

Our victory is not in the last step actually it starts from our first step



11th std Chemistry Bestie

With additional question & answers



Dr.R.Karthic M.Sc., B.Ed., M.A(Edu)., M.Phil., Ph.D.

PG Assistant in chemistry

Government Higher Secondary School - Vallipattu

INDEX

S. No	LESSON	Page No
1	Basic Concepts of Chemistry and Chemical Calculation	1
2	Quantum Mechanical Model of Atom	10
3	Periodic Classification of Elements	17
4	Hydrogen	24
5	Alkali and Alkaline Earth Metals	31
6	Gaseous State	36
7	Thermodynamics	45
8	Physical and Chemical Equilibrium	52
9	Solutions	59
10	Chemical Bonding	65
11	Fundamentals of Organic Chemistry	76
12	Basic Concepts of Organic Reactions	91
13	Hydrocarbons	100
14	Haloalkanes and Haloarenes	111
15	Environmental Chemistry	123

தெய்வத்தான் ஆகா தெனினும் முயற்சிதன்
மெய்வருத்தக் கூலி தரும் - திருக்குறள்
Even if God has given up, perseverance will pay
the wages for one's efforts.

1. BASIC CONCEPTS OF CHEMISTRY AND CHEMICAL CALCULATION

1	Define relative atomic mass. $\text{Relative atomic mass} = \frac{\text{Average mass of the atom}}{\text{Unified atomic mass}}$																	
2	What do you understand by the term mole. (Jun-19, Jun-23) One mole is the amount of substance of a system, which contains as many elementary particles as there are atoms in 12 g of carbon-12 isotope. The elementary particles can be molecules, atoms, ions, electrons or any other specified particles.																	
3	Define equivalent mass. (May-22, Mar-24) Gram equivalent mass is defined as the mass of an element (compound or ion) that combines or displaces 1.008 g hydrogen or 8 g oxygen or 35.5 g chlorine.																	
4	What do you understand by the term 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																	
5	Distinguish between Oxidation and Reduction. (Mar-23) <table><tr><td></td><td>Oxidation</td><td>Reduction</td></tr><tr><td>1</td><td>Addition of oxygen</td><td>Addition of hydrogen</td></tr><tr><td>2</td><td>Removal of hydrogen</td><td>Removal of oxygen</td></tr><tr><td>3</td><td>Reaction in which oxidation number of the element increases</td><td>Reaction in which oxidation number of the element decreases</td></tr><tr><td>4</td><td>Loss of electron</td><td>Gain of electron</td></tr></table>				Oxidation	Reduction	1	Addition of oxygen	Addition of hydrogen	2	Removal of hydrogen	Removal of oxygen	3	Reaction in which oxidation number of the element increases	Reaction in which oxidation number of the element decreases	4	Loss of electron	Gain of electron
	Oxidation	Reduction																
1	Addition of oxygen	Addition of hydrogen																
2	Removal of hydrogen	Removal of oxygen																
3	Reaction in which oxidation number of the element increases	Reaction in which oxidation number of the element decreases																
4	Loss of electron	Gain of electron																
6	Calculate the molar mass of the following compounds. <table><tr><td>i) Urea [CO(NH₂)₂] N = 2 X 14 = 28 H = 4 X 1 = 4 C = 1 X 12 = 12 O = 1 X 16 = 16 <u>60</u> molar mass = 60 g mol⁻¹.</td><td>ii) Acetone [CH₃COCH₃] C = 3 X 12 = 36 H = 6 X 1 = 6 O = 1 X 16 = 16 <u>58</u> molar mass = 58 g mol⁻¹.</td></tr><tr><td>iii) Boric acid [H₃BO₃] B = 1 X 11 = 11 H = 3 X 1 = 3 O = 3 X 16 = 48 <u>62</u> molar mass = 62 g mol⁻¹.</td><td>iv) Sulphuric acid [H₂SO₄] S = 1 X 32 = 32 H = 2 X 1 = 2 O = 4 X 16 = 64 <u>98</u> molar mass = 98 g mol⁻¹.</td></tr></table>			i) Urea [CO(NH₂)₂] N = 2 X 14 = 28 H = 4 X 1 = 4 C = 1 X 12 = 12 O = 1 X 16 = 16 <u>60</u> molar mass = 60 g mol ⁻¹ .	ii) Acetone [CH₃COCH₃] C = 3 X 12 = 36 H = 6 X 1 = 6 O = 1 X 16 = 16 <u>58</u> molar mass = 58 g mol ⁻¹ .	iii) Boric acid [H₃BO₃] B = 1 X 11 = 11 H = 3 X 1 = 3 O = 3 X 16 = 48 <u>62</u> molar mass = 62 g mol ⁻¹ .	iv) Sulphuric acid [H₂SO₄] S = 1 X 32 = 32 H = 2 X 1 = 2 O = 4 X 16 = 64 <u>98</u> molar mass = 98 g mol ⁻¹ .											
i) Urea [CO(NH₂)₂] N = 2 X 14 = 28 H = 4 X 1 = 4 C = 1 X 12 = 12 O = 1 X 16 = 16 <u>60</u> molar mass = 60 g mol ⁻¹ .	ii) Acetone [CH₃COCH₃] C = 3 X 12 = 36 H = 6 X 1 = 6 O = 1 X 16 = 16 <u>58</u> molar mass = 58 g mol ⁻¹ .																	
iii) Boric acid [H₃BO₃] B = 1 X 11 = 11 H = 3 X 1 = 3 O = 3 X 16 = 48 <u>62</u> molar mass = 62 g mol ⁻¹ .	iv) Sulphuric acid [H₂SO₄] S = 1 X 32 = 32 H = 2 X 1 = 2 O = 4 X 16 = 64 <u>98</u> molar mass = 98 g mol ⁻¹ .																	
7	The density of carbon dioxide is equal to 1.965 kgm⁻³ at 273 K and 1 atm pressure. Calculate the molar mass of CO₂. At 273 K and 1 atm pressure, 1 mole of CO ₂ occupies a volume of 22.4L $\text{Mass of 1 mole of CO}_2 = \frac{1.965\text{Kg}}{1\text{m}^3} \times 22.4 \text{ L} = \frac{1.965 \times 10^3\text{g} \times 22.4 \times 10^{-3} \text{ m}^3}{1\text{m}^3} = 44.01 \text{ g mol}^{-1}.$ Molar mass of CO ₂ = 44.01 g mol ⁻¹ .																	
8	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 H₂O <table><tr><td>Compound</td><td>Given number of atoms</td><td>Number of oxygen atoms</td></tr><tr><td>Ethanol - C₂H₅OH</td><td>1</td><td>1 X 6.022 X 10²³</td></tr><tr><td>Formic acid - HCOOH</td><td>1</td><td>1 X 6.022 X 10²³</td></tr><tr><td>Water – H₂O</td><td>1</td><td>1 X 6.022 X 10²³</td></tr></table>			Compound	Given number of atoms	Number of oxygen atoms	Ethanol - C ₂ H ₅ OH	1	1 X 6.022 X 10 ²³	Formic acid - HCOOH	1	1 X 6.022 X 10 ²³	Water – H ₂ O	1	1 X 6.022 X 10 ²³			
Compound	Given number of atoms	Number of oxygen atoms																
Ethanol - C ₂ H ₅ OH	1	1 X 6.022 X 10 ²³																
Formic acid - HCOOH	1	1 X 6.022 X 10 ²³																
Water – H ₂ O	1	1 X 6.022 X 10 ²³																

9	Calculate the average atomic mass of naturally occurring magnesium using the following data																																																				
<table><tr><th>Isotope</th><th colspan="3">Isotopic atomic mass</th><th colspan="3">Abundance (%)</th></tr><tr><td>Mg²⁴</td><td colspan="3">23.99</td><td colspan="3">78.99</td></tr><tr><td>Mg²⁵</td><td colspan="3">24.99</td><td colspan="3">10.00</td></tr><tr><td>Mg²⁶</td><td colspan="3">25.98</td><td colspan="3">11.01</td></tr></table>								Isotope	Isotopic atomic mass			Abundance (%)			Mg ²⁴	23.99			78.99			Mg ²⁵	24.99			10.00			Mg ²⁶	25.98			11.01																				
Isotope	Isotopic atomic mass			Abundance (%)																																																	
Mg ²⁴	23.99			78.99																																																	
Mg ²⁵	24.99			10.00																																																	
Mg ²⁶	25.98			11.01																																																	
Average atomic mass = $\frac{((78.99 \times 23.99)+(10 \times 24.99)+(11.01 \times 25.98))}{100} = \frac{2430.9}{100} = 24.31u$																																																					
10	In a reaction $x + y + z_2 \rightarrow xyz_2$ 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																																																				
<table><tr><th rowspan="2"></th><th colspan="3">Number of moles of reactants allowed to react</th><th colspan="3">Number of moles of reactance consumed during reaction</th><th rowspan="2">Limiting reagent</th></tr><tr><th>x</th><th>y</th><th>Z_2</th><th>x</th><th>y</th><th>Z_2</th></tr><tr><td>a)</td><td>200 atoms</td><td>200 atoms</td><td>50 molecules</td><td>50 atoms</td><td>50 atoms</td><td>50 molecules</td><td>Z_2</td></tr><tr><td>b)</td><td>1 mole</td><td>1 mole</td><td>3 mole</td><td>1 mole</td><td>1 mole</td><td>1 mole</td><td>x and y</td></tr><tr><td>c)</td><td>50 atoms</td><td>25 atoms</td><td>50 molecules</td><td>25 atoms</td><td>25 atoms</td><td>25 molecules</td><td>y</td></tr><tr><td>d)</td><td>2.5 mole</td><td>5 mole</td><td>5 mole</td><td>2.5 mole</td><td>2.5 mole</td><td>2.5 mole</td><td>x</td></tr></table>									Number of moles of reactants allowed to react			Number of moles of reactance 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 mole	1 mole	3 mole	1 mole	1 mole	1 mole	x and y	c)	50 atoms	25 atoms	50 molecules	25 atoms	25 atoms	25 molecules	y	d)	2.5 mole	5 mole	5 mole	2.5 mole	2.5 mole	2.5 mole	x
	Number of moles of reactants allowed to react			Number of moles of reactance 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 mole	1 mole	3 mole	1 mole	1 mole	1 mole	x and y																																														
c)	50 atoms	25 atoms	50 molecules	25 atoms	25 atoms	25 molecules	y																																														
d)	2.5 mole	5 mole	5 mole	2.5 mole	2.5 mole	2.5 mole	x																																														
11	Mass of one atom of an element is 6.645×10^{-23} g. How many moles of element are there in 0.320 kg. Mass of one atom = 6.645×10^{-23} g Mass of one mole of atom = 6.645×10^{-23} g $\times 6.022 \times 10^{23}$ = 40 g Number of moles of element in 0.320 kg = $\frac{1 \text{ mole}}{40 \text{ g}} \times 0.320 \text{ kg} = \frac{1 \text{ mole}}{40 \text{ g}} \times 320 \text{ g} = 8 \text{ mole}.$																																																				
12	What is the difference between molecular mass and molar mass? Calculate the molecular mass and molar mass for carbon monoxide.																																																				
<table><tr><th></th><th>Molecular mass</th><th>Molar mass</th></tr><tr><td>1</td><td>It is the ratio of the mass of a molecule to the unified atomic mass unit.</td><td>The mass of one mole of a substance</td></tr><tr><td>2</td><td>The relative molecular mass of any compound can be calculated by adding the relative atomic masses of its constituent atoms.</td><td>The molar mass of a compound is equal to the sum of the relative atomic masses of its constituents</td></tr><tr><td>3</td><td>It is expressed in amu (or) u.</td><td>It is expressed in g mol^{-1}.</td></tr><tr><td>4</td><td>Molecular mass of CO = 12+16 = 28u.</td><td>Molar mass of CO = 12+16 = 28 g mol^{-1}.</td></tr></table>									Molecular mass	Molar mass	1	It is the ratio of the mass of a molecule to the unified atomic mass unit.	The mass of one mole of a substance	2	The relative molecular mass of any compound can be 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	3	It is expressed in amu (or) u.	It is expressed in g mol^{-1} .	4	Molecular mass of CO = 12+16 = 28u.	Molar mass of CO = 12+16 = 28 g mol^{-1} .																															
	Molecular mass	Molar mass																																																			
1	It is the ratio of the mass of a molecule to the unified atomic mass unit.	The mass of one mole of a substance																																																			
2	The relative molecular mass of any compound can be 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																																																			
3	It is expressed in amu (or) u.	It is expressed in g mol^{-1} .																																																			
4	Molecular mass of CO = 12+16 = 28u.	Molar mass of CO = 12+16 = 28 g mol^{-1} .																																																			
13	What is the empirical formula of the following? (Sep-21) i) Fructose ($\text{C}_6\text{H}_{12}\text{O}_6$) found in honey ii) Caffeine ($\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2$) a substance found in tea and coffee.																																																				
<table><tr><th>Compound</th><th>Molecular formula</th><th>Empirical formula</th></tr><tr><td>fructose</td><td>$\text{C}_6\text{H}_{12}\text{O}_6$</td><td>$\text{CH}_2\text{O}$</td></tr><tr><td>Caffein</td><td>$\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2$</td><td>$\text{C}_4\text{H}_5\text{N}_2\text{O}$</td></tr></table>								Compound	Molecular formula	Empirical formula	fructose	$\text{C}_6\text{H}_{12}\text{O}_6$	CH_2O	Caffein	$\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2$	$\text{C}_4\text{H}_5\text{N}_2\text{O}$																																					
Compound	Molecular formula	Empirical formula																																																			
fructose	$\text{C}_6\text{H}_{12}\text{O}_6$	CH_2O																																																			
Caffein	$\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2$	$\text{C}_4\text{H}_5\text{N}_2\text{O}$																																																			

14	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) $2\text{Al} + \text{Fe}_2\text{O}_3 \rightarrow \text{Al}_2\text{O}_3 + 2\text{Fe}$; 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? <table><tr><th rowspan="2"></th><th colspan="2">Reagents</th><th colspan="2">Products</th></tr><tr><th>Al</th><th>Fe_2O_3</th><th>Al_2O_3</th><th>Fe</th></tr><tr><td>amount of reactant allowed to react</td><td>324 g</td><td>1.12 kg</td><td>-</td><td>-</td></tr><tr><td>number of moles allowed to react</td><td>$\frac{324}{27} = 12\text{mol}$</td><td>$\frac{1.12 \times 10^3}{160} = 7\text{mol}$</td><td>-</td><td>-</td></tr><tr><td>stock your metric coefficient</td><td>2</td><td>1</td><td>1</td><td>2</td></tr><tr><td>number of moles consumed during reaction</td><td>12 mol</td><td>6 mol</td><td>-</td><td>-</td></tr><tr><td>number of moles of reactant unreacted and number of moles of product formed</td><td>-</td><td>1 mol</td><td>6 mol</td><td>12 mol</td></tr></table> Molar mass of Al_2O_3 formed $\text{Al}_2\text{O}_3 = (2 \times 27) + (3 \times 16) = 54 + 48 = 102$ = 6 mol X 102 g mol⁻¹ = 612 g Excess reagent left at the end of the reaction = Fe_2O_3 The excess amount of reagent left at the end of the reaction = 1 mol x 160 g mol⁻¹ = 160 g [$\text{Fe}_2\text{O}_3 = (2 \times 56) + (3 \times 16) = 112 + 48 = 160$]		Reagents		Products		Al	Fe_2O_3	Al_2O_3	Fe	amount of reactant allowed to react	324 g	1.12 kg	-	-	number of moles allowed to react	$\frac{324}{27} = 12\text{mol}$	$\frac{1.12 \times 10^3}{160} = 7\text{mol}$	-	-	stock your metric coefficient	2	1	1	2	number of moles consumed during reaction	12 mol	6 mol	-	-	number of moles of reactant unreacted and number of moles of product formed	-	1 mol	6 mol	12 mol
	Reagents		Products																																
	Al	Fe_2O_3	Al_2O_3	Fe																															
amount of reactant allowed to react	324 g	1.12 kg	-	-																															
number of moles allowed to react	$\frac{324}{27} = 12\text{mol}$	$\frac{1.12 \times 10^3}{160} = 7\text{mol}$	-	-																															
stock your metric coefficient	2	1	1	2																															
number of moles consumed during reaction	12 mol	6 mol	-	-																															
number of moles of reactant unreacted and number of moles of product formed	-	1 mol	6 mol	12 mol																															
15	How many moles of ethane is required to produce 44 g of CO_2 (g) after combustion. $\text{C}_2\text{H}_6 + \frac{7}{2} \text{O}_2 \longrightarrow 2\text{CO}_2 + 3\text{H}_2\text{O}$ To produce 2 moles of CO_2, 1 mole of ethane is required ∴ To produce 1 mole (44g) of CO_2, required number of moles of ethane = $\frac{1 \text{ mole ethane} \times 1 \text{ mole } \text{CO}_2}{2 \text{ mole } \text{CO}_2}$ = $\frac{1}{2}$ mole of ethane = 0.5 mole of ethane																																		
16	Hydrogen peroxide is an oxidising agent. It oxidises ferrous ion to ferric ion and reduced itself to water. Write a balanced equation. $\overset{-1}{\text{H}_2\text{O}_2} + \overset{-2}{\text{Fe}^{+2}} \longrightarrow \overset{-2}{\text{Fe}^{+3}} + \text{H}_2\text{O}$ $\begin{array}{c} \uparrow \qquad \downarrow \\ (1e^- \times 2) \quad 1e^- \end{array}$ $\text{H}_2\text{O}_2 + 2\text{Fe}^{+2} \longrightarrow \text{Fe}^{+3} + 2\text{H}_2\text{O}$ $\text{H}_2\text{O}_2 + 2\text{Fe}^{+2} + 2\text{H}^+ \longrightarrow \text{Fe}^{+3} + 2\text{H}_2\text{O}$																																		

- 17 Calculate the empirical and molecular formula of a compound containing 76.6% carbon, 6.38 % hydrogen and rest oxygen. (Jul-22) Its vapour density is 47. (Sep-20)

Element	Percentage	Atomic mass	Relative number of moles	simple ratio	whole number
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

Emperical formula = C₆H₆O (Mar-19)

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

$$= \frac{2 \times \text{vapour density}}{94} = \frac{2 \times 47}{94} = 1.$$

Molecular formula (C₆H₆O) × 1 = C₆H₆O

- 18 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). (Mar-23)

Element	Percentage	Atomic mass	Relative number of moles	simple ratio	whole number
Na	14.31	23	$\frac{14.31}{23} = 0.62$	$\frac{0.62}{0.31} = 2$	2
S	9.97	32	$\frac{9.97}{32} = 0.31$	$\frac{0.31}{0.31} = 1$	1
H	6.22	1	$\frac{6.22}{1} = 6.22$	$\frac{6.22}{0.31} = 20$	20
O	69.5	16	$\frac{69.5}{16} = 4.34$	$\frac{4.34}{0.31} = 14$	14

Emperical formula = Na₂SH₂₀O₁₄

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

$$= \frac{322}{322} = 1.$$

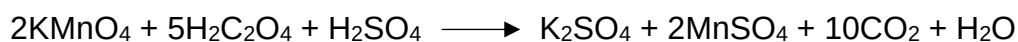
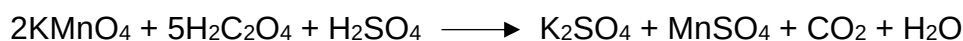
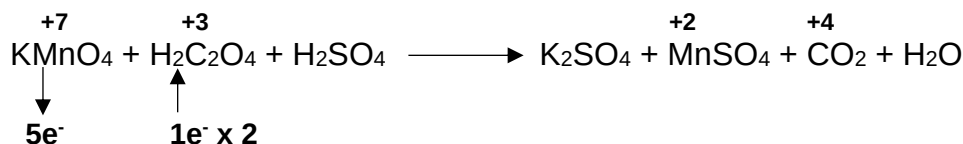
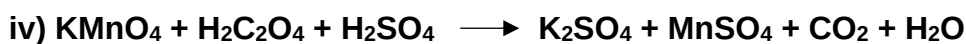
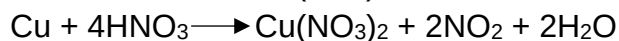
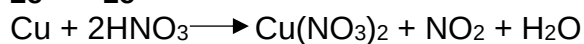
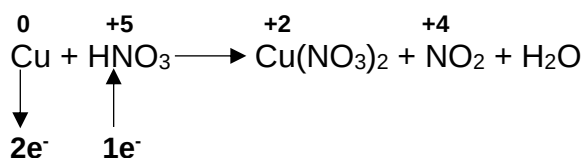
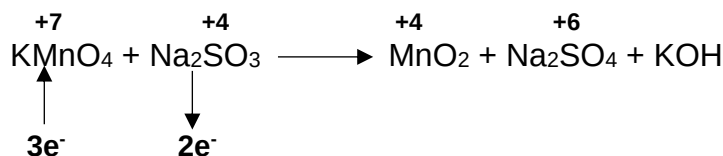
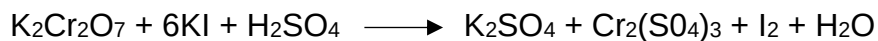
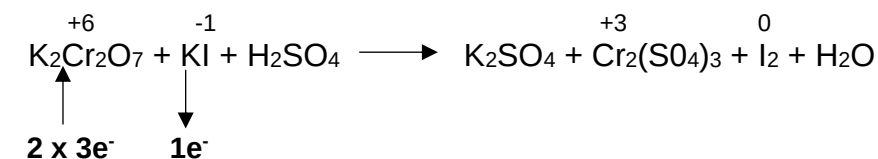
$$\text{Na}_2\text{SH}_{20}\text{O}_{14} = (2 \times 23) + (1 \times 32) + (20 \times 1) + (14 \times 16)$$

$$= 46 + 32 + 20 + 224 = 322$$

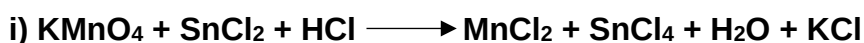
Molecular formula= Na₂SH₂₀O₁₄

All the hydrogen in the compound present as water, molecular formula is = Na₂SO₄ . 10H₂O.

