissociate while dissolving in the solvent.

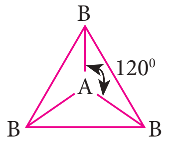
(ii) (a)



pyramidal

A= N atom; B= H atoms

(b)

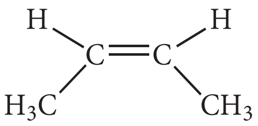


Trigonal planar

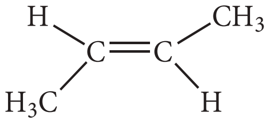
A= B atom; B= F atoms

(or)

b (i)



Cis -2-butene



Trans 2-butene

(ii) Positive resonance effect occurs, when the electrons move away from substituent attached to the conjugated system. It occurs, if the electron releasing substituents are attached to the conjugated system.

In such cases, the attached group has a tendency to release electrons through resonance. These electron releasing groups are usually denoted as +R or +M groups.

Examples : –OH, –SH, –OR, –SR, $–NH_2$, –O–

37. (a)

(i) **IUPAC names**

(a) 2- methylbutane

(b) 2,2-dimethylpropane

(ii) Nucleophiles are reagents that have high affinity for electro positive centers.

(any two examples)

Types	Examples	Electron rich site
Neutral molecules having unshared pair of electron	Ammonia (NH_3) and amines (RNH_2)	N:
	Water (H_2O), alcohols (ROH) and ethers (R-O-R)	:O:
	Hydrogen sulphide (H_2S) and thiols (RSH)	:S:
Negatively charged nucleophiles	Chlorides (Cl^-), bromides (Br^-) and iodides (I^-)	X^-
	Hydroxide (HO^-), alkoxide (RO^-) and Carboxlate ions ($RCOO^-$)	O^-
	Cyanide (CN^-)	N^-

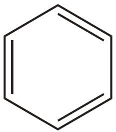
Electrophiles are reagents that are attracted towards negative charge or electron rich center. (any two examples)

Types	Examples	Electron rich site
Neutral electrophiles	Carbon dioxide (CO_2), dichlorocarbene ($:CCl_2$)	C
	Aluminium chloride ($AlCl_3$), boron trifluoride (BF_3) and ferric chloride ($FeCl_3$)	Metal (M)
Positively charged electrophiles	Carbocations (R^+)	C^+
	Proton (H^+)	H^+
	Alkyl halides (RX)	X^+
	Oxonium ion (H_3O^+) and nitrosonium ion (NO^+)	O^+
	Nitronium ion ($^+NO_2$)	N^+

(or)

(b) (i)

(a) $3\ CH\equiv CH \xrightarrow[873\ K]{\text{Red Hot Iron tube}}$



Benzene

(b) $C_6H_5OH + Zn \longrightarrow C_6H_6 + ZnO$

Phenol Benzene

(c) $C_6H_6 + CH_3Cl \xrightarrow{\text{anhydrous } AlCl_3}$

Benzene chloromethane

$C_6H_5CH_3 + HCl$

toluene

(ii)

Name of the Fraction	Temperature Range	Name of the Compenents
1. Crude light oil	350 - 443 K	Benzene, Toluene, Xylenes
2. Middle oil	443 - 503 K	Phenol, Naphthalene
3. Heavy oil	503 - 543 K	Naphthalene, Cresol
4. Green oil	543 - 633 K	Anthracene
5. Pitch	Alone 633 K	Residue

38. (a) (i)

Empirical Formula = C_6H_6O

$$n = \frac{\text{Molar mass}}{\text{Calculated empirical formula mass}}$$

$$= \frac{2 \times \text{vapour density}}{94} = \frac{2 \times 47}{94} = 1$$

molecular formula $(C_6H_6O) \times 1 = C_6H_6O$

(ii) $\underset{(A)}{C_6H_6} + Br_2 \xrightarrow{FeBr_3} \underset{(B)}{C_6H_5Br}$

$C_6H_6 + 3H_2 \xrightarrow{\text{Raney Ni}} C_6H_{12} + HBr$

A-Benzene; B-Bromo benzene; C-Cyclohexane

(or)

(b) (i)

$$C(g) + O_2(g) \longrightarrow CO_2(g)$$

$$\Delta S_r^0 = \sum S^0_{\text{products}} - \sum S^0_{\text{reactants}}$$

$$\Delta S_r^0 = \left\{S^0_{CO_2}\right\} - \left\{S^0_C + S^0_{O_2}\right\}$$

$$\Delta S_r^0 = 213.6 - [5.74 + 205]$$

$$\Delta S_r^0 = 213.6 - [210.74]$$

$$\Delta S_r^0 = 2.86\ JK^{-1}$$

(ii)

$$R - C \equiv \xrightarrow{H_2O/H^+} \underset{(A)}{RCONH_2} \xrightarrow{H_2O/H^+} \underset{(B)}{RCOOH}$$

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NOTES