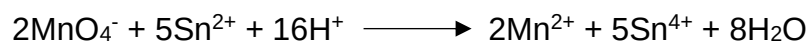
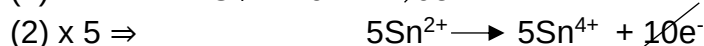
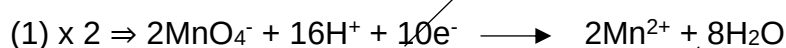
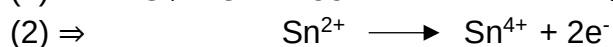
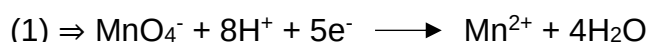
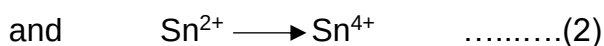
19 **Balance the following equations by oxidation number method**



20 **Balance the following equations by ion electron method.**



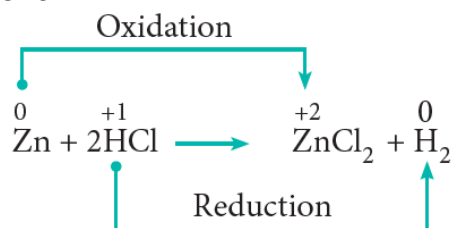
Half reaction:



	ii) $\text{C}_2\text{O}_4^{2-} + \text{Cr}_2\text{O}_7^{2-} \longrightarrow \text{Cr}^{3+} + \text{CO}_2$ (in acid medium) Half reaction: $\overset{+3}{\text{C}_2\text{O}_4^{2-}} \longrightarrow \overset{+4}{\text{CO}_2} \quad \dots\dots\dots(1)$ and $\overset{+6}{\text{Cr}_2\text{O}_7^{2-}} \longrightarrow \text{Cr}^{3+} \quad \dots\dots\dots(2)$ $(1) \Rightarrow \text{C}_2\text{O}_4^{2-} \longrightarrow 2 \text{CO}_2 + 2\text{e}^- \quad \dots\dots\dots(3)$ $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ \longrightarrow 2 \text{Cr}^{3+} + 7\text{H}_2\text{O} \quad \dots\dots\dots(4)$ $(3) \times 3 \Rightarrow \begin{array}{l} 3\text{C}_2\text{O}_4^{2-} \longrightarrow 6\text{CO}_2 + 6\text{e}^- \\ \text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \longrightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} \\ \hline \text{Cr}_2\text{O}_7^{2-} + 3\text{C}_2\text{O}_4^{2-} + 14\text{H}^+ \longrightarrow 2\text{Cr}^{3+} + 6\text{CO}_2 + 7\text{H}_2\text{O} \end{array}$ iii) $\text{Na}_2\text{S}_2\text{O}_3 + \text{I}_2 \longrightarrow \text{Na}_2\text{S}_4\text{O}_6 + \text{NaI}$ Half reaction: $\text{S}_2\text{O}_3^{2-} \longrightarrow \text{S}_4\text{O}_6^{2-} \quad \dots\dots\dots(1)$ and $\text{I}_2 \longrightarrow \text{I}^- \quad \dots\dots\dots(2)$ $(1) \Rightarrow 2\text{S}_2\text{O}_3^{2-} \longrightarrow \text{S}_4\text{O}_6^{2-} + 2\text{e}^-$ $(2) \Rightarrow \text{I}_2 + 2\text{e}^- \longrightarrow 2\text{I}^-$ $\hline 2\text{S}_2\text{O}_3^{2-} + \text{I}_2 \longrightarrow \text{S}_4\text{O}_6^{2-} + 2\text{I}^-$ iv) $\text{Zn} + \text{NO}_3^- \longrightarrow \text{Zn}^{2+} + \text{NO}$ (in acid medium) Half reaction: $\overset{0}{\text{Zn}} \longrightarrow \text{Zn}^{2+} \quad \dots\dots\dots(1)$ and $\overset{+6}{\text{NO}_3^-} \longrightarrow \text{NO} \quad \dots\dots\dots(2)$ $(1) \Rightarrow \text{Zn} \longrightarrow \text{Zn}^{2+} + 2\text{e}^- \quad \dots\dots\dots(3)$ $(2) \Rightarrow \text{NO}_3^- + 3\text{e}^- + 4\text{H}^+ \longrightarrow \text{NO} + 2\text{H}_2\text{O} \quad \dots\dots\dots(4)$ $(3) \times 3 \Rightarrow 3\text{Zn} \longrightarrow 3\text{Zn}^{2+} + 6\text{e}^-$ $(4) \times 2 \Rightarrow \begin{array}{l} 2\text{NO}_3^- + 6\text{e}^- + 8\text{H}^+ \longrightarrow 2\text{NO} + 4\text{H}_2\text{O} \\ \hline 3\text{Zn} + 2\text{NO}_3^- + 8\text{H}^+ \longrightarrow 3\text{Zn}^{2+} + 2\text{NO} + 4\text{H}_2\text{O} \end{array}$
21	Define unified atomic mass? The C-12 atom is considered as standard by the IUPAC and its mass is fixed as 12 amu (or) u. The amu (or) unified atomic mass unit is defined as one twelfth of the mass of a Carbon-12 atom in its ground state. (1 amu (or) 1 u= 1.6605x10⁻²⁷ kg)
22	Define Avogadro Number? The total number of entities present in one mole of any substance is equal to 6.022 x 10²³. This number is called Avogadro number
23	Define 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.
24	Define limiting reagent? (Jul-22) 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. The other reagents which are in excess are called the excess reagents.

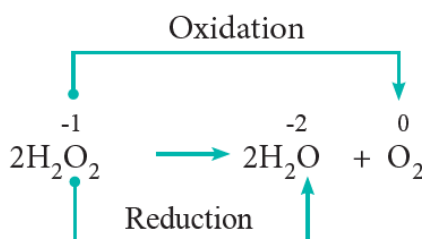
25	Write the equations for calculating equivalent mass of acids, bases, oxidizing and reducing agents? Equivalent mass of acid = $\frac{\text{Molar mass of the acid}}{\text{Basicity of the acid}}$ Equivalent mass of base = $\frac{\text{Molar mass of the base}}{\text{Acidity of the base}}$ Equivalent mass of oxidising agent = $\frac{\text{Molar mass of the oxidising agent}}{\text{No.of moles of electrons gained by one mole of the oxidising agent}}$ Equal and mass of reducing agent = $\frac{\text{Molar mass of the reducing agent}}{\text{No.of moles of electrons lost by one mole of the reducing agent}}$
26	Explain the types of redox reactions? 1. Combination reactions: Redox reactions in which two substances combine to form a single compound are called combination reaction. $\begin{array}{ccc} \text{oxidation} & & \\ \downarrow & & \downarrow \\ 0 & & +4 \\ \text{C} + \text{O}_2 & \xrightarrow{\quad} & \text{CO}_2 \\ \uparrow & & \uparrow \\ & \text{Reduction} & \\ 0 & & -2 \end{array}$ 2. Decomposition reactions: Redox reactions in which a compound breaks down into two or more components are called decomposition reactions. In these reactions, the oxidation number of the different elements in the same substance is changed. $\begin{array}{ccc} \text{Oxidation} & & \\ \downarrow & & \downarrow \\ -2 & & 0 \\ 2\text{KClO}_3 & \xrightarrow{\Delta} & 2\text{KCl} + 3\text{O}_2 \\ \uparrow & & \uparrow \\ +5 & & -1 \\ & \text{Reduction} & \end{array}$ 3. 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. They are further classified into two types. (i) Metal displacement reactions: $\begin{array}{ccc} \text{Oxidation} & & \\ \downarrow & & \downarrow \\ 0 & & +2 \\ \text{CuSO}_4(\text{aq}) + \text{Zn}(\text{s}) & \xrightarrow{\quad} & \text{Cu}(\text{s}) + \text{ZnSO}_4(\text{aq}) \\ \uparrow & & \uparrow \\ +2 & & 0 \\ & \text{Reduction} & \end{array}$

ii) Non-metal displacement



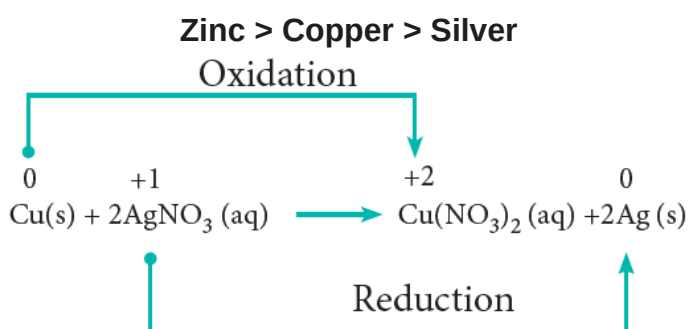
4. Disproportionation reaction (Auto redox reactions) (Jun-19)

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.



5. Competitive electron transfer reaction

These reactions explain the electron releasing and gaining behavior between metals. Among the three metals, namely, zinc, copper and silver, the electron releasing tendency is in the following order.



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

Element	Percentage	Atomic Mass	Relative no. of moles	Simplest ratio	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 CH₂O

28	Calculate the oxidation number of underlined elements		
i)	<u>C</u> O ₂	$x + 2(-2) = 0 \quad ; \quad x - 4 = 0 \quad ; x = +4$	
ii)	K ₂ <u>Cr</u> ₂ O ₇	$2(+1) + 2x + 7(-2) = 0 \quad ; \quad 2 + 2x - 14 = 0 \quad ; \quad 2x - 12 = 0 \quad ; \quad 2x = 12 \quad ; \quad x = \frac{12}{2} \quad ; \quad x = 6$	
iii)	K <u>Mn</u> O ₄	$1 + x + 4(-2) = 0 \quad ; \quad 1 + x - 8 = 0 \quad ; \quad x - 7 = 0 \quad ; \quad x = +7$	
iv)	H ₂ <u>S</u> O ₄	$2(+1) + x + 4(-2) = 0 \quad ; \quad 2 + x - 8 = 0 \quad ; \quad x - 6 = 0 \quad ; \quad x = +6$	
v)	<u>S</u> ₂ O ₇ ²⁻	$2x + 7(-2) = -2 \quad ; \quad 2x - 14 = -2 \quad ; \quad 2x = 14 - 2 \quad ; \quad 2x = 12 \quad ; \quad x = \frac{12}{2} \quad ; \quad x = 6$	
vi)	H ₂ <u>O</u> ₂ (Jun-23)	$2(+1) + 2x = 0 \quad ; \quad 2 + 2x = 0 \quad ; \quad 2x = -2 \quad ; \quad x = \frac{-2}{2} \quad ; \quad x = -1$	

29	Calculate the equivalent mass of					
i) Acids (Eg – H₂SO₄) (Mar-19)						
H ₂ SO ₄ basicity = 2 eq mol ⁻¹						
Molar mass of H ₂ SO ₄ = (2 × 1) + (1 × 32) + (4 × 16) = 98 g mol ⁻¹						
Equivalent mass = $\frac{\text{Molar mass of the acid}}{\text{Basicity of the acid}} = \frac{98}{2} = 49 \text{ g eq}^{-1}$						
ii) Bases (Eg – KOH)						
KOH acidity = 1 eq mol ⁻¹						
Molar mass of KOH = (1 × 39) + (1 × 16) + (1 × 1) = 56 g mol ⁻¹						
Equivalent mass = $\frac{\text{Molar mass of the base}}{\text{Acidity of the Base}} = \frac{56}{1} = 56 \text{ g eq}^{-1}$						
iii) Oxidizing or Reducing agent (Eg – KMnO₄)						
KMnO ₄ is an oxidising agent						
Molar mass of KMnO ₄ = (1 × 39) + (1 × 55) + (4 × 16) = 158 g mol ⁻¹						
In acid medium permanganate is reduced during oxidation and is given by the following equation,						
$\text{.MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \longrightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$						
$\therefore n = 5 \text{ eq mol}^{-1}.$						
Equivalent mass = $\frac{\text{Molar mass of the oxidising (or) reducing agent}}{\text{No.of moles of electrons gained or lost by one mole of the oxidising (or) reducing agent}} = \frac{158}{5} = 31.6 \text{ g eq}^{-1}$						

2. QUANTUM MECHANICAL MODEL OF ATOM

1	Which quantum number reveal information about the shape, energy, orientation and size of orbitals? 1. Principal quantum number - Size and shape 2. Azimuthal Quantum number - Energy 3. Magnetic quantum number - Orientation																									
2	How many orbitals are possible for n =4? 4s, 4p, 4d and 4f orbitals = 1 + 3 + 5 + 7 = 16 orbitals																									
3	How many radial nodes for 2s, 4p, 5d and 4f orbitals exhibit? How many angular nodes? <table border="1"><thead><tr><th>orbitals</th><th>n</th><th><i>l</i></th><th>radial nodes $n - l - 1$</th><th>angular nodes <i>l</i></th></tr></thead><tbody><tr><td>2s</td><td>2</td><td>0</td><td>1</td><td>0</td></tr><tr><td>4p</td><td>4</td><td>1</td><td>2</td><td>1</td></tr><tr><td>5d</td><td>5</td><td>2</td><td>2</td><td>2</td></tr><tr><td>4f</td><td>4</td><td>3</td><td>0</td><td>3</td></tr></tbody></table>	orbitals	n	<i>l</i>	radial nodes $n - l - 1$	angular nodes <i>l</i>	2s	2	0	1	0	4p	4	1	2	1	5d	5	2	2	2	4f	4	3	0	3
orbitals	n	<i>l</i>	radial nodes $n - l - 1$	angular nodes <i>l</i>																						
2s	2	0	1	0																						
4p	4	1	2	1																						
5d	5	2	2	2																						
4f	4	3	0	3																						
4	The stabilisation of a half-filled d - orbital is more pronounced than that of the p-orbital why? The half field orbitals are more stable due to symmetry and exchange energy. when a greater number of exchanges are possible, more exchange energy is released and more stable half-filled d orbitals - 10 possible exchanges. half-filled p orbitals - 3 possible exchanges.																									
5	Consider the following electronic arrangements for the d⁵ configuration. <table border="1"><tr><td>↑↓</td><td>↑↓</td><td>↑</td><td></td><td></td></tr></table> (a) <table border="1"><tr><td>↑</td><td>↑</td><td>↑</td><td>↑↓</td><td></td></tr></table> (b) <table border="1"><tr><td>↑</td><td>↑</td><td>↑</td><td>↑</td><td>↑</td></tr></table> (c) (i) which of these represents the ground state	↑↓	↑↓	↑			↑	↑	↑	↑↓		↑	↑	↑	↑	↑										
↑↓	↑↓	↑																								
↑	↑	↑	↑↓																							
↑	↑	↑	↑	↑																						

10	Explain briefly the time independent schrodinger wave equation? Erwin Schrödinger expressed the wave nature of electron in terms of a differential equation. This equation determines the change of wave function in space depending on the field of force in which the electron moves. The time independent Schrödinger equation can be expressed as, $\hat{H}\Psi = E\Psi$ Where $\hat{H}$ is called Hamiltonian operator, Ψ is the wave function and is a function of position co-ordinates of the particle and is denoted as $\Psi(x,y,z)$ E is the energy of the system $\hat{H} = \left[\frac{-h^2}{8\pi^2m} \left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2} \right) + V \right]$ (2.12) can be written as, $\left[\frac{-h^2}{8\pi^2m} \left(\frac{\partial^2 \Psi}{\partial x^2} + \frac{\partial^2 \Psi}{\partial y^2} + \frac{\partial^2 \Psi}{\partial z^2} \right) + V\Psi \right] = E\Psi$ Multiply by $-\frac{8\pi^2m}{h^2}$ and rearranging $\frac{\partial^2 \Psi}{\partial x^2} + \frac{\partial^2 \Psi}{\partial y^2} + \frac{\partial^2 \Psi}{\partial z^2} + \frac{8\pi^2m}{h^2}(E - V)\Psi = 0$ The above schrodinger wave equation does not contain time as a variable and is referred to as time independent Schrödinger wave equation.																								
11	Determine the values of all the four quantum numbers of the 8th electron in O- atom and 15th electron in Cl atom. i) 8 electron of oxygen atom is present in 2px orbital $1s^2$ 1↓ $2s^2$ 1↓ $2p_x^2 \ 2p_y^1 \ 2p_z^1$ 1↓ 1 1 <table><tr><th>Electron</th><th>n</th><th>l</th><th>m</th><th>s</th></tr><tr><td>2p⁴ th</td><td>2</td><td>1</td><td>+1 or -1</td><td>-1/2</td></tr><tr><td>3p³ th</td><td>3</td><td>1</td><td>+1 or -1</td><td>+1/2</td></tr></table> ii) 15th electron of chlorine atom is present in 3p_z orbital $1s^2$ 1↓ $2s^2$ 1↓ $2p^6$ 1↓ 1↓ 1↓ $3s^2$ 1↓ $3p_x^2 \ 3p_y^2 \ 3p_z^1$ 1↓ 1↓ 1	Electron	n	l	m	s	2p ⁴ th	2	1	+1 or -1	-1/2	3p ³ th	3	1	+1 or -1	+1/2									
Electron	n	l	m	s																					
2p ⁴ th	2	1	+1 or -1	-1/2																					
3p ³ th	3	1	+1 or -1	+1/2																					
12	How fast must a 54g tennis ball travel in order to have a de Broglie wavelength that is equal to that of a photon of green light 5400 Å? $\lambda = 5400 \text{ Å} = 5400 \times 10^{-10} \text{ m} \quad ; \quad m = 54\text{g} = 54 \times 10^{-3} \text{ Kg} \quad ; \quad V = ?$ $\lambda = \frac{h}{mV} \quad ; \quad V = \frac{h}{m\lambda} = \frac{6.626 \times 10^{-34} \text{ Kg m}^2 \text{ s}^{-1}}{54 \times 10^{-3} \text{ Kg} \times 5400 \times 10^{-10} \text{ m}} \quad ; \quad \boxed{V = 2.27 \times 10^{-26} \text{ ms}^{-1}}$																								
13	For each of the following, give the sub level designation, the allowable m values and the number of orbitals i) $n = 4, l = 2$, ii) $n = 5, l = 3$ iii) $n = 7, l = 0$ <table><tr><th></th><th>n</th><th>l</th><th>sub level</th><th>m values</th><th>number of orbitals</th></tr><tr><td>i)</td><td>4</td><td>2</td><td>4d</td><td>-2, -1, 0, +1, +2</td><td>5</td></tr><tr><td>ii)</td><td>5</td><td>3</td><td>5f</td><td>-3, -2, -1, 0, +1, +2, +3</td><td>7</td></tr><tr><td>iii)</td><td>7</td><td>0</td><td>7s</td><td>0</td><td>1</td></tr></table>		n	l	sub level	m values	number of orbitals	i)	4	2	4d	-2, -1, 0, +1, +2	5	ii)	5	3	5f	-3, -2, -1, 0, +1, +2, +3	7	iii)	7	0	7s	0	1
	n	l	sub level	m values	number of orbitals																				
i)	4	2	4d	-2, -1, 0, +1, +2	5																				
ii)	5	3	5f	-3, -2, -1, 0, +1, +2, +3	7																				
iii)	7	0	7s	0	1																				

14	An atom of an element contains 35 electrons and 45 neutrons. Deduce i) the number of protons ii) the electronic configuration for the element iii) All the four quantum numbers for the last electron An atom of an element has 35 electrons and 45 neutrons contains, i) the number of protons = 35 ii) the electronic configuration for the element = $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$ iii) All the 4 quantum numbers for the last electron are <table border="1" style="display: inline-table; vertical-align: middle;"><tr><td>1↓</td><td>1↓</td><td>1</td></tr></table> $4p_x^2 \ 4p_y^2 \ 4p_z^1$ $n = 4; \quad l = 1; \quad m = +1 \text{ (or) } -1; \quad s = -1/2$	1↓	1↓	1
1↓	1↓	1		
15	Calculate the energy required for the process. $\text{He}^+_{(g)} \rightarrow \text{He}^{2+}_{(g)} + e^-$. The ionisation energy for the H atom in its ground state is $-13.6 \text{ eV atom}^{-1}$. $\text{He}^+_{(g)} \longrightarrow \text{He}^+_{(g)} + e^- \quad E = ?$ $E_n = -\frac{13.6 Z^2}{n^2}$ $E_1 = -\frac{13.6 \times (2)^2}{1^2} = -56.4 \text{ eV} \quad (\because \text{Atomic number of He } Z = 2)$ $E_\infty = -\frac{13.6 \times (2)^2}{\infty^2} = 0 \text{ eV}$ The energy required for the process = $E_\infty - E_1 = 0 - (-56.4) = 56.4 \text{ eV}$.			
16	Show that the circumference of the Bohr orbit for the hydrogen atom is an integral multiple of the de Broglie wave length associated with the electron revolving around the nucleus. According to the de Broglie concept, the electron that revolves around the nucleus exhibits both particle and wave character. In order for the electron wave to exist in phase, the circumference of the orbit should be an integral multiple of the wavelength of the electron wave. Otherwise, the electron wave is out of phase. Circumference of the orbit $= n\lambda$ $2\pi r = n\lambda$ Here, $\lambda = \frac{h}{mv}$ $2\pi r = \frac{nh}{mv}$ $mvr = \frac{nh}{2\pi}$ Angular momentum $= \frac{nh}{2\pi}$ The above equation was already predicted by Bohr. Hence, De Broglie and Bohr's concepts are in agreement with each other.			
17	Give the electronic configuration of Mn^{2+} and Cr^{3+} The electronic configuration of Mn^{2+} and Cr^{3+} were, $_{25}\text{Mn}^{2+} (23 \text{ e}^- \text{s}) : 1s^2 2s^2 2p^6 3s^2 3p^6 4s^0 3d^5$ $_{24}\text{Cr}^{3+} (21 \text{ e}^- \text{s}) : 1s^2 2s^2 2p^6 3s^2 3p^6 4s^0 3d^3$			

18	An ion with mass number 37 possesses unit negative charge. If the ion contains 11.1% more neutrons than electrons. Find the symbol of the ion. Given: An ion with mass number 37 is $^{37}_Z\text{X}^-$ If No. of electrons = x Then No. of protons = x – 1 No. of neutrons = 11.1% more neutrons than electrons = x + 11.1% x $= x + \frac{11.1}{100} x = 1.11 x$ $\Rightarrow (x - 1) + 1.11 x = 37$ $2.11 x - 1 = 37 \Rightarrow 2.11 x = 37 + 1$ $2.11 x = 38$ $x = \frac{38}{2.11} = 18$ $\therefore \text{Atomic number } Z = \text{No. of protons}$$= x - 1$$= 18 - 1 = 17$ So, the symbol of the ion = $^{37}_{17}\text{Cl}^-$ ஆகும்.																																								
19	The Li^{2+} ion is a hydrogen like ion that can be described by the Bohr model. Calculate the Bohr radius of the third orbit and calculate the energy of an electron in 4th orbit. $r_n = \frac{0.529n^2}{Z} \text{ \AA} \quad ; \quad E_n = -\frac{13.6 Z^2}{n^2} \text{ eV atom}^{-1}$ Atomic number of Li^{2+} ion = 3; No. of electrons = 1 i) Bohr radius of the third orbit $r_3 = \frac{0.529(3)^2}{3} = 1.587 \text{ \AA}$ ii) Energy of an electron in 4th orbit $E_4 = -\frac{13.6 (3)^2}{4^2} = -7.65 \text{ eV atom}^{-1}$																																								
20	Identify the missing quantum numbers and the sub energy level <table><tr><th>n</th><th>l</th><th>m</th><th>Sub energy level</th></tr><tr><td>?</td><td>?</td><td>0</td><td>4d</td></tr><tr><td>3</td><td>1</td><td>0</td><td>?</td></tr><tr><td>?</td><td>?</td><td>?</td><td>5p</td></tr><tr><td>?</td><td>?</td><td>-2</td><td>3d</td></tr></table> Ans: <table><tr><th>n</th><th>l</th><th>m</th><th>Sub energy level</th></tr><tr><td>4</td><td>2</td><td>0</td><td>4d</td></tr><tr><td>3</td><td>1</td><td>0</td><td>3p</td></tr><tr><td>5</td><td>1</td><td>0 (or) +1 (or) -1</td><td>5p</td></tr><tr><td>3</td><td>2</td><td>-2</td><td>3d</td></tr></table>	n	l	m	Sub energy level	?	?	0	4d	3	1	0	?	?	?	?	5p	?	?	-2	3d	n	l	m	Sub energy level	4	2	0	4d	3	1	0	3p	5	1	0 (or) +1 (or) -1	5p	3	2	-2	3d
n	l	m	Sub energy level																																						
?	?	0	4d																																						
3	1	0	?																																						
?	?	?	5p																																						
?	?	-2	3d																																						
n	l	m	Sub energy level																																						
4	2	0	4d																																						
3	1	0	3p																																						
5	1	0 (or) +1 (or) -1	5p																																						
3	2	-2	3d																																						
21	Calculate the total number of angular nodes and radial nodes present in 3d and 4f orbitals? (Sep-20) <table><tr><th>Orbitals</th><th>n</th><th>l</th><th>Radial nodes (n – l – 1)</th><th>Angular nodes l</th><th>Total nodes (n – 1)</th></tr><tr><td>3d</td><td>3</td><td>2</td><td>0</td><td>2</td><td>2</td></tr><tr><td>4f</td><td>4</td><td>3</td><td>0</td><td>3</td><td>3</td></tr></table>	Orbitals	n	l	Radial nodes (n – l – 1)	Angular nodes l	Total nodes (n – 1)	3d	3	2	0	2	2	4f	4	3	0	3	3																						
Orbitals	n	l	Radial nodes (n – l – 1)	Angular nodes l	Total nodes (n – 1)																																				
3d	3	2	0	2	2																																				
4f	4	3	0	3	3																																				
22	Energy of an electron in ground state of hydrogen atom is -13.6eV What is the energy of this electron in the second excited state? $E_n = -\frac{13.6 Z^2}{n^2} \text{ eV atom}^{-1}$ For first excited state n = 2. so, for second excited state n = 3 $\therefore E_3 = -\frac{13.6 (1)^2}{3^2} = -1.51 \text{ eV atom}^{-1}$																																								

23	Write the assumptions of Bohr's atomic model? 1. The energies of electrons in an atom are quantised. 2. The electron is revolving around the nucleus in a certain circular path of fixed energy called stationary orbit. 3. Electron can revolve only in those orbits in which the angular momentum (mvr) of the electron must be equal to an integral multiple of $h/2\pi$. i.e. $mvr = nh/2\pi$ where $n = 1, 2, 3... \text{ etc.,}$ 4. 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 $\nu = \frac{E_2 - E_1}{h}$ Energy of an electron $E_n = \frac{-13.6 Z^2}{n^2} \text{ eV atom}^{-1}$ (or) $E_n = \frac{-1312.8 Z^2}{n^2} \text{ KJmol}^{-1}$ Radius of an atom $r_n = \frac{(0.529)n^2}{Z} \text{ \AA}$
24	Write two limitation of Bohr's atom model? 1. The Bohr's atom model is applicable only to species having one electron such as hydrogen, Li^{2+} etc... and not applicable to multi electron atoms. 2. It was unable to explain the splitting of spectral lines in the presence of magnetic field (Zeeman effect) or an electric field (Stark effect).
25	Derive de Broglie equation? (Mar-19) Planck's quantum hypothesis: $E = h\nu$ (particle nature)(1) Einstein's mass-energy relationship $E = mc^2$ (wave nature).....(2) From eqn (1) and (2), $h\nu = mc^2$ $\therefore \nu = \frac{c}{\lambda}$ $h \frac{c}{\lambda} = mc^2$ $\lambda = \frac{h}{mc}$ For a particle of matter with mass m and moving with a velocity v, the above equation can be written as, $\lambda = \frac{h}{mv}$
26	State Heisenberg uncertainty principle? (Sep-20, Jul-22, Mar-23) It is impossible to accurately determine both the position and the momentum of a microscopic particle simultaneously. $\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$ where, Δx and Δp are uncertainties in determining the position and momentum, respectively.

27	Write the main features of the quantum mechanical model of an atom? 1. The energy of electrons in atoms is quantised 2. The solutions of Schrödinger wave equation gives the allowed energy levels (orbits). 3. Orbital is a three-dimensional space in which the probability of finding the electron is maximum. 4. The solution of Schrödinger wave equation for the allowed energies of an atom gives the wave function ψ, which represents an atomic orbital. The wave nature of electron present in an orbital can be well defined by the wave function ψ. 5. The wave function ψ itself has no physical meaning. However, the probability of finding the electron in a small volume $dx dy dz$ around a point (x,y,z) is proportional to $\psi(x,y,z) ^2 dx dy dz$. $\psi(x,y,z) ^2$ is known as probability density and is always positive.
28	Explain (n+l) rule? • Other than hydrogen atom the relative order of energies of various orbitals is given approximately by the (n+ l) rule. • It states that, the lower the value of (n + l) for an orbital, the lower is its energy. If two orbitals have the same value of (n + l), the orbital with lower value of n will have the lower energy.
29	Define Exchange energy? (Sep-21) If two or more electrons with the same spin are present in degenerate orbitals, there is a possibility for exchanging their positions. During exchange process the energy is released and the released energy is called exchange energy.
30	Explain the experiment confirms the wave nature of an electron? (Davison and Germer experiment) • The wave nature of electron was experimentally confirmed by Davisson and Germer. • They allowed the accelerated beam of electrons to fall on a nickel crystal and recorded the diffraction pattern. The resultant diffraction pattern is similar to the x-ray diffraction pattern.
31	Define radial node? Give examples. • The region where this probability density function reduces to zero is called nodal surface or a radial node. • it has been found that ns-orbital has (n–1) nodes. In other words, number of radial nodes for 2s orbital is one, for 3s orbital it is two and so on.
32	What is effective nuclear charge? • In a multi-electron atom, in addition to the electrostatic attractive force between the electron and nucleus, there exists a repulsive force among the electrons. These two forces are operating in the opposite direction. • This results in the decrease in the nuclear force of attraction on electron. The net charge experienced by the electron is called effective nuclear charge.
33	Write a short note on Quantum numbers? The electron in an atom can be characterised by a set of four quantum numbers, namely principal quantum number (n), azimuthal quantum number (l), magnetic quantum number (m) and spin quantum number (s).

Principal quantum number (n) (Sep-21, Mar-23):

- This quantum number represents the energy level in which electron revolves around the nucleus and is denoted by the symbol 'n'.
- The 'n' can have the values 1, 2, 3,... n=1 represents K shell; n=2 represents L shell and n = 3, 4, 5 represent the M, N, O shells, respectively.
- The maximum number of electrons that can be accommodated in a given shell is $2n^2$.
- 'n' gives the energy of the electron, $E_n = \frac{(-1312.8)Z^2}{n^2}$ KJ mol⁻¹ and the distance of the electron from the nucleus is given by $r_n = \frac{(0.529)n^2}{Z}$ Å°

Azimuthal Quantum number (l) or subsidiary quantum number (Jun-23):

- It is represented by the letter 'l', and can take integral values from zero to n-1, where n is the principal quantum number
- Each l value represents a subshell (orbital). l = 0, 1, 2, 3 and 4 represents the s, p, d, f and g orbitals respectively.
- The maximum number of electrons in a given subshell (orbital) is $2(2l + 1)$.
- It is used to calculate the orbital angular momentum using the expression, Angular momentum = $\sqrt{l(l+1)} \frac{h}{2\pi}$

Magnetic quantum number (m_l) (Jul-22, Jun-23):

- It is denoted by the letter 'm_l'. It takes integral values ranging from -l to +l through 0. i.e. if l=1; m = -1, 0 and +1
- Different values of m for a given l value, represent different orientation of orbitals in space.
- The Zeeman Effect (the splitting of spectral lines in a magnetic field justifies this quantum number.
- The magnitude of the angular momentum is determined by the quantum number l while its direction is given by magnetic quantum number.

Spin quantum number (m_s) (Mar-24):

- It represents the spin of the electron and is denoted by the letter 'm_s'
- The electron in an atom revolves not only around the nucleus but also spins in its own axis either in a clockwise direction or in anti-clockwise direction.
- Corresponding to the clockwise and anti-clockwise spinning of the electron, maximum two values are possible for this quantum number.
- The values of 'm_s' is equal to +½ and -½

3. PERIODIC CLASSIFICATION OF ELEMENTS

1	Define modern periodic law. (Mar-23) Modern periodic law states that, “the physical and chemical properties of the elements are periodic functions of their atomic numbers.”
2	What are isoelectronic ions? Give examples. Ions of different elements having the same number of electrons are called isoelectronic ions. Eg: Na^+, Mg^{2+}, Al^{3+}, F^-, O^{2-} (all having 10 electrons)
3	What is effective nuclear charge? The net nuclear charge experienced by valence electrons in the outermost shell is called the effective nuclear charge. $Z_{\text{eff}} = Z - S$ Where Z is the atomic number and 'S' is the screening constant.
4	Is the definition given below for ionisation enthalpy is correct? "Ionisation enthalpy is defined as the energy required to remove the most loosely bound electron from the valence shell of an atom" The above definition for ionisation enthalpy is correct. Ionisation enthalpy is defined as “the minimum amount of energy required to remove the most loosely bound electron from the valence shell of the isolated neutral gaseous atom in its ground state”.
5	Magnesium loses electrons successively to form Mg^+, Mg^{2+} and Mg^{3+} ions. Which step will have the highest ionisation energy and why? $\text{Mg} + \text{IE}_1 \longrightarrow \text{Mg}^+ + \text{e}^- \text{ step: 1}$ $\text{Mg}^+ + \text{IE}_2 \longrightarrow \text{Mg}^{2+} + \text{e}^- \text{ step: 2}$ $\text{Mg}^{2+} + \text{IE}_3 \longrightarrow \text{Mg}^{3+} + \text{e}^- \text{ step: 3}$ The formation of the Mg^{+3} ion from Mg^{+2} ion requires more ionization energy because, • Mg^{+2} has stable noble gas configurations of 2,8 electrons • Since the valence orbital is completely filled it requires more energy to remove an electron. • Mg^{+2} ion has more effective nuclear charge.
6	Define electronegativity. (Sep-21, Mar-24) It is defined as the relative tendency of an element present in a covalently bonded molecule, to attract the shared pair of electrons towards itself.
7	How would you explain the fact that the second ionisation potential is always higher than first ionisation potential? (Jun-23) The total number of electrons are less in the cation than the neutral atom while the nuclear charge remains the same. Therefore, the effective nuclear charge of the cation is higher than the corresponding neutral atom. Thus, the successive ionisation energies, always increase in the following order $\text{IE}_1 < \text{IE}_2 < \text{IE}_3 \dots\dots\dots$
8	The electronic configuration of atom is one of the important factors which affects the value of ionisation potential and electron gain enthalpy. Explain Ionisation potential: • Since the half-filled or completely filled electronic configuration is more stable than partially filled orbitals. • Due to this type of stable electronic configuration, it requires higher energy to remove an electron from the orbital.

15	Mention any two anomalous properties of second period elements. - Lithium and beryllium form more covalent compounds, unlike the alkali and alkaline earth metals which predominantly form ionic compounds. - The elements of the second period have only four orbitals (2s & 2p) in the valence shell and have a maximum co-valence of 4, whereas the other members of the subsequent periods have more orbitals in their valence shell and shows higher valences. For example, boron forms BF_4^- and aluminium forms AlF_6^{3-}
16	Explain the periodic trend of ionisation potential. (Mar-24) Periodic Trends in Ionisation Energy: - The ionisation energy usually increases along a period with few exceptions. - when we move from left to right along a period, the valence electrons are added to the same shell, at the same time protons are added to the nucleus. - This successive increase of nuclear charge increases the electrostatic attractive force on the valence electron - Thus, more energy is required to remove the valence electron resulting in high ionisation energy. Periodic variation in group: - The ionisation energy decreases down a group. - As we move down a group, the valence electron occupies new shells. - The distance between the nucleus and the valence electron increases. - So, the nuclear forces of attraction on valence electron decreases - Hence ionisation energy also decreases down a group.
17	Explain the diagonal relationship. - On moving diagonally across the periodic table, the second and third period elements show certain similarities. - Even though the similarity is not same as we see in a group, it is quite pronounced in the following pair of elements. <pre> Li Be B C \ / / \ Na Mg Al Si </pre> - The similarity in properties existing between the diagonally placed elements is called 'diagonal relationship'.
18	Why the first ionisation enthalpy of sodium is lower than that of magnesium while its second ionisation enthalpy is higher than that of magnesium? - Electronic configuration of sodium $_{11}\text{Na} = 1s^2 2s^2 2p^6 3s^1$ - Electronic configuration of magnesium $_{12}\text{Mg} = 1s^2 2s^2 2p^6 3s^2$ 3s orbital of magnesium is completely filled. Hence, it is difficult to remove an electron from it. But, 3s orbital of sodium is partially filled. Hence an electron can be easily be removed from its orbital. - Therefore, the first ionization potential of sodium is lower than that of magnesium. - It is difficult to remove the second electron from sodium, due to the stability of the completely filled 2p orbital. Therefore, the second ionization energy of sodium is higher than that of magnesium.
19	Define valency? The valence of an atom is the combining capacity relative to hydrogen atom. It is usually equal to the total number of electrons in the valence shell or equal to eight minus the number of valence electrons.

20	Explain the following, give appropriate reasons. (i) Ionisation potential of N is greater than that of O - Electronic configuration of nitrogen: ${}_{7}\text{N} = 1s^2 2s^2 2p^3$ - Electronic configuration of oxygen: ${}_{8}\text{O} = 1s^2 2s^2 2p^4$ - Nitrogen has half filled 2p orbital which is more stable than partially filled valence shell electronic configuration of oxygen. - so, the ionization potential of nitrogen is greater than that of oxygen (ii) First ionisation potential of C-atom is greater than that of B atom, whereas the reverse is true is for second ionisation potential. - Electronic configuration of boron: ${}_{5}\text{B} = 1s^2 2s^2 2p^1$ - Electronic configuration of carbon: ${}_{6}\text{C} = 1s^2 2s^2 2p^2$ - The first ionization potential of carbon is higher because the nuclear charge of carbon is higher than that of boron and carbon is smaller in size than boron. - Boron loses an electron $1s^2 2s^2$ so, its secondary ionization energy is higher than that of carbon due to its fully-filled electron configuration (iii) The electron affinity values of Be and Mg are almost zero and those of N (0.02 eV) and P (0.80 eV) are very low. - Electronic configuration of beryllium: ${}_{4}\text{Be} = 1s^2 2s^2$ - Electronic configuration of magnesium: ${}_{12}\text{Mg} = 1s^2 2s^2 2p^6 3s^2$ - Beryllium and magnesium have completely filled stable electronic configuration. Hence, addition of further electron is unfavourable and has zero electron affinity. - Electronic configuration of nitrogen: ${}_{7}\text{N} = 1s^2 2s^2 2p^3$ - Electronic configuration of phosphorus: ${}_{15}\text{P} = 1s^2 2s^2 2p^6 3s^2 3p^3$ - Nitrogen and phosphorus have half-filled stable electronic configuration and the addition of further electron is unfavourable and has very low electron affinity. (iv) The formation of $\text{F}^{-}(\text{g})$ from $\text{F}(\text{g})$ is exothermic while that of $\text{O}^{2-}(\text{g})$ from $\text{O}(\text{g})$ is endothermic. - F is highly electronegative. Hence, it accepts an electron and has a stable electron configuration and becomes ionized F^{-}. - The heat is released during the above process. therefore, the formation of $\text{F}^{-}(\text{g})$ from $\text{F}(\text{g})$ is exothermic. - The reaction that adds an electron to oxygen is exothermic. But when a second electron is added, an electron-electron repulsion force occurs. - To accomplish this, an electron enters the orbital by absorbing heat from outside. - Therefore, the formation of $\text{O}^{2-}(\text{g})$ from $\text{O}(\text{g})$ is an endothermic reaction.
21	What is screening effect? - In addition to the electrostatic forces of attraction between the nucleus and the electrons, there exists repulsive forces among the electrons. - The repulsive force between the inner shell electrons and the valence electrons leads to a decrease in the electrostatic attractive forces acting on the valence electrons by the nucleus. - Thus, the inner shell electrons act as a shield between the nucleus and the valence electrons. This effect is called shielding effect.

22	What is the fundamental difference in approach between Mendeleev's periodic table and modern periodic table? Mendeleev arranged the elements in ascending order of their atomic masses, but Henry Moseley arranged the elements in ascending order of atomic number in the modern periodic table.
23	Briefly give the basis for Pauling's scale of electronegativity. - Pauling assigned arbitrary value of electronegativities for hydrogen and fluorine as 2.1 and 4.0 respectively. - Based on this the electronegativity values for other elements can be calculated using the following expression $(X_A - X_B) = 0.182 \sqrt{(E_{AB} - (E_{AA} \times E_{BB})^{\frac{1}{2}})}$ Where E_{AB}, E_{AA} and E_{BB} are the bond dissociation energies (Kcal) of AB, A_2 and B_2 molecules respectively. - The electronegativity of any given element is not a constant and its value depends on the element to which it is covalently bound.
24	State the trends in the variation of electronegativity in group and periods. (Sep-21, Jul-22) Variation of Electronegativity in a period: - The electronegativity generally increases across a period from left to right. - The atomic radius decreases in a period, as the attraction between the valence electron and the nucleus increases. - Hence the tendency to attract shared pair of electrons increases. - Therefore, electronegativity also increases in a period Variation of Electronegativity in a group: - The electronegativity generally decreases down a group. - As we move down a group the atomic radius increases and the nuclear attractive force on the valence electron decreases. Hence, the electronegativity decreases.
25	Define Electron Affinity? (May-22) It is defined as the amount of energy released, when an electron is added to the valence shell of an isolated neutral gaseous atom in its ground state to form its anion. It is expressed in kJ mol^{-1}.
26	Define law of octaves? J. Newland made an attempt to classify the elements and proposed the law of octaves. On arranging the elements in the increasing order of atomic weights, he observed that the properties of every eighth element are similar to the properties of the first element. This law holds good for lighter elements up to calcium.
27	Explain the anomalies of Mendeleev's periodic table? - Some elements with similar properties were placed in different groups and those with dissimilar properties were placed in same group. - Similarly, elements with higher atomic weights were placed before lower atomic weights based on their properties in contradiction to his periodic law.
28	Why do inert gases not react chemically? Inert gases do not gain or lose electrons because they have a completely filled electron configuration.
29	Define covalent bond? It is one-half of the internuclear distance between two identical atoms linked together by a single covalent bond.

30 Explain the nomenclature of elements with atomic number greater than 100?

Digit	0	1	2	3	4	5	6	7	8	9
Root	nil	un	bi	tri	quad	pent	hex	sept	oct	enn
Abbreviation	n	u	b	t	q	p	h	s	o	e

1. The numerical roots corresponding to the atomic number are put together and 'ium' is added as suffix
2. The final 'n' of 'enn' is omitted when it is written before 'nil' (enn + nil = enil) similarly the final 'i' of 'bi' and 'tri' is omitted when it is written before 'ium' (bi + ium = bium; tri + ium = trium)
3. The symbol of the new element is derived from the first letter of the numerical roots.

Atomic number	Temporary Name	Temporary Symbol	Name of the element	Symbol
101	Unnilunium	Unu	Mendelevium	Md
102	Unnilbium	Unb	Nobelium	No
103	Unniltrium	Unt	Lawrencium	Lr
104	Unnilquadium	Unq	Rutherfordium	Rf
105	Unnilpentium	Unp	Dubnium	Db
106	Unnilhexium	Unh	Seaborgium	Sg
107	Unnilseptium	Uns	Bohrium	Bh
108	Unniloctium	Uno	Hassium	Hs

31 Oxygen and fluorine have lower electron affinity values than sulphur and chlorine respectively. Why?

- They are smaller in size and have higher electron density.
- An extra electron added to oxygen and chlorine goes to 2p orbital.
- This 2p orbital has a close structure compared to the 3p orbital of sulphur and chlorine.
- Hence, oxygen and fluorine have a lower electron affinity value than sulfur and chlorine which present next to them in their group.

32 Differentiate electronegativity and electron affinity?

	Electronegativity	Electron affinity
1	The tendency of an element present in a covalently bonded molecule, to attract the shared pair of electrons towards itself	The amount of energy released, when an electron is added to the valence shell of an isolated neutral gaseous atom in its ground state to form its anion
2	It is not a measurable quantity. However, a number of scales are available to calculate its value.	It will be calculated by experiments.
3	No unit.	Unit: eV / atom, KJ / mol or Kcal / mol
4	Not having a constant value.	The electron affinity of an element does not change.
5	varies steadily in periods and does not vary smoothly in groups.	Does not vary smoothly in periods and groups.

33	Why the covalent radius is always shorter than the atomic radius? The formation of covalent bond involves the overlapping of atomic orbitals and it reduces the expected internuclear distance. Therefore, covalent radius is always shorter than the actual atomic radius.																																										
34	Using Slater's rule calculate the effective nuclear charge on a 3p electron in aluminium and chlorine. Explain how these results relate to the atomic radii of the two atoms? <table><tr><td> Atomic number of Aluminium Z = 13 Electronic configuration of Aluminium = $1s^2 \quad 2s^2 2p^6 \quad 3s^2 3p^1$ others (n - 1) n <table><tr><th>Electron Group</th><th>No. of electrons</th><th>Contribution of each electron</th><th>Electron contribution of particular group</th></tr><tr><td>n</td><td>2</td><td>0.35</td><td>0.70</td></tr><tr><td>n - 1</td><td>8</td><td>0.85</td><td>6.80</td></tr><tr><td>others</td><td>2</td><td>1.00</td><td>2.00</td></tr><tr><td colspan="3">S value</td><td>9.50</td></tr></table> Effective nuclear charge = Z - S (Z_{eff})_{Al} = 13 - 9.5 = 3.5 </td><td> Atomic number of chlorine Z = 17 Electronic configuration of chlorine = $1s^2 \quad 2s^2 2p^6 \quad 3s^2 3p^5$ others (n - 1) n <table><tr><th>Electron Group</th><th>No. of electrons</th><th>Contribution of each electron</th><th>Electron contribution of particular group</th></tr><tr><td>n</td><td>6</td><td>0.35</td><td>2.10</td></tr><tr><td>n - 1</td><td>8</td><td>0.85</td><td>6.80</td></tr><tr><td>others</td><td>2</td><td>1.00</td><td>2.00</td></tr><tr><td colspan="3">S value</td><td>10.90</td></tr></table> Effective nuclear charge = Z - S (Z_{eff})_{Cl} = 17 - 10.90 = 6.10 </td></tr></table> $\therefore (Z_{\text{eff}})_{\text{Cl}} > (Z_{\text{eff}})_{\text{Al}} \quad \text{SO} \quad r_{\text{Cl}} < r_{\text{Al}}$	Atomic number of Aluminium Z = 13 Electronic configuration of Aluminium = $1s^2 \quad 2s^2 2p^6 \quad 3s^2 3p^1$ others (n - 1) n <table><tr><th>Electron Group</th><th>No. of electrons</th><th>Contribution of each electron</th><th>Electron contribution of particular group</th></tr><tr><td>n</td><td>2</td><td>0.35</td><td>0.70</td></tr><tr><td>n - 1</td><td>8</td><td>0.85</td><td>6.80</td></tr><tr><td>others</td><td>2</td><td>1.00</td><td>2.00</td></tr><tr><td colspan="3">S value</td><td>9.50</td></tr></table> Effective nuclear charge = Z - S (Z_{eff})_{Al} = 13 - 9.5 = 3.5	Electron Group	No. of electrons	Contribution of each electron	Electron contribution of particular group	n	2	0.35	0.70	n - 1	8	0.85	6.80	others	2	1.00	2.00	S value			9.50	Atomic number of chlorine Z = 17 Electronic configuration of chlorine = $1s^2 \quad 2s^2 2p^6 \quad 3s^2 3p^5$ others (n - 1) n <table><tr><th>Electron Group</th><th>No. of electrons</th><th>Contribution of each electron</th><th>Electron contribution of particular group</th></tr><tr><td>n</td><td>6</td><td>0.35</td><td>2.10</td></tr><tr><td>n - 1</td><td>8</td><td>0.85</td><td>6.80</td></tr><tr><td>others</td><td>2</td><td>1.00</td><td>2.00</td></tr><tr><td colspan="3">S value</td><td>10.90</td></tr></table> Effective nuclear charge = Z - S (Z_{eff})_{Cl} = 17 - 10.90 = 6.10	Electron Group	No. of electrons	Contribution of each electron	Electron contribution of particular group	n	6	0.35	2.10	n - 1	8	0.85	6.80	others	2	1.00	2.00	S value			10.90
Atomic number of Aluminium Z = 13 Electronic configuration of Aluminium = $1s^2 \quad 2s^2 2p^6 \quad 3s^2 3p^1$ others (n - 1) n <table><tr><th>Electron Group</th><th>No. of electrons</th><th>Contribution of each electron</th><th>Electron contribution of particular group</th></tr><tr><td>n</td><td>2</td><td>0.35</td><td>0.70</td></tr><tr><td>n - 1</td><td>8</td><td>0.85</td><td>6.80</td></tr><tr><td>others</td><td>2</td><td>1.00</td><td>2.00</td></tr><tr><td colspan="3">S value</td><td>9.50</td></tr></table> Effective nuclear charge = Z - S (Z_{eff})_{Al} = 13 - 9.5 = 3.5	Electron Group	No. of electrons	Contribution of each electron	Electron contribution of particular group	n	2	0.35	0.70	n - 1	8	0.85	6.80	others	2	1.00	2.00	S value			9.50	Atomic number of chlorine Z = 17 Electronic configuration of chlorine = $1s^2 \quad 2s^2 2p^6 \quad 3s^2 3p^5$ others (n - 1) n <table><tr><th>Electron Group</th><th>No. of electrons</th><th>Contribution of each electron</th><th>Electron contribution of particular group</th></tr><tr><td>n</td><td>6</td><td>0.35</td><td>2.10</td></tr><tr><td>n - 1</td><td>8</td><td>0.85</td><td>6.80</td></tr><tr><td>others</td><td>2</td><td>1.00</td><td>2.00</td></tr><tr><td colspan="3">S value</td><td>10.90</td></tr></table> Effective nuclear charge = Z - S (Z_{eff})_{Cl} = 17 - 10.90 = 6.10	Electron Group	No. of electrons	Contribution of each electron	Electron contribution of particular group	n	6	0.35	2.10	n - 1	8	0.85	6.80	others	2	1.00	2.00	S value			10.90		
Electron Group	No. of electrons	Contribution of each electron	Electron contribution of particular group																																								
n	2	0.35	0.70																																								
n - 1	8	0.85	6.80																																								
others	2	1.00	2.00																																								
S value			9.50																																								
Electron Group	No. of electrons	Contribution of each electron	Electron contribution of particular group																																								
n	6	0.35	2.10																																								
n - 1	8	0.85	6.80																																								
others	2	1.00	2.00																																								
S value			10.90																																								
35	<table><tr><td> Calculate the effective nuclear charge on 4s electron in scandium. (Jun-23) Atomic number of scandium Z = 21 Electronic configuration of scandium = $1s^2 \quad 2s^2 2p^6 \quad 3s^2 3p^6 3d^1 \quad 4s^2$ (n - 3) (n - 2) (n - 1) n <table><tr><th>Electron Group</th><th>No. of electrons</th><th>Contribution of each electron</th><th>Electron contribution of particular group</th></tr><tr><td>n</td><td>1</td><td>0.35</td><td>0.35</td></tr><tr><td>n - 1</td><td>9</td><td>0.85</td><td>7.65</td></tr><tr><td>(n-2) & others</td><td>10</td><td>1.00</td><td>10.00</td></tr><tr><td colspan="3">S value</td><td>18.00</td></tr></table> Effective nuclear charge = Z - S (Z_{eff})_{Sc} = 21 - 18 = 3 </td><td> Calculate the effective nuclear charge on 3d¹ electron in scandium. Atomic number of scandium Z = 21 Electronic configuration of scandium = $1s^2 \quad 2s^2 2p^6 \quad 3s^2 3p^6 3d^1 \quad 4s^2$ (n - 3) (n - 2) (n - 1) n <table><tr><th>Electron Group</th><th>No. of electrons</th><th>Contribution of each electron</th><th>Electron contribution of particular group</th></tr><tr><td>n</td><td>0</td><td>0.35</td><td>0</td></tr><tr><td>(n-1) & others</td><td>18</td><td>1</td><td>18</td></tr><tr><td colspan="3">S value</td><td>18</td></tr></table> Effective nuclear charge = Z - S (Z_{eff})_{Sc} = 21 - 18 = 3 </td></tr></table>	Calculate the effective nuclear charge on 4s electron in scandium. (Jun-23) Atomic number of scandium Z = 21 Electronic configuration of scandium = $1s^2 \quad 2s^2 2p^6 \quad 3s^2 3p^6 3d^1 \quad 4s^2$ (n - 3) (n - 2) (n - 1) n <table><tr><th>Electron Group</th><th>No. of electrons</th><th>Contribution of each electron</th><th>Electron contribution of particular group</th></tr><tr><td>n</td><td>1</td><td>0.35</td><td>0.35</td></tr><tr><td>n - 1</td><td>9</td><td>0.85</td><td>7.65</td></tr><tr><td>(n-2) & others</td><td>10</td><td>1.00</td><td>10.00</td></tr><tr><td colspan="3">S value</td><td>18.00</td></tr></table> Effective nuclear charge = Z - S (Z_{eff})_{Sc} = 21 - 18 = 3	Electron Group	No. of electrons	Contribution of each electron	Electron contribution of particular group	n	1	0.35	0.35	n - 1	9	0.85	7.65	(n-2) & others	10	1.00	10.00	S value			18.00	Calculate the effective nuclear charge on 3d¹ electron in scandium. Atomic number of scandium Z = 21 Electronic configuration of scandium = $1s^2 \quad 2s^2 2p^6 \quad 3s^2 3p^6 3d^1 \quad 4s^2$ (n - 3) (n - 2) (n - 1) n <table><tr><th>Electron Group</th><th>No. of electrons</th><th>Contribution of each electron</th><th>Electron contribution of particular group</th></tr><tr><td>n</td><td>0</td><td>0.35</td><td>0</td></tr><tr><td>(n-1) & others</td><td>18</td><td>1</td><td>18</td></tr><tr><td colspan="3">S value</td><td>18</td></tr></table> Effective nuclear charge = Z - S (Z_{eff})_{Sc} = 21 - 18 = 3	Electron Group	No. of electrons	Contribution of each electron	Electron contribution of particular group	n	0	0.35	0	(n-1) & others	18	1	18	S value			18				
Calculate the effective nuclear charge on 4s electron in scandium. (Jun-23) Atomic number of scandium Z = 21 Electronic configuration of scandium = $1s^2 \quad 2s^2 2p^6 \quad 3s^2 3p^6 3d^1 \quad 4s^2$ (n - 3) (n - 2) (n - 1) n <table><tr><th>Electron Group</th><th>No. of electrons</th><th>Contribution of each electron</th><th>Electron contribution of particular group</th></tr><tr><td>n</td><td>1</td><td>0.35</td><td>0.35</td></tr><tr><td>n - 1</td><td>9</td><td>0.85</td><td>7.65</td></tr><tr><td>(n-2) & others</td><td>10</td><td>1.00</td><td>10.00</td></tr><tr><td colspan="3">S value</td><td>18.00</td></tr></table> Effective nuclear charge = Z - S (Z_{eff})_{Sc} = 21 - 18 = 3	Electron Group	No. of electrons	Contribution of each electron	Electron contribution of particular group	n	1	0.35	0.35	n - 1	9	0.85	7.65	(n-2) & others	10	1.00	10.00	S value			18.00	Calculate the effective nuclear charge on 3d¹ electron in scandium. Atomic number of scandium Z = 21 Electronic configuration of scandium = $1s^2 \quad 2s^2 2p^6 \quad 3s^2 3p^6 3d^1 \quad 4s^2$ (n - 3) (n - 2) (n - 1) n <table><tr><th>Electron Group</th><th>No. of electrons</th><th>Contribution of each electron</th><th>Electron contribution of particular group</th></tr><tr><td>n</td><td>0</td><td>0.35</td><td>0</td></tr><tr><td>(n-1) & others</td><td>18</td><td>1</td><td>18</td></tr><tr><td colspan="3">S value</td><td>18</td></tr></table> Effective nuclear charge = Z - S (Z_{eff})_{Sc} = 21 - 18 = 3	Electron Group	No. of electrons	Contribution of each electron	Electron contribution of particular group	n	0	0.35	0	(n-1) & others	18	1	18	S value			18						
Electron Group	No. of electrons	Contribution of each electron	Electron contribution of particular group																																								
n	1	0.35	0.35																																								
n - 1	9	0.85	7.65																																								
(n-2) & others	10	1.00	10.00																																								
S value			18.00																																								
Electron Group	No. of electrons	Contribution of each electron	Electron contribution of particular group																																								
n	0	0.35	0																																								
(n-1) & others	18	1	18																																								
S value			18																																								
36	Define atomic radius? (Sep-21) Atomic radius of an atom is defined as the distance between the centre of its nucleus and the outermost shell containing the valence electron.																																										
37	Define Metallic radius? It is defined as one-half of the distance between two adjacent metal atoms in the closely packed metallic crystal lattice.																																										

4. HYDROGEN

1	Explain why hydrogen is not placed with the halogen in the periodic table. - Like the formation of halides (X^-) from halogens, hydrogen also has a tendency to gain one electron to form hydride ion (H^-) - However, the electron affinity of hydrogen is much less than that of halogen atoms. - So, hydrogen is not placed with the halogen in the periodic table
2	Discuss the three types of covalent hydrides. - Electron precise hydrides (CH_4, C_2H_6, SiH_4, GeH_4), - Electron-deficient hydrides (B_2H_6) - Electron-rich hydrides (NH_3, H_2O).
3	Predict which of the following hydrides is a gas on a solid (a) HCl (b) NaH. Give your reason. HCl – They are individual, small molecules. It is in the form of gas due to less force of attraction between them. NaH – It is a hydride. It is formed by transferring an electron from sodium metal to hydrogen as a gas on solid.
4	Write the expected formulas for the hydrides of 4th period elements. What is the trend in the formulas? In what way the first two members of the series different from the others? - The expected formulas for the hydrides of 4th period elements are MH or MH_2. - Hydrides possesses non-stoichiometric with variable composition. - First two elements form ionic hydrides others form covalent and metallic hydrides.
5	Write chemical equation for the following reactions. i) Reaction of hydrogen with tungsten (VI) oxide on heating. ii) Hydrogen gas and chlorine gas. i) $WO_3 + 3H_2 \longrightarrow W + 3H_2O$ ii) $H_2 + Cl_2 \longrightarrow 2HCl$
6	Complete the following chemical reactions and classify them in to (a) hydrolysis (b) redox (c) hydration reactions. i) $KMnO_4 + H_2O_2 \rightarrow$ ii) $CrCl_3 + H_2O \rightarrow$ iii) $CaO + H_2O \rightarrow$ i) $2KMnO_4 + 3H_2O_2 \longrightarrow 2MnO_2 + 2KOH + 2H_2O + 3O_2$ – Redox reaction ii) $CrCl_3 + 6H_2O \longrightarrow [Cr(H_2O)_6]Cl_3$ – Hydration reaction iii) $CaO + H_2O \longrightarrow Ca(OH)_2$ – Hydrolysis reaction
7	Hydrogen peroxide can function as an oxidising agent as well as reducing agent. substantiate this statement with suitable examples. Hydrogen peroxide can act both as an oxidizing agent and a reducing agent. Oxidation is usually performed in acidic medium $H_2O_2 + 2H^+ + 2e^- \longrightarrow 2H_2O$ ($E^\circ = +1.77V$) Eg: $2FeSO_4 + H_2SO_4 + H_2O_2 \longrightarrow Fe_2(SO_4)_3 + 2H_2O$ Reduction reactions are performed in basic medium $H_2O_2 + OH^- \longrightarrow O_2 + 2H_2O + 2e^-$ ($E^\circ = +0.08V$) Eg: $2KMnO_4(aq) + 3H_2O_2(aq) \longrightarrow 2MnO_2 + 2KOH + 2H_2O + 3O_2(g)$

8	Do you think that heavy water can be used for drinking purposes? - There are differences in properties between water and heavy water. - Because of the difference, the reactions of hydrogen and deuterium take place in different ways. - The rate of reaction involving heavy water is lower than the rate of reaction involving water. - Hence, drinking of heavy water will affect physiological processes. Therefore, hard water is not suitable for drinking.
9	What is water-gas shift reaction? $\text{water gas} + \text{steam} \xrightarrow[\text{Fe/Cu}]{400^{\circ}\text{C}} \text{CO}_2 + \text{H}_2$ In this method, carbon monoxide in water gas (CO + H₂) mixture is converted to carbon dioxide. This reaction is called as water-gas shift reaction.
10	Justify the position of hydrogen in the periodic table? Similarities with alkali metals: - The hydrogen has the electronic configuration of 1s¹ which resembles with ns¹ general valence shell configuration of alkali metals and shows similarity with them as follows. - It forms unipositive ion (H⁺) like alkali metals (Na⁺, K⁺, Cs⁺) - It forms halides (HX), oxides (H₂O), peroxides (H₂O₂) and sulphides (H₂S) like alkali metals - It also acts as a reducing agent. Variation from alkali metals: - unlike alkali metals which have ionization energy ranging from 377 to 520 kJ mol⁻¹, the hydrogen has 1,314 KJ mol⁻¹ which is much higher than alkali metals. - Like the formation of halides (X⁻) from halogens, hydrogen also has a tendency to gain one electron to form hydride ion (H⁻) whose electronic configuration is similar to the noble gas, helium. - The electron affinity of hydrogen is much less than that of halogen atoms, the tendency of hydrogen to form hydride ion is low compared to that of halogens to form the halide ions. - However, in most of its compound's hydrogen exists in +1 oxidation state. Therefore, it is reasonable to place the hydrogen in group 1 along with alkali metals
11	What are isotopes? Write the names of isotopes of hydrogen. Atoms of the same element having same atomic number and different mass numbers are called as isotopes. Isotopes of Hydrogen: - Protium (¹H¹ or H) - Deuterium (¹H² or D) - Tritium (¹H³ or T)
12	Give the uses of heavy water. - Heavy water is widely used as moderator in nuclear reactors as it can lower the energies of fast neutrons - It is commonly used as a tracer to study organic reaction mechanisms and mechanism of metabolic reactions - It is also used as a coolant in nuclear reactors as it absorbs the heat generated.
13	Explain the exchange reactions of deuterium. $\text{CH}_4 + 2\text{D}_2 \longrightarrow \text{CD}_4 + 2\text{H}_2$ $2\text{NH}_3 + 3\text{D}_2 \longrightarrow 2\text{ND}_3 + 3\text{H}_2$

14	How do you convert para hydrogen into ortho hydrogen? The para-form can be catalytically transformed into ortho-form by, • Adding platinum or iron catalyst. • By passing an electric discharge. • Heating above 800°C. • Mixing with paramagnetic molecules such as O₂, NO, NO₂. • By adding nascent/atomic hydrogen.														
15	Mention the uses of deuterium. • To prepare heavy water – used as a moderator in nuclear reactors. • Deuterium exchange reactions - deuterium can replace reversibly hydrogen in compounds either partially or completely depending upon the reaction conditions. • It is commonly used as a tracer to study organic reaction mechanisms.														
16	Explain preparation of hydrogen using electrolysis. • High purity hydrogen (>99.9 %) is obtained by the electrolysis of water containing traces of acid or alkali. • The electrolysis of aqueous solution of sodium hydroxide or potassium hydroxide using a nickel anode and iron cathode. • However, this process is not economical for large-scale production. • At anode: $2\text{OH}^- \longrightarrow \text{H}_2\text{O} + \frac{1}{2} \text{O}_2 + 2\text{e}^-$ • At cathode: $\cancel{2\text{H}_2\text{O}} + 2\text{e}^- \longrightarrow \cancel{2\text{OH}^-} + \text{H}_2$ • Overall reaction: $\text{H}_2\text{O} \longrightarrow \text{H}_2 + \frac{1}{2} \text{O}_2$														
17	Arrange NH₃, H₂O and HF in the order of increasing magnitude of hydrogen bonding and explain the basis for your arrangement. • The increasing order of hydrogen bonding is NH₃ < H₂O < HF • The nature of hydrogen bonding depends on the shape and electronegativity of the other atoms. • The electronegativity order of N, O and F is F > O > N • Therefore, HF has high hydrogen bonding properties.														
18	A group-1 metal (A) which is present in common salt reacts with (B) to give compound (C) in which hydrogen is present in –1 oxidation state. (B) on reaction with a gas (C) to give universal solvent (D). The compound (D) on reacts with (A) to give (E), a strong base. Identify A, B, C, D and E. Explain the reactions. common salt – NaCl The 1st group element (A) present in it is Na Na + (B) $\longrightarrow$ (C) Oxidation state of hydrogen in it is -1 2Na + H₂ $\longrightarrow$ 2NaH (A) (B) (C) H₂ + D $\longrightarrow$ E (universal solvent) H₂ + O₂ $\longrightarrow$ 2H₂O (B) (D) (E) Water is an universal solvent Na + H₂O $\longrightarrow$ NaOH + H₂ (A) (E) (F) <table border="1"> <thead> <tr> <th></th><th>Name / formula</th></tr> </thead> <tbody> <tr> <td>(A)</td><td>Sodium (Na)</td></tr> <tr> <td>(B)</td><td>Hydrogen (H₂)</td></tr> <tr> <td>(C)</td><td>Sodium hydride (NaH)</td></tr> <tr> <td>(D)</td><td>Oxygen (O₂)</td></tr> <tr> <td>(E)</td><td>Water (H₂O)</td></tr> <tr> <td>(F)</td><td>Sodium hydroxide (NaOH)</td></tr> </tbody> </table>		Name / formula	(A)	Sodium (Na)	(B)	Hydrogen (H ₂)	(C)	Sodium hydride (NaH)	(D)	Oxygen (O ₂)	(E)	Water (H ₂ O)	(F)	Sodium hydroxide (NaOH)
	Name / formula														
(A)	Sodium (Na)														
(B)	Hydrogen (H ₂)														
(C)	Sodium hydride (NaH)														
(D)	Oxygen (O ₂)														
(E)	Water (H ₂ O)														
(F)	Sodium hydroxide (NaOH)														

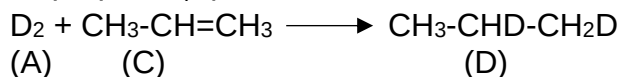
- 19 An isotope of hydrogen (A) reacts with diatomic molecule of element which occupies group number 16 and period number 2 to give compound (B) is used as a moderator in nuclear reaction. (A) adds on to a compound (C), which has the molecular formula C_3H_6 to give (D). Identify A, B, C and D.

An isotope of hydrogen (A) reacts with oxygen to give heavy water (B).



(A) (B)

Deuterium (A) reacts with propene (C) to form deutero propene (D).



	Name / formula
(A)	Deuterium (D_2)
(B)	Heavy water (D_2O)
(C)	Propene ($CH_3-CH=CH_3$)
(D)	Deutero propene ($CH_3-CHD-CH_2D$)

- | | |
|----|---|
| 20 | NH ₃ has exceptionally high melting point and boiling point as compared to those of the hydrides of the remaining element of group 15 - Explain. |
|----|---|

- Due to the presence of intermolecular hydrogen bonding in NH_3 .
- The amount of energy required to break hydrogen is high therefore melting and boiling points are high.

- | | |
|----|---|
| 21 | Why interstitial hydrides have a lower density than the parent metal. |
|----|---|

- In interstitial hydrides, hydrogen occupies the interstitial sites.
- Most of the hydrides are non-stoichiometric with variable composition so, it has lower density than the parent metal.

- | | |
|----|--|
| 22 | How do you expect the metallic hydrides to be useful for hydrogen storage? |
|----|--|

- In some metal hydrides, hydrogen is absorbed as a hydrogen atom.
- The interstitial space widens due to the adsorbed hydrogen atom.
- During heating the hydrogen atoms diffuse through the metal and recombine at the surface to form molecular hydrogen.
- Technically metal hydride formation is caused by a chemical reaction. But it works like a natural storage system.
- It acts like a water sponge, absorbing and releasing.
- Thus, the reversible acceptance of hydrogen by metals and metal alloys is suitable for applications in hydrogen storage and rechargeable metal hydride batteries.

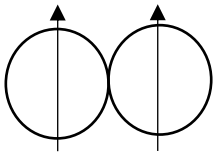
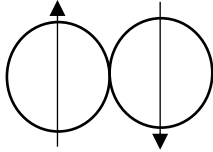
- | | |
|----|---|
| 23 | What is responsible for the antibacterial action of chlorine water? |
|----|---|

Chlorine forms hydrochloric acid and hypo chlorous acid. It is responsible for the antibacterial action of chlorine water, and for its use as bleach.



- | | |
|----|---|
| 24 | Compare the structures of H_2O and H_2O_2 . |
|----|---|

	Structure of H ₂ O	Structure of H ₂ O ₂
1	It has a bend structure	It has open book structure. i.e., H ₂ O ₂ has a non-planar structure
2	Bond angle of H-O-H is 104.5°	Bond angle of H-O-O-H in gaseous state is 94.8° and in solid state is 101.9°
3		Structurally, H ₂ O ₂ is represented by the dihydroxyl formula in which the two OH groups do not lie in the same plane.

25	Define ortho and para hydrogen? In the hydrogen atom, the nucleus has a spin. When molecular hydrogen is formed, the spins of two hydrogen nuclei can be in the same direction or in the opposite direction as shown in the figure. These two forms of hydrogen molecules are called <i>ortho</i> and <i>para</i> hydrogens respectively.  Ortho hydrogen  Para hydrogen																
26	Differentiate ortho and para hydrogen? <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th><th style="text-align: center;">Ortho hydrogen</th><th style="text-align: center;">Para hydrogen</th></tr> </thead> <tbody> <tr> <td>1</td><td>The spins of two hydrogen nuclei in H₂ can be in the same direction</td><td>The spins of two hydrogen nuclei in H₂ can be in the opposite direction</td></tr> <tr> <td>2</td><td>melting point is 13.95 K</td><td>melting point is 13.83 K</td></tr> <tr> <td>3</td><td>Boiling point is 20.39 K</td><td>Boiling point is 20.26 K</td></tr> <tr> <td>4</td><td>The magnetic moment of ortho hydrogen is twice that of a proton</td><td>Since the nuclear spins are in opposite directions the magnetic moment of para hydrogen is zero</td></tr> </tbody> </table>			Ortho hydrogen	Para hydrogen	1	The spins of two hydrogen nuclei in H ₂ can be in the same direction	The spins of two hydrogen nuclei in H ₂ can be in the opposite direction	2	melting point is 13.95 K	melting point is 13.83 K	3	Boiling point is 20.39 K	Boiling point is 20.26 K	4	The magnetic moment of ortho hydrogen is twice that of a proton	Since the nuclear spins are in opposite directions the magnetic moment of para hydrogen is zero
	Ortho hydrogen	Para hydrogen															
1	The spins of two hydrogen nuclei in H ₂ can be in the same direction	The spins of two hydrogen nuclei in H ₂ can be in the opposite direction															
2	melting point is 13.95 K	melting point is 13.83 K															
3	Boiling point is 20.39 K	Boiling point is 20.26 K															
4	The magnetic moment of ortho hydrogen is twice that of a proton	Since the nuclear spins are in opposite directions the magnetic moment of para hydrogen is zero															
27	Explain the preparation of Tritium? ${}^6_3\text{Li} + {}^1_0\text{n} \longrightarrow {}^4_2\text{He} + {}^3_1\text{T}$																
28	Give the uses of hydrogen peroxide? 1. It is used in water treatment to oxidize pollutants 2. It is used as a mild antiseptic 3. It is used to bleach in textile, paper and hair-care industry																
29	What is water gas? • Mixture of carbon monoxide and hydrogen is called as water gas. • steam is passed over a red-hot coke to produce water gas (CO+H₂). This is also called <i>syngas</i> (Synthetic gas) as it is used in the synthesis of organic compounds. $\text{C} + \text{H}_2\text{O} \xrightarrow{1000^\circ\text{C}} \underbrace{\text{CO} + \text{H}_2}_{\text{Water gas/Syngas}}$																
30	Give the uses of hydrogen? 1. Over 90 % hydrogen produced in industry is used for synthetic applications. 2. Unsaturated fatty oils can be converted into saturated fats called vanaspati by the reduction reaction with Pt / H₂. 3. In metallurgy, it can be used to reduce many metal oxides to metals at high temperatures. 4. Atomic hydrogen and oxy-hydrogen torches are used for cutting and welding. 5. Liquid hydrogen is used as a rocket fuel. 6. Hydrogen is also used in fuel cells for generating electrical energy.																
31	What is hard water and soft water? • Hard water contains high amounts of mineral ions like, magnesium & calcium, though iron, aluminium, and manganese may also be found in certain areas. Presence of these metal salts in the form of bicarbonate, chloride and sulphate in water makes water 'hard'. • On the other hand, water free from soluble salts of calcium and magnesium is called soft water.																

32	What is temporary hardness? How it can be removed. - Temporary hardness is due to the presence of soluble bicarbonates of magnesium and calcium. - This can be removed by boiling the hard water followed by filtration. Upon boiling, these salts decompose into insoluble carbonate which leads to their precipitation. - The magnesium carbonate thus formed further hydrolysed to give insoluble magnesium hydroxide.
33	What is permanent hardness? How it can be removed. Permanent hardness of water is due to the presence of soluble salts of magnesium and calcium in the form of chlorides and sulphates in it. It can be removed by adding washing soda, which reacts with these metal (Ca or Mg) chlorides and sulphates in hard water to form insoluble carbonates.
34	Explain ion-exchange process? - ion-exchange is the process used to soften the hard water. - hardness can be removed by passing through an ion-exchange bed like zeolites or column containing ion-exchange resin. - Zeolites are hydrated sodium alumino-silicates with a general formula, $\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot x\text{SiO}_2 \cdot y\text{H}_2\text{O}$ ($x = 2$ to 10, $y = 2$ to 6). - Zeolites have porous structure in which the monovalent sodium ions are loosely held and can be exchanged with hardness producing metal ions ($M = \text{Ca}^{2+}$ or Mg^{2+}) in water. - When exhausted, the materials can be regenerated by treating with aqueous sodium chloride.
35	What are hydrides? Explain its types. Hydrogen forms binary hydrides with many electropositive elements including metals and non-metals. They are 3 types, Ionic (Saline) hydrides: These are hydrides composed of an electropositive metal, generally, an alkali or alkaline-earth metal, except beryllium and magnesium, formed by transfer of electrons from metal to hydrogen atoms. They can be prepared by the reaction of elements at about 400°C. These are salt-like, high-melting, white crystalline solids having hydride ions (H^-) and metal cations (M^{n+}). Covalent (Molecular) hydrides: - They are compounds in which hydrogen is attached to another element by sharing of electrons. - The most common examples of covalent hydrides of non-metals are methane, ammonia, water and hydrogen chloride. - Since most of the covalent hydrides consist of discrete, small molecules that have relatively weak intermolecular forces, they are generally gases or volatile liquids. - Covalent hydrides are further divided into three categories, viz., electron precise (CH_4, C_2H_6, SiH_4, GeH_4), electron-deficient (B_2H_6) and electron-rich hydrides (NH_3, H_2O). Metallic (Interstitial) hydrides: - Metallic hydrides are usually obtained by hydrogenation of metals and alloys. - In metals and alloys, hydrogen occupies the interstitial sites so, they are called as interstitial hydrides. - The hydrides show properties similar to parent metals and hence they are also

	known as metallic hydrides. Eg: $\text{TiH}_{1.5-1.8}$ (or) $\text{PdH}_{0.6-0.8}$ (or) MH (or) MH_2 ($\text{M} = \text{Ti, Zr, Hf, V, Zn}$)
36	Define hydrogen bonding? - When a hydrogen atom (H) is covalently bonded to a highly electronegative atom such as fluorine (F) or oxygen (O) or nitrogen (N), the bond is polarized. - Due to this effect, the polarized hydrogen atom is able to form a weak electrostatic interaction with another electronegative atom present in the vicinity. This interaction is called as a hydrogen bond
37	Explain the types of hydrogen bonding? Intramolecular Hydrogen Bond - Intramolecular hydrogen bonds are those which occur within a single molecule. - Eg: Ortho-Nitrophenol, Salicilaldehyde Intermolecular hydrogen bond - 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 in positions which enable the hydrogen bonding interactions. - For example, intermolecular hydrogen bonds can occur between ammonia molecule themselves or between water molecules themselves or between ammonia and water.

5. ALKALI AND ALKALINE EARTH METALS

1	Why sodium hydroxide is much more water soluble than sodium chloride? - NaOH is a stronger base - NaOH dissolve freely in water with evolution of much heat on account of intense hydration - NaOH ionises easily due to ionic character. Whereas, NaCl is partially covalent in nature - at 273 K temperature, 36.0g of NaCl dissolves in 100g of water. - Rise in temperature does not increase the solubility.														
2	Write the chemical equations for the reactions involved in solvay process of preparation of sodium carbonate. $2\text{NH}_3 + \text{H}_2\text{O} + \text{CO}_2 \longrightarrow (\text{NH}_4)_2\text{CO}_3$ $(\text{NH}_4)_2\text{CO}_3 + \text{H}_2\text{O} + \text{CO}_2 \longrightarrow 2\text{NH}_4\text{HCO}_3$ $2\text{NH}_4\text{HCO}_3 + \text{NaCl} \longrightarrow \text{NH}_4\text{Cl} + \text{NaHCO}_3$ $2 \text{NaHCO}_3 \longrightarrow \text{Na}_2\text{CO}_3 + \text{CO}_2 + \text{H}_2\text{O}$														
3	Write balanced chemical equation for each of the following chemical reactions. (i) Lithium metal with nitrogen gas $6\text{Li} + \text{N}_2 \longrightarrow 2\text{Li}_3\text{N}$ (ii) Heating solid sodium bicarbonate $2\text{NaHCO}_3 \xrightarrow{\Delta} \text{Na}_2\text{CO}_3 + \text{CO}_2 + \text{H}_2\text{O}$ (iii) Rubidium with oxygen gas $\text{Rb} + \text{O}_2 \xrightarrow{\Delta} \text{RbO}_2 \text{ (Rubidium superoxide)}$ $2\text{Rb} + \text{O}_2 \xrightarrow{\Delta} \text{Rb}_2\text{O}_2 \text{ (Rubidium peroxide)}$ (iv) Solid potassium hydroxide with CO₂ $\text{KOH} + \text{CO}_2 \longrightarrow \text{KHCO}_3$ (v) Heating calcium carbonate $\text{CaCO}_3 \xrightleftharpoons{\Delta} \text{CaO} + \text{CO}_2$ (vi) Heating calcium with oxygen $2\text{Ca} + \text{O}_2 \xrightarrow{\Delta} 2\text{CaO}$														
4	Discuss briefly the similarities between beryllium and aluminium. (May-22, Sep-21, Jun-23, Mar-24) Beryllium shows a diagonal relationship with aluminium. So, their properties per unit area is closer. <table border="1"> <thead> <tr> <th></th><th>Properties</th></tr> </thead> <tbody> <tr> <td>1</td><td>Beryllium chloride forms a dimeric structure like aluminium chloride with chloride bridges. Beryllium chloride also forms polymeric chain structure in addition to dimer. Both are soluble in organic solvents and are strong Lewis acids.</td></tr> <tr> <td>2</td><td>Beryllium hydroxide dissolves in excess of alkali and gives beryllate ion and $[\text{Be}(\text{OH})_4]^{2-}$ and hydrogen as aluminium hydroxide which gives aluminate ion, $[\text{Al}(\text{OH})_4]^-$.</td></tr> <tr> <td>3</td><td>Beryllium and aluminium ions have strong tendency to form complexes, BeF_4^{2-}, AlF_6^{3-}.</td></tr> <tr> <td>4</td><td>Both beryllium and aluminium hydroxides are amphoteric in nature.</td></tr> <tr> <td>5</td><td>Carbides of beryllium (Be_2C) like aluminium carbide (Al_4C_3) give methane on hydrolysis.</td></tr> <tr> <td>6</td><td>Both beryllium and aluminium are rendered passive by nitric acid.</td></tr> </tbody> </table>		Properties	1	Beryllium chloride forms a dimeric structure like aluminium chloride with chloride bridges. Beryllium chloride also forms polymeric chain structure in addition to dimer. Both are soluble in organic solvents and are strong Lewis acids.	2	Beryllium hydroxide dissolves in excess of alkali and gives beryllate ion and $[\text{Be}(\text{OH})_4]^{2-}$ and hydrogen as aluminium hydroxide which gives aluminate ion, $[\text{Al}(\text{OH})_4]^-$.	3	Beryllium and aluminium ions have strong tendency to form complexes, BeF_4^{2-} , AlF_6^{3-} .	4	Both beryllium and aluminium hydroxides are amphoteric in nature.	5	Carbides of beryllium (Be_2C) like aluminium carbide (Al_4C_3) give methane on hydrolysis.	6	Both beryllium and aluminium are rendered passive by nitric acid.
	Properties														
1	Beryllium chloride forms a dimeric structure like aluminium chloride with chloride bridges. Beryllium chloride also forms polymeric chain structure in addition to dimer. Both are soluble in organic solvents and are strong Lewis acids.														
2	Beryllium hydroxide dissolves in excess of alkali and gives beryllate ion and $[\text{Be}(\text{OH})_4]^{2-}$ and hydrogen as aluminium hydroxide which gives aluminate ion, $[\text{Al}(\text{OH})_4]^-$.														
3	Beryllium and aluminium ions have strong tendency to form complexes, BeF_4^{2-} , AlF_6^{3-} .														
4	Both beryllium and aluminium hydroxides are amphoteric in nature.														
5	Carbides of beryllium (Be_2C) like aluminium carbide (Al_4C_3) give methane on hydrolysis.														
6	Both beryllium and aluminium are rendered passive by nitric acid.														

12	Explain the important common features of Group 2 elements. 1. Electron configuration is ns^2. 2. It is highly reactive and does not occur alone in nature. 3. Atomic and ionic radius increases in group. 4. General oxidation state is +2. 5. The ionization energy decreases in group. 6. Electronegativity decreases in group. 7. It possess higher hydration enthalpy. Hydration series $Be > Mg > Ca > Sr > Ba$. 8. HCl wetted alkali metal salts impart a specific color to the flame. ○ Calcium - brick red ○ Strontium - crimson red ○ Barium - apple green
13	How is plaster of paris prepared? • It is a hemihydrate of calcium sulphate. • It is obtained when gypsum, $CaSO_4 \cdot 2H_2O$, is heated to 393 K. $2CaSO_4 \cdot 2H_2O(s) \longrightarrow 2CaSO_4 \cdot \frac{1}{2}H_2O + 3H_2O$
14	Mention the uses of plaster of paris. (Mar-23) It is used in, • Building industries (plasters) • Immobilising (bone fracture or sprain) • Dentistry, in ornamental work and for making casts of statues and busts.
15	Give the uses of gypsum. • Gypsum is used in making drywalls or plaster boards. Plaster boards are used as the finish for walls and ceilings, and for partitions. • Gypsum is heated to about 300°F to produce plaster of Paris, which is also known as gypsum plaster. It is mainly used as a sculpting material. • Gypsum is used in making surgical and orthopedic casts, such as surgical splints and casting moulds. • Gypsum plays an important role in agriculture as a soil additive, conditioner, and fertilizer. It helps loosen up compact or clay soil, and provides calcium and sulphur, which are essential for the healthy growth of a plant. • Gypsum is used in toothpastes, shampoos, and hair products, mainly due to its binding and thickening properties. • Gypsum is a component of Portland cement, where it acts as a hardening retarder to control the speed at which concrete sets.
16	Describe briefly the biological importance of Calcium and magnesium. A typical adult human body contains about 25 g of magnesium and 1200 g of calcium. Biological importance of magnesium: • Magnesium plays an important role in many biochemical reactions catalysed by enzymes. • It is the co-factor of all enzymes that utilize ATP in phosphate transfer and energy release. • It also essential for DNA synthesis and proper functioning of DNA. • It is also used for balancing electrolytes in our body. • Deficiency of magnesium results into convulsion and neuromuscular irritation. • The main pigment that is responsible for photosynthesis, chlorophyll, contains magnesium. Biological importance of calcium: • Calcium is a major component of bones and teeth.

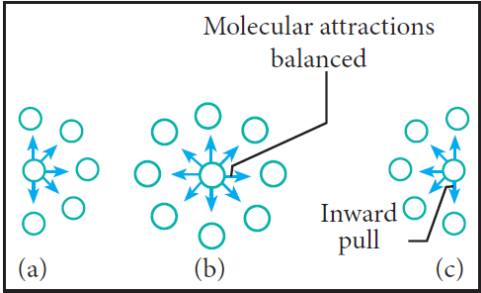
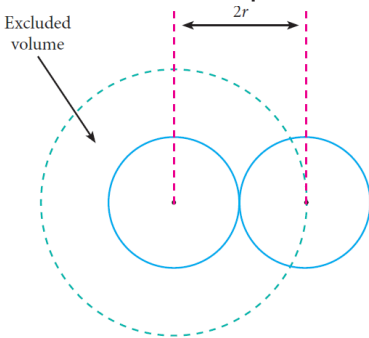
	- It is also present in blood and its concentration is maintained by hormones (calcitonin and parathyroid hormone). - Deficiency of calcium in blood causes it to take longer time to clot. - It is also important for muscle contraction.														
17	Which would you expect to have a higher melting point, magnesium oxide or magnesium fluoride? Explain your reasoning. MgO has a high melting point. because, - Ionic character of O^{2-} is twice in MgO. - Due to its strong ionic bond, more energy is required to break it. - The melting enthalpy of MgO is very high. Hence, stability is also high.														
18	Why do beryllium and nitrogen have almost zero electron affinity? Be - $1s^2 2s^2$ N - $1s^2 2s^2 2p^3$ When an electron is added to elements like beryllium and nitrogen, their stable electron configuration is lost. Hence, such elements have an almost zero electron affinity value.														
19	Compare the distinctive properties of lithium with other elements of the group? (Jul-22) The distinctive behaviour of Li^+ ion is due to its exceptionally small size, high polarising power, high hydration energy and non-availability of d-orbitals. <table border="1"> <thead> <tr> <th>Lithium</th><th>Other elements of the family</th></tr> </thead> <tbody> <tr> <td>Hard, high melting and boiling point</td><td>Soft and Lower melting and boiling point</td></tr> <tr> <td>Least reactive</td><td>More reactive</td></tr> <tr> <td>Reacts with nitrogen to give Li_3N $6Li + N_2 \rightarrow 2Li_3N$</td><td>No reaction</td></tr> <tr> <td>Reacts with bromine slowly</td><td>React violently</td></tr> <tr> <td>Reacts directly with carbon to form ionic carbides. For example, $2Li + 2C \rightarrow Li_2C_2$</td><td>Do not react with carbon directly, but can react with carbon compounds. $2Na + C_2H_2 \rightarrow Na_2C_2 + H_2$</td></tr> <tr> <td>Lithium nitrate decomposes to give an oxide</td><td>Decompose to give nitrites</td></tr> </tbody> </table>	Lithium	Other elements of the family	Hard, high melting and boiling point	Soft and Lower melting and boiling point	Least reactive	More reactive	Reacts with nitrogen to give Li_3N $6Li + N_2 \rightarrow 2Li_3N$	No reaction	Reacts with bromine slowly	React violently	Reacts directly with carbon to form ionic carbides. For example, $2Li + 2C \rightarrow Li_2C_2$	Do not react with carbon directly, but can react with carbon compounds. $2Na + C_2H_2 \rightarrow Na_2C_2 + H_2$	Lithium nitrate decomposes to give an oxide	Decompose to give nitrites
Lithium	Other elements of the family														
Hard, high melting and boiling point	Soft and Lower melting and boiling point														
Least reactive	More reactive														
Reacts with nitrogen to give Li_3N $6Li + N_2 \rightarrow 2Li_3N$	No reaction														
Reacts with bromine slowly	React violently														
Reacts directly with carbon to form ionic carbides. For example, $2Li + 2C \rightarrow Li_2C_2$	Do not react with carbon directly, but can react with carbon compounds. $2Na + C_2H_2 \rightarrow Na_2C_2 + H_2$														
Lithium nitrate decomposes to give an oxide	Decompose to give nitrites														
20	Explain the preparation of calcium oxide and write its properties? It is produced on a commercial scale by heating limestone in a lime kiln in the temperature range 1070-1270K. $CaCO_3 \rightleftharpoons CaO + CO_2$ The reaction being reversible, carbon dioxide is removed as soon as it is produced to enable the reaction to proceed to completion. Properties: Calcium oxide is a white amorphous solid. It has a melting point of 2870 K. (i) It absorbs moisture and carbon dioxide on exposure to atmosphere. $CaO + H_2O \rightarrow Ca(OH)_2$ $CaO + CO_2 \rightarrow CaCO_3$ (ii) The addition of limited amount of water breaks the lump of lime. This process is called slaking of lime and the product is slaked lime. $CaO + H_2O \rightarrow Ca(OH)_2$														
21	Write a balanced equation for the effect of heat on calcium carbonate. (May-22, Mar-24) $CaCO_3 \rightleftharpoons CaO + CO_2$														

22	Compare the distinctive properties of Beryllium with other elements of the group? (May-22) The anomalous properties of beryllium is mainly due to • Its small size and high polarising power • High ionisation energy and high electronegativity <table border="1"> <thead> <tr> <th>Beryllium</th><th>Other elements of the family</th></tr> </thead> <tbody> <tr> <td>Forms covalent compounds</td><td>Forms ionic compounds</td></tr> <tr> <td>High melting and boiling point</td><td>Low melting and boiling point</td></tr> <tr> <td>Does not react with water even at elevated temperature</td><td>React with water</td></tr> <tr> <td>Does not combine directly with hydrogen</td><td>Combine directly with hydrogen</td></tr> <tr> <td>Does not combine directly with halogens. Halides are covalent.</td><td>Combine directly with halogens Halides are electrovalent.</td></tr> <tr> <td>Hydroxide and oxides of beryllium are amphoteric in nature</td><td>Basic in nature.</td></tr> <tr> <td>It is not readily attacked by acids because of the presence of an oxide film</td><td>Readily attacked by acids</td></tr> <tr> <td>Beryllium carbide evolves methane with water.</td><td>evolve acetylene with water.</td></tr> <tr> <td>Salts of Be are extensively hydrolysed</td><td>Hydrolysed</td></tr> </tbody> </table>	Beryllium	Other elements of the family	Forms covalent compounds	Forms ionic compounds	High melting and boiling point	Low melting and boiling point	Does not react with water even at elevated temperature	React with water	Does not combine directly with hydrogen	Combine directly with hydrogen	Does not combine directly with halogens. Halides are covalent.	Combine directly with halogens Halides are electrovalent.	Hydroxide and oxides of beryllium are amphoteric in nature	Basic in nature.	It is not readily attacked by acids because of the presence of an oxide film	Readily attacked by acids	Beryllium carbide evolves methane with water.	evolve acetylene with water.	Salts of Be are extensively hydrolysed	Hydrolysed
Beryllium	Other elements of the family																				
Forms covalent compounds	Forms ionic compounds																				
High melting and boiling point	Low melting and boiling point																				
Does not react with water even at elevated temperature	React with water																				
Does not combine directly with hydrogen	Combine directly with hydrogen																				
Does not combine directly with halogens. Halides are covalent.	Combine directly with halogens Halides are electrovalent.																				
Hydroxide and oxides of beryllium are amphoteric in nature	Basic in nature.																				
It is not readily attacked by acids because of the presence of an oxide film	Readily attacked by acids																				
Beryllium carbide evolves methane with water.	evolve acetylene with water.																				
Salts of Be are extensively hydrolysed	Hydrolysed																				
23	Explain the biological importance of sodium and potassium? Monovalent sodium and potassium ions are found in large proportions in biological fluids. • These ions perform important biological functions such as maintenance of ion balance and nerve impulse conduction. • A typical 70 kg man contains about 90 g of sodium and 170 g of potassium. • Sodium ions are found primarily on the outside of cells, being located in blood plasma and in the interstitial fluid which surrounds the cells. • These ions participate in the transmission of nerve signals, in regulating the flow of water across cell membranes and in the transport of sugars and amino acids into cells. • potassium ions are the most abundant cations within cell fluids, where they activate many enzymes, participate in the oxidation of glucose to produce ATP. • Sodium–potassium pump plays an important role in transmitting nerve signals.																				
24	Write the uses of sodium bicarbonate? (Jun-23) • Primarily used as an ingredient in baking. • Sodium hydrogen carbonate is a mild antiseptic for skin infections. • It is also used in fire extinguishers.																				

6. GASEOUS STATE

1	State Boyle's law? At a given temperature the volume occupied by a fixed mass of a gas is inversely proportional to its pressure. $V \propto \frac{1}{P} \quad (T \text{ and } n \text{ are fixed})$ (or) $V = k \times \frac{1}{P}$ (or) $PV = k$								
2	Name two items that can serve as a model for Gay Lusaac' law and explain. - The candle test proves that air contains one-fifth oxygen. - A test in which a hard-boiled egg is placed in the lid of a vial.								
3	What are ideal gases? (Mar-19) In what way real gases differ from ideal gases. Gases that obey the gas equation $PV = nRT$ under all conditions are called ideal gases. <table border="1"> <thead> <tr> <th>Ideal gases</th><th>Real gases</th></tr> </thead> <tbody> <tr> <td>It obeys the gas law under all conditions of temperature and pressure</td><td>It obeys the gas law only at low pressure and high temperature</td></tr> <tr> <td>The individual gas molecules occupy negligible volume when compared to the total volume of the gas</td><td>The volume occupied by the individual gas molecules can't be neglected</td></tr> <tr> <td>There are no attractive forces between the gaseous molecules</td><td>There are attractive forces between the gaseous molecules</td></tr> </tbody> </table>	Ideal gases	Real gases	It obeys the gas law under all conditions of temperature and pressure	It obeys the gas law only at low pressure and high temperature	The individual gas molecules occupy negligible volume when compared to the total volume of the gas	The volume occupied by the individual gas molecules can't be neglected	There are no attractive forces between the gaseous molecules	There are attractive forces between the gaseous molecules
Ideal gases	Real gases								
It obeys the gas law under all conditions of temperature and pressure	It obeys the gas law only at low pressure and high temperature								
The individual gas molecules occupy negligible volume when compared to the total volume of the gas	The volume occupied by the individual gas molecules can't be neglected								
There are no attractive forces between the gaseous molecules	There are attractive forces between the gaseous molecules								
4	Give the mathematical expression that relates gas volume and moles? (Jun-19, Mar-23) Avagadro hypothesis gives the mathematical expression which relates gas volume and moles. $V \propto n$								
5	Can a Vander Waals gas with $a=0$ be liquefied? explain. When Vander Waals constant $a=0$ for a gas, then there will be no intermolecular forces of attraction between the gas molecules. So, it cannot be liquefied.								
6	Suppose there is a tiny sticky area on the wall of a container of gas. Molecules hitting this area stick there permanently. Is the pressure greater or less than on the ordinary area of walls? The pressure on the sticky wall is greater than on the ordinary area of walls.								
7	Explain the following observations a) Aerated water bottles are kept under water during summer As the temperature rises during the summer, the aerated water bottles containing CO_2 gas expands and the pressure increases (according to Gay-Lussac's Law). The aerated water bottle is likely to explode due to increase in pressure. To avoid this, soft drinks are kept in water. b) Liquid ammonia bottle is cooled before opening the seal - The vapour pressure of ammonia at room temperature is very high and hence the ammonia will evaporate unless the vapour pressure is decreased. - On cooling, the vapour pressure decreases so that the liquid remains 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 In summer, due to hot weather conditions, the air inside the tyre expands to a large volume due to heat as compared to winter, therefore inflated to lesser pressure in summer.								

	d) The size of a weather balloon becomes larger and larger as it ascends up into larger altitude As we move to higher altitude, the atmospheric pressure degree, Decreases, therefore the balloon can easily expand to a large volume.				
8	Give suitable explanation for the following facts about gases. a) Gases don't settle at the bottom of a container According to kinetic theory, gas molecules are moving continuously at random motion due to less attractive forces between the molecules. Hence, they do not settle at the bottom of a container. b) Gases diffuse through all the space available to them Due to the less attractive forces between the gaseous molecules the kinetic energy increases and diffuses through all the space available to them.				
9	Suggest why there is no hydrogen (H₂) in our atmosphere. Why does the moon have no atmosphere? - Hydrogen has tendency to combine with oxygen to form water vapour, so there is no hydrogen in our atmosphere. - The gravitational force on the moon is very less so all the gases escape easily from the moon's surface. hence, there is no atmosphere in the moon.				
10	Explain whether a gas approaches ideal behaviour or deviates from ideal behaviour if a) It is compressed to a smaller volume at constant temperature. - When the gas is compressed to a smaller volume at constant temperature, pressure increased. - At high pressure, the gas molecules are, close to each other and the interaction between gas molecules is increased. The gas deviate from ideal behaviour. b) The temperature is raised while keeping the volume constant - At constant volume, the pressure of a fixed mass of a gas is directly proportional to temperature. (Gay-Lussac's Law) - At high temperature keeping the volume constant, the pressure of the gas will increase. At high pressure the gas deviates from ideal behaviour. c) More gas is introduced into the same volume and at the same temperature - When more gases are introduced in to the same volume the pressure increases. - Due to more pressure, the attractive forces between the molecules increase. So, it deviates from ideal behaviour.				
11	Which of the following gases would you expect to deviate from ideal behaviour under conditions of low temperature F₂, Cl₂ or Br₂? Explain. - The conditions to deviate from ideal behaviour are high pressure and low temperature. In both these conditions the amount of attraction between molecules increases. - The larger the size of the molecule, greater the deviation from an ideal gas clearly bromine has the biggest size than others and deviates from the ideal gas behaviour.				
12	Distinguish between diffusion and effusion. (Jul-22, Jun-23) <table border="1"> <thead> <tr> <th>Diffusion</th><th>Effusion (Mar-19)</th></tr> </thead> <tbody> <tr> <td>This property of gas which involves the movement of the gas molecules through another gases is called diffusion.</td><td>Effusion is another process in which a gas escapes from a container through a very small hole.</td></tr> </tbody> </table>	Diffusion	Effusion (Mar-19)	This property of gas which involves the movement of the gas molecules through another gases is called diffusion.	Effusion is another process in which a gas escapes from a container through a very small hole.
Diffusion	Effusion (Mar-19)				
This property of gas which involves the movement of the gas molecules through another gases is called diffusion.	Effusion is another process in which a gas escapes from a container through a very small hole.				

13	Aerosol cans carry clear warning of heating of the can. Why? This is because the pressure will build up to so much that the can will burst. So the Aerosol cans carry clear warning of heating of the can
14	Would it be easier to drink water with a straw on the top of Mount Everest? It is difficult to drink water with a straw on the top of mount Everest. This is because at higher altitudes the pressure decreases and hence it is difficult to drink water through straw.
15	Write the Van der Waals equation for a real gas. (Mar-24) Explain the correction term for pressure and volume The van der Waals equation of state for real gases $\left(P + \frac{an^2}{V^2}\right) (V - nb) = nRT$ Pressure Correction: - The pressure of a gas is directly proportional to the force created by the bombardment of molecules on the walls of the container. - The speed of a molecule moving towards the wall of the container is reduced by the attractive forces exerted by its neighbours. - Hence, the measured gas pressure is lower than the ideal pressure of the gas. Hence, van der Waals introduced a correction term to this effect.  Van der Waals found out the forces of attraction experienced by a molecule near the wall are directly proportional to the square of the density of the gas. $P' \propto \rho^2$ $\rho = \frac{n}{V}$ $\Rightarrow P' \propto \frac{n^2}{V^2}$ $\Rightarrow P' = a \frac{n^2}{V^2}$ Where, n is the number of moles of gas V is the volume of the container where a is proportionality constant and depends on the nature of gas Therefore, $P_{\text{ideal}} = P + \frac{an^2}{V^2}$ Volume Correction - As every individual molecule of a gas occupies a certain volume, the actual volume is less than the volume of the container, V. - Van der Waals introduced a correction factor V' to this effect. Let us calculate the correction term by considering gas molecules as spheres. 

	V = excluded volume Excluded volume for two molecules = $\frac{4}{3} \pi (2r)^3 = 8 \left(\frac{4}{3} \pi r^3 \right) = 8 V_m$ where V_m is a volume of a single molecule Excluded volume for single molecule = $\frac{8 V_m}{2} = 4 V_m$ Excluded volume for n molecule = $n (4 V_m) = nb$ Where b is vander waals constant which is equal to $4 V_m$ $\Rightarrow V' = nb$ $V_{ideal} = V - nb$ Replacing the corrected pressure and volume in the ideal gas equation $PV=nRT$ we get the van der Waals equation of state for real gases as below, $\left(P + \frac{an^2}{V^2} \right) (V - nb) = nRT$ The constants a and b are van der Waals constants and their values vary with the nature of the gas. It is an approximate formula for the non-ideal gas.
16	Derive the values of critical constants in terms of van der Waals constants. (Mar-23) The van der Waals equation for n moles is $\left(P + \frac{an^2}{V^2} \right) (V - nb) = nRT \quad \dots\dots\dots (1)$ For 1 mole, $\left(P + \frac{a}{V^2} \right) (V - b) = RT \quad \dots\dots\dots (2)$ From the equation we can derive the values of critical constants P_c, V_c and T_c in terms of a and b, the van der Waals constants, On expanding the above equation, $PV + \frac{a}{V} - Pb - \frac{ab}{V^2} - RT = 0 \quad \dots\dots\dots (3)$ Multiply equation (3) by $\frac{V^2}{P}$ $\frac{V^2}{P} \left(PV + \frac{a}{V} - Pb - \frac{ab}{V^2} - RT \right) = 0$ $V^3 + \frac{aV}{P} - bV^2 - \frac{ab}{P} - \frac{RTV^2}{P} = 0 \quad \dots\dots\dots (4)$ When the above equation is rearranged in powers of 'V' $V^3 - \left[\frac{RT}{P} + b \right] V^2 + \left[\frac{a}{P} \right] V - \left[\frac{ab}{P} \right] = 0 \quad \dots\dots\dots (5)$ The equation (5) is a cubic equation in V. On solving this equation, we will get three solutions. At the critical point all these three solutions of V are equal to the critical volume V_c. The pressure and temperature become P_c and T_c respectively. i.e, $V = V_c$ $V - V_c = 0$ $(V - V_c)^3 = 0$ $V^3 - 3V_c V^2 + 3V_c^2 V - V_c^3 = 0 \quad \dots\dots\dots (6)$ As equation (5) is identical with equation (6) we can equate the coefficients of V^2, V and constant terms in equation (5) and (6).

$$\cancel{3} V_C \cancel{V_C}^2 = \cancel{\left[\frac{RT_C}{P_C} + b \right]} \cancel{V_C}^2$$

$$3 V_C = \frac{RT_C}{P_C} + b \dots\dots\dots (7)$$

$$3V_C^2 = \frac{a}{P_C} \dots\dots\dots (8)$$

$$V_C^3 = \frac{ab}{P_C} \dots\dots\dots (9)$$

Divide equation (9) by equation (8),

$$\frac{\cancel{V_C}^3}{3\cancel{V_C}^2} = \frac{\cancel{\frac{ab}{P_C}}}{\frac{a}{\cancel{P_C}}}$$

$$\frac{V_C}{3} = b$$

i.e. $V_C = 3b \dots\dots\dots (10)$

the value of V_C is substituted in equation (8),

$$3V_C^2 = \frac{a}{P_C}$$

$$P_C = \frac{a}{3 V_C^2} = \frac{a}{3(3b^2)} = \frac{a}{3 \times 9b^2} = \frac{a}{27b^2}$$

$$P_C = \frac{a}{27b^2} \dots\dots\dots (11)$$

substituting the values of V_C and P_C in equation (7)

$$3 V_C = b + \frac{RT_C}{P_C}$$

$$3 (3b) = b + \frac{RT_C}{\left(\frac{a}{27 b^2}\right)}$$

$$9b - b = \left(\frac{RT_C}{a}\right) 27b^2$$

$$8b = \frac{T_C R 27b^2}{a}$$

$$\therefore T_C = \frac{8ab}{27 R b^2} = \frac{8 a}{27 R b}$$

$$T_C = \frac{8 a}{27 R b} \dots\dots\dots (12)$$

The critical constants can be calculated using the values of van der waals constant of a gas and vice versa.

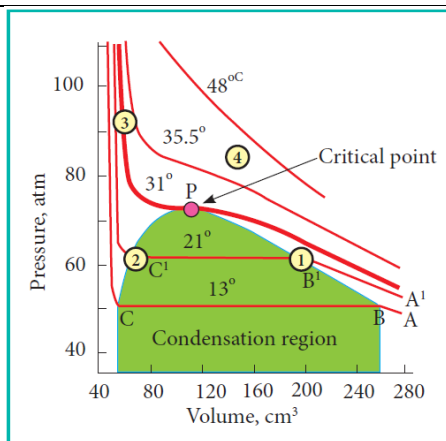
$$a = 3 V_C^2 P_C \text{ and } b = \frac{V_C}{3}$$

17 **Why do astronauts have to wear protective suits when they are on the surface of moon?**

- Astronauts must wear space suits whenever they leave a space craft. In a space there is no air to breath and no air pressure.
- Space is extremely cold and filled with dangerous radiation without protection an astronauts would quickly die in space.
- Space suits are specially designed to protect astronauts from the cold, radiation and low pressure they also provide air to breathe.

18	When ammonia combines with HCl, NH_4Cl is formed as white dense fumes. Why do more fumes appear near HCl? - The Molecular weight of Ammonia is less than HCl. - The rate of diffusion is inversely proportional to the molecular weight of the gas. Lower the molecular weight, faster is the diffusion. - Hence ammonia diffuses faster than HCl and thus appear as dense whiter fumes near HCl.
19	What happens when a balloon is moved from an ice-cold water bath to a boiling water bath? When a balloon is moved from an ice-cold water bath to a boiling water bath, the temperature of the gas increases. As a result, the gas molecules inside the balloon move faster and gas expands. Hence, the volume increases.
20	Explain the following laws. 1) Charles Law: For a fixed mass of a gas at constant pressure, the volume is directly proportional to its temperature (K). at constant P and n, $V \propto T$ (or) $\frac{V}{T} = \text{Constant}$ 2) Gay-Lussac's Law: At constant volume the pressure of a fixed mass of a gas is directly proportional to temperature. $P \propto T$ or $\frac{P}{T} = \text{Constant k}$ 3) Dalton's law of partial pressures (May-22, May-24): The total pressure of a mixture of non-reacting gases is the sum of partial pressures of the gases present in the mixture. $P_{\text{total}} = P_1 + P_2 + P_3 + \dots$ 4) Graham's Law of Diffusion: The rate of diffusion or effusion is inversely proportional to the square root of molar mass. Rate of diffusion $\propto \frac{1}{\sqrt{M}}$ 5) Avogadro's Hypothesis: Avogadro hypothesised that equal volumes of all gases under the same conditions of temperature and pressure contain equal number of molecules. $V \propto n$
21	Explain the below: 1) Critical temperature (T_c): It is defined as the temperature above which it cannot be liquefied at any pressure. 2) Critical pressure (P_c): It is defined as the minimum pressure required to liquefy 1 mole of a gas at its critical temperature. 3) Critical volume (V_c): It is defined as the volume occupied by 1 mole of a gas at its critical temperature and critical pressure. 4) Boyle temperature: The temperature at which a real gas obeys ideal gas law over an appreciable range of pressure is called Boyle temperature or Boyle point.
22	Define the below: 1) Joule-Thomson effect (Jun-23): The phenomenon of lowering of temperature when a gas is made to expand adiabatically from a region of high pressure into a region of low pressure is known as Joule- Thomson effect. 2) Inversion temperature (T_i) (Jun-19): The temperature below which a gas obeys Joule-Thomson effect is called inversion temperature (T_i). This value is given using van der waals constants a and b. $T_i = \frac{2a}{Rb}$

23	Give the significance of van der Waals constants? - Van der waal's constant 'a' is a measure of the attractive force between gas molecules. As the value of 'a' increases, the force of attraction between the molecules increases. - Van der waals constant 'b' is the measure of volume of a gas. Its value is the exact volume of 4 times of a molecule ($b = 4 V_m$). It is assigned as excluded volume of a molecule.														
24	H₂ And He gases are not liquefied using high pressure at room temperature. Why? H₂ and He gases have critical temperature values lower than room temperature. Therefore, the Joule Thomson effect can be used for effective cooling.														
25	Differentiate ideal and real gases? <table border="1"> <thead> <tr> <th>Ideal gas</th><th>Real gas</th></tr> </thead> <tbody> <tr> <td>Ideal gases obey the gas law under all conditions of temperature and pressure</td><td>Real gases only obey at low pressure and high temperature</td></tr> <tr> <td>No gas is ideal.</td><td>All gases are real gases.</td></tr> <tr> <td>The volume occupied by the gas is very small compare to the total volume of the gas</td><td>The volume occupied by the gas is not small compare to the total volume of the gas</td></tr> <tr> <td>There is no force of attraction between the gas molecules</td><td>There is a force of attraction between the gas molecules</td></tr> <tr> <td>They obey Ideal gas equation ($PV=nRT$)</td><td>They obey the Van der waals equation. $\left(P + \frac{an^2}{V^2}\right) (V - nb) = nRT$</td></tr> <tr> <td>$Z = 1$</td><td>$Z \neq 1$</td></tr> </tbody> </table>	Ideal gas	Real gas	Ideal gases obey the gas law under all conditions of temperature and pressure	Real gases only obey at low pressure and high temperature	No gas is ideal.	All gases are real gases.	The volume occupied by the gas is very small compare to the total volume of the gas	The volume occupied by the gas is not small compare to the total volume of the gas	There is no force of attraction between the gas molecules	There is a force of attraction between the gas molecules	They obey Ideal gas equation ($PV=nRT$)	They obey the Van der waals equation. $\left(P + \frac{an^2}{V^2}\right) (V - nb) = nRT$	$Z = 1$	$Z \neq 1$
Ideal gas	Real gas														
Ideal gases obey the gas law under all conditions of temperature and pressure	Real gases only obey at low pressure and high temperature														
No gas is ideal.	All gases are real gases.														
The volume occupied by the gas is very small compare to the total volume of the gas	The volume occupied by the gas is not small compare to the total volume of the gas														
There is no force of attraction between the gas molecules	There is a force of attraction between the gas molecules														
They obey Ideal gas equation ($PV=nRT$)	They obey the Van der waals equation. $\left(P + \frac{an^2}{V^2}\right) (V - nb) = nRT$														
$Z = 1$	$Z \neq 1$														
26	What is compressibility factor(Z) (Sep-20)? How does it relate with ideal gas volume and real gas volume? The deviation of real gases from ideal behaviour is measured in terms of a ratio of PV to nRT. This is termed as compressibility factor. Mathematically, $Z = \frac{PV}{nRT}$ For real gases it can be rewritten as, $Z = \frac{PV_{\text{real}}}{nRT}$(1) For ideal gases $V_{\text{ideal}} = \frac{nRT}{P}$(2) Comparing equations (1) and (2), $Z = \frac{V_{\text{real}}}{V_{\text{ideal}}}$ Here, V_{real} = molar volume of real gases V_{ideal} = molar volume of ideal gases														
27	Explain Pressure-Volume isotherms of Carbon dioxide using Andrew's isotherm? - Thomas Andrew gave the first complete data on pressure-volume- temperature of a substance in the gaseous and liquid states. He plotted isotherms of carbon dioxide at different temperatures, from the plots we can infer the following. - At low temperature isotherms, for example, at 13°C as the pressure increases, the volume decreases along AB and is a gas until the point B is reached. At B, a liquid separates along the line BC, both the liquid and gas co-exist and the pressure remains constant. At C, the gas is completely converted into liquid. If the pressure is higher than at C, only the liquid is compressed so, there is no significant change in the volume.														



- The successive isotherms show similar trend with the shorter flat region. i.e. The volume range in which the liquid and gas coexist becomes shorter. At the temperature of 31.1°C the length of the shorter portion is reduced to zero at point P. In other words, the CO₂ gas is liquefied completely at this point. This temperature is known as the liquefaction temperature or critical temperature of CO₂.
- At this point the pressure is 73 atm. Above this temperature CO₂ remains as a gas at all pressure values.

28 **What are the methods used for liquefaction of gases? (Sep-20, Jun-23)**

- 1) In Linde's method**, Joule-Thomson effect is used to get liquid air or any other gas.
- 2) In Claude's process**, the gas is allowed to perform mechanical work in addition to Joule-Thomson effect so that more cooling is produced.
- 3) In Adiabatic process**, cooling is produced by removing the magnetic property of magnetic material such as gadolinium sulphate. By this method, a temperature of 10⁻⁴ K i.e. as low as 0 K can be achieved.

29 **State and explain Dalton's law of partial pressures?**

- The total pressure of a mixture of non-reacting gases is the sum of partial pressures of the gases present in the mixture.
- The partial pressure of a component gas is the pressure that it would exert if it were present alone in the same volume and temperature. This is known as Dalton's law of partial pressures.
- For a mixture containing three gases 1, 2 and 3 with partial pressures p_1 , p_2 and p_3 in a container with volume V , the total pressure P_{total} will be given by,

$$P_{\text{total}} = p_1 + p_2 + p_3$$

- Assuming that the gases behave ideally,

$$P_1 = n_1 \frac{RT}{V}; \quad P_2 = n_2 \frac{RT}{V}; \quad P_3 = n_3 \frac{RT}{V};$$

$$P_{\text{total}} = n_1 \frac{RT}{V} + n_2 \frac{RT}{V} + n_3 \frac{RT}{V}$$

$$= (n_1 + n_2 + n_3) \frac{RT}{V}$$

$$P_{\text{total}} = n_{\text{total}} \frac{RT}{V}$$

30	The transition temperatures of H₂O, NH₃ and CO₂ are 647.4K, 405.5K and 304.2K respectively. When we perform cooling from 700K temperature, find out which turns into liquid first and which turns into liquid last? - The temperature above which a gas cannot be liquefied at high pressure is called transition temperature. - Water first liquefies when cooled from a temperature of 700K. It is followed by ammonia and finally carbon dioxide.
31	why do all passenger aeroplane cabins have to be artificially pressurised? - Most commercial aeroplanes fly at about 30,000 feet altitude. The pressure decreases with the increase in altitude as there are fewer molecules per unit volume of air. - Hence, while at air, the pressure around the aeroplane will be so low that one could pass out for lack of oxygen. - For this reason, aeroplanes cabins are artificially pressurized.
32	Why does a mountaineer feel a slight pain in his ears? - The effect of drop in pressure is felt as a little pain in the ears by a person while ascending a mountain in a plain. - Though the external pressure drops, the internal pressure within the ear cavities remains the same. This creates an imbalance. - The greater internal pressure forces the eardrum to bulge outward causing pain. - The excess air within the ear cavities escapes after some time and with the help of yawning and thereby equalizing the internal and external pressure to relieve the pain.
33	Derive the ideal gas equation? (June 2019 & April 2022) Boyle's law: $V \propto \frac{1}{P}$ Charles law: $V \propto T$ Avogadro law: $V \propto n$ By combining above equations, $V \propto \frac{nT}{P}$ $V = \frac{nRT}{P}$ $PV = nRT$ This is called as ideal gas equation

7. THERMODYNAMICS

1	State the first law of thermodynamics. (Sep-21) The first law of thermodynamics, known as the law of conservation of energy, states that "Energy can neither be created nor destroyed, but may be converted from one form to another".
2	Define Hess's law of constant heat summation. (Sep-21, Mar-24) According to Hess's law, the enthalpy change of a reaction either at constant volume or constant pressure is the same whether it takes place in a single or multiple steps provided the initial and final states are same.
3	Explain intensive properties with two examples. (Sep-20, Jun-23) The property that is independent of the mass or the size of the system is called an intensive property. Examples: Refractive index, Surface tension, density, temperature, Boiling point, Freezing point, molar volume, etc., Explain extensive properties with two examples. The property that depends on the mass or the size of the system is called an extensive property. Examples: Volume, Number of moles, Mass, Internal energy, etc.,
4	Define the following terms: a. isothermal process An isothermal process is defined as one in which the temperature of the system remains constant, during the change from its initial to final state. The system exchanges heat with its surrounding and the temperature of the system remains constant. $dT = 0$ b. adiabatic process An adiabatic process is defined as one in which there is no exchange of heat (q) between the system and surrounding during the process. This condition is attained by thermally insulating the system. $q = 0$ c. isobaric process An isobaric process is defined as one in which the pressure of the system remains constant during its change from the initial to final state. $dP = 0$ d. isochoric process An isochoric process is defined as the one in which the volume of system remains constant during its change from initial to final state. $dV = 0$
5	What is the usual definition of entropy? What is the unit of entropy? (Jul-22) Entropy is a measure of the molecular disorder (randomness) of a system. $dS = \frac{dq_{rev}}{T}; \quad \text{SI unit} = \text{JK}^{-1}$
6	Predict the feasibility of a reaction when i) both ΔH and ΔS positive Both ΔH and ΔS positive means reaction is spontaneous at high temperature, i.e, ΔG becomes negative at high temperature only. ii) both ΔH and ΔS negative Both ΔH and ΔS negative means reaction is spontaneous at low temperature, i.e, ΔG becomes negative at low temperature only. iii) ΔH decreases but ΔS increases ΔH decreases but ΔS increases means reaction is spontaneous at all temperatures, i.e, ΔG is negative at all temperatures.

7	Define is Gibb's free energy. (Jul-22) It is defined as the "available energy" to do work in a system. $G = H - TS$ G = Gibb's energy, H = Enthalpy T = Temperature S = Entropy
8	Define enthalpy of combustion. It is defined as "The change in enthalpy of a system when one mole of the substance is completely burnt in excess of air or oxygen". It is denoted by ΔH_c
9	Define molar heat capacity. Give its unit. (Jun-19) It is defined as "The amount of heat absorbed by one mole of the substance to raise its temperature by 1 kelvin". SI unit: $\text{JK}^{-1} \text{mol}^{-1}$
10	Define the calorific value of food. What is the unit of calorific value? The calorific value is defined as the amount of heat produced in calories (or joules) when one gram of the substance is completely burnt. SI unit: JKg^{-1}, However, it is usually expressed in Cal g^{-1}.
11	Define enthalpy of neutralization. It is defined as "The change in enthalpy when one gram equivalent of an acid is completely neutralised by one gram equivalent of a base or vice versa in dilute solution".
12	What is lattice energy? Lattice energy is defined as the amount of energy required to completely remove the constituent ions from its crystal lattice to an infinite distance from one mole of crystal.
13	What are state and path functions? Give two examples. • State function (Mar-23): A thermodynamic system can be defined by using the variables P, V, T and 'n'. • A state function is a thermodynamic property of a system • which has a specific value for a given state and does not depend on the path (or manner) by which the particular state is reached. • Example: Pressure (P), Volume (V), Temperature(T), Internal energy (U), Enthalpy (H), free energy (G) etc. ❖ Path functions (Jul-22, Mar-23): ❖ A path function is a thermodynamic property of the system. ❖ whose value depends on the path by which the system changes from its initial to final states. ❖ Example: Work (w), Heat (q).
14	Give Kelvin statement of second law of thermodynamics. Kelvin-Planck statement: It is impossible to construct a machine that absorbs heat from a hot source and converts it completely into work by a cyclic process without transferring a part of heat to a cold sink.
15	The equilibrium constant of a reaction is 10, what will be the sign of ΔG? Will this reaction be spontaneous? $\Delta G = - 2.303 RT \log K$ $= - 2.303 RT \log (10) \quad (\because \log 10 = 1)$ $\Delta G = - 2.303 RT$ ΔG is negative. So the reaction will be spontaneous.

16	Enthalpy of neutralization is always a constant when a strong acid is neutralized by a strong base: account for the statement. The reason for this can be explained on the basis of Arrhenius theory of acids and bases which states that strong acids and strong bases completely ionise in aqueous solution to produce H^+ and OH^- ions respectively. $H^+_{(aq)} + OH^-_{(aq)} \longrightarrow H_2O_{(l)} \quad \Delta H = -57.32 \text{ KJ}$ The value does not changes depending on the nature of acid or base used.										
17	State the third law of thermodynamics. (Mar-19) - The entropy of pure crystalline substance at absolute zero is zero. - 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. - Mathematically, $\lim_{T \rightarrow 0} S = 0$ for a perfectly ordered crystalline state.										
18	Write down the Born-Haber cycle for the formation of $CaCl_2$? Born-Haber cycle for the formation of $CaCl_2$ $\begin{array}{ccccc} Ca_{(s)} + & Cl_{2(g)} & \xrightarrow{\Delta H_f} & & CaCl_{2(s)} \\ \downarrow \Delta H_1 & \downarrow \Delta H_2 & & \uparrow \Delta H_5 & \\ & 2Cl_{(g)} + 2e^- & \xrightarrow{\Delta H_4} & & 2Cl^-_{(g)} \\ & & & & + \\ & & & & Ca^{2+} + 2e^- \\ \uparrow \Delta H_3 & & & & \\ Ca_{(g)} & & & & \end{array}$ ΔH_1 = Heat of Sublimation of $Ca_{(s)}$ ΔH_2 = Dissociation Energy of $Cl_{2(g)}$ ΔH_3 = Ionisation Energy of $Ca_{(g)}$ ΔH_4 = Electron Affinity of $Cl_{(g)}$ ΔH_5 = Lattice Energy of $CaCl_2$ ΔH_f = Heat of Formation of $CaCl_2$ $\Delta H_f = \Delta H_1 + \Delta H_2 + \Delta H_3 + \Delta H_4 + \Delta H_5$										
19	Identify the state and path functions out of the following: a) Enthalpy b) Entropy c) Heat d) Temperature e) Work f) Free energy. <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>State functions</th><th>Path functions</th></tr> </thead> <tbody> <tr> <td>1. Enthalpy</td><td>1. Heat</td></tr> <tr> <td>2. Entropy</td><td>2. Work</td></tr> <tr> <td>3. Temperature</td><td></td></tr> <tr> <td>4. Free energy</td><td></td></tr> </tbody> </table>	State functions	Path functions	1. Enthalpy	1. Heat	2. Entropy	2. Work	3. Temperature		4. Free energy	
State functions	Path functions										
1. Enthalpy	1. Heat										
2. Entropy	2. Work										
3. Temperature											
4. Free energy											
20	State the various statements of second law of thermodynamics. (Mar-23) 1. Entropy statement: The entropy of an isolated system increases during a spontaneous process. Entropy is a measure of the molecular disorder (randomness) of a system. 2. Kelvin-Planck statement: It is impossible to construct a machine that absorbs heat from a hot source and converts it completely into work by a cyclic process without transferring a part of heat to a cold sink. 3. Clausius statement: It is impossible to transfer heat from a cold reservoir to a hot reservoir without doing some work. 4. Efficiency: $\text{Efficiency} = \frac{\text{work performed}}{\text{heat absorbed}} \quad ; \quad \text{Efficiency} = \left[1 - \frac{T_c}{T_h} \right] \times 100$										
21	Write Zeroth law of thermodynamics? (Sep-20) The law states that 'If two systems are separately in thermal equilibrium with a third one, then they tend to be in thermal equilibrium with themselves'.										

22	What are spontaneous reactions? What are the conditions for the spontaneity of a process? (May-22) A reaction that occurs under the given set of conditions without any external driving force is called a spontaneous reaction. Criteria for spontaneity of a process: If the enthalpy change of a process is negative, then the process is exothermic and may be spontaneous. ($\Delta H < 0$) If the entropy change of a process is positive, then the process may occur spontaneously. ($\Delta S > 0$) The Gibbs free energy should be negative. ($\Delta G < 0$)
23	Define cyclic process? When a system returns to its original state after completing a series of changes, then it is said that a cycle is completed. This process is known as a cyclic process. For a cyclic process $dU = 0$, $dH = 0$, $dP=0$, $dV=0$, $dT=0$
24	List the characteristics of internal energy. (May-22, Mar-24) - 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. ($\Delta U_{\text{cyclic}} = 0$) - If $U_f < U_i$, then ΔU would be negative. - If $U_f > U_i$, then ΔU would be positive.
25	Derive the relation between C_p and C_v for an ideal gas. As we know, $C_p = \left(\frac{\partial H}{\partial T}\right)_p$ and $C_v = \left(\frac{\partial U}{\partial T}\right)_v$ From the definition of enthalpy, $H = U + PV$ (1) for 1 mole of an ideal gas, $PV = nRT$ (2) By substituting eqn. (2) in eqn. (1), $H = U + nRT$ (3) Differentiating the above equation with respect to T, $\frac{\partial H}{\partial T} = \frac{\partial U}{\partial T} + nR \frac{\partial T}{\partial T}$ $C_p = C_v + nR(1)$ $C_p - C_v = nR$ $\therefore \left(\frac{\partial H}{\partial T}\right)_p = C_p$ $\therefore \left(\frac{\partial U}{\partial T}\right)_v = C_v$
26	List the characteristics of Gibbs free energy. (Sep-21) $G = H - TS$; where H, S are state functions so G is also a state function. - Gibbs free energy (G) is an extensive property - G has a single value for the thermodynamic state of the function. $\Delta G < 0$ (or) $\Delta G =$ negative value - spontaneous process $\Delta G > 0$ (or) $\Delta G =$ positive value – non-spontaneous process $\Delta G = 0$ equilibrium process. $-\Delta G = W - P\Delta V$ Here, $-P\Delta V$ represents the work done due to expansion against a constant external pressure. Therefore, it is clear that the decrease in free energy ($-\Delta G$) accompanying a process taking place at constant temperature and pressure is equal to the maximum work obtainable from the system other than the work of expansion.

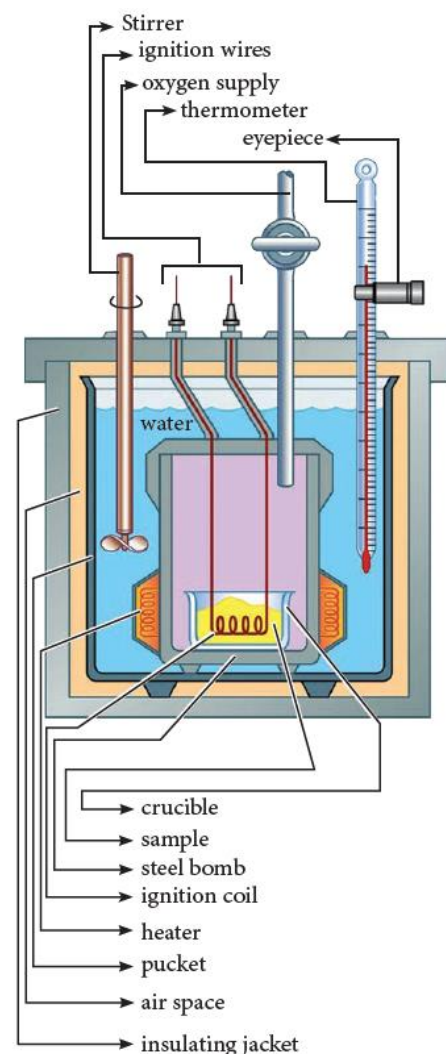
27 **Explain how heat absorbed at constant volume is measured using bomb calorimeter with a neat diagram.**

- For chemical reactions, heat evolved at constant volume, is measured in a bomb calorimeter.
- The inner vessel (the bomb) and its cover are made of strong steel. The cover is fitted tightly to the vessel by means of metal lid and screws.
- A weighed amount of the substance is taken in a platinum cup connected with electrical wires for striking an arc instantly to kindle combustion.
- The bomb is then tightly closed and pressurized with excess oxygen. The bomb is immersed in water, in the inner volume of the calorimeter.
- A stirrer is placed in the space between the wall of the calorimeter and the bomb, so that water can be stirred, uniformly. The reaction is started by striking the substance through electrical heating.
- A known amount of combustible substance is burnt in oxygen in the bomb. Heat evolved during the reaction is absorbed by the calorimeter as well as the water in which the bomb is immersed. The change in temperature is measured using a Beckman thermometer.
- Since the bomb is sealed its volume does not change and hence the heat measurements is equal to the heat of combustion at a constant volume (ΔU_c°).
- The amount of heat produced in the reaction (ΔU_c°) is equal to the sum of the heat absorbed by the calorimeter and water.
- Heat absorbed by the calorimeter, $q_1 = k \Delta T$
- where k is a calorimeter constant equal to $m_c C_c$ (m_c is mass of the calorimeter and C_c is heat capacity of calorimeter)
- Heat absorbed by the water, $q_2 = m_w C_w \Delta T$
- where m_w is molar mass of water
- C_w is molar heat capacity of water ($75.29 \text{ JK}^{-1} \text{ mol}^{-1}$)
- Therefore $U_c = q_1 + q_2$

$$= k \Delta T + m_w C_w \Delta T$$

$$= (k + m_w C_w) \Delta T$$
- Calorimeter constant can be determined by burning a known mass of standard sample (benzoic acid) for which the heat of combustion is known (-3227 kJmol^{-1})
- The enthalpy of combustion at constant pressure of the substance is calculated from the below equation

$$\Delta H_c^\circ (\text{pressure}) = \Delta U_c^\circ (\text{Vol}) + \Delta n_g RT$$



28 **Calculate the work involved in expansion and compression process.**

Let us consider a cylinder which contains 'n' moles of an ideal gas fitted with a frictionless piston of cross-sectional area A . The total volume of the gas inside is V_i and pressure of the gas inside is P_{int} .

If the external pressure P_{ext} is greater than P_{int} , the piston moves inward till the pressure inside becomes equal to P_{ext} . Let this change be achieved in a single step and the final volume be V_f .

In this case, the work is done on the system (+w). It can be calculated as follows

$$w = - F \cdot \Delta x \quad \dots\dots\dots (1)$$

where Δx is the distance moved by the piston during the compression and F is the force acting on the gas.

$$F = P_{\text{ext}} A \quad \dots\dots\dots (2)$$

Substituting eqn. (2) in eqn. (1)

$$w = - P_{\text{ext}} \cdot A \cdot \Delta x$$

$$A \cdot \Delta x = \text{change in volume} = V_f - V_i$$

$$w = - P_{\text{ext}} \cdot (V_f - V_i) \quad \dots\dots\dots (3)$$

$$w = - P_{\text{ext}} (- \Delta V) \quad \dots\dots\dots (4)$$

$$w = P_{\text{ext}} \cdot \Delta V$$

Since work is done on the system, it is a positive quantity.

If the pressure is not constant, but changes during the process such that it is always infinitesimally greater than the pressure of the gas, then, at each stage of compression, the volume decreases by an infinitesimal amount, dV . In such a case we can calculate the work done on the gas by the relation

$$w_{\text{rev}} = - \int_{V_i}^{V_f} P_{\text{ext}} dV$$

In a compression process, P_{ext} the external pressure is always greater than the pressure of the system.

$$P_{\text{ext}} = (P_{\text{int}} + dP)$$

In an expansion process, the external pressure is always less than the pressure of the system

$$P_{\text{ext}} = (P_{\text{int}} - dP)$$

When pressure is not constant and changes in infinitesimally small steps (reversible conditions) during compression from V_i to V_f , the P - V plot looks like in figure. Work done on the gas is represented by the shaded area.

In general case we can write, $P_{\text{ext}} = (P_{\text{int}} \pm dP)$. Such processes are called reversible processes. For a compression process work can be related to internal pressure of the system under reversible conditions by writing equation

$$w_{\text{rev}} = - \int_{V_i}^{V_f} P_{\text{int}} dV$$

For a given system with an ideal gas,

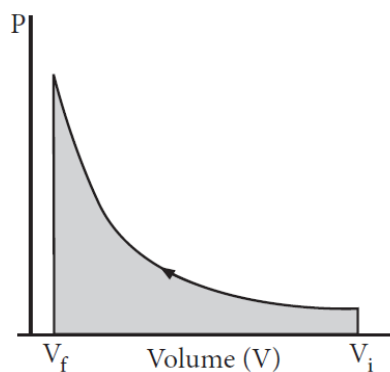
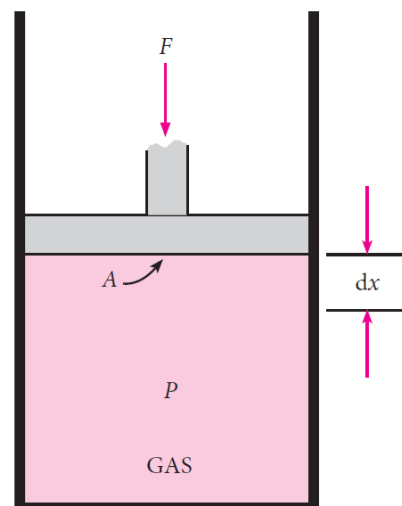
$$P_{\text{int}} V = nRT$$

$$P_{\text{int}} = \frac{nRT}{V}$$

$$w_{\text{rev}} = - \int_{V_i}^{V_f} \frac{nRT}{V} dV$$

$$w_{\text{rev}} = - nRT \int_{V_i}^{V_f} \left(\frac{dV}{V} \right)$$

$$w_{\text{rev}} = - nRT \ln \left(\frac{V_f}{V_i} \right)$$



	$W_{\text{rev}} = - 2.303 nRT \log \left(\frac{V_f}{V_i} \right)$ If $V_f > V_i$ (expansion), the sign of work done by the process is negative. If $V_f < V_i$ (compression) the sign of work done on the process is positive.
29	Derive the relation between ΔH and ΔU for an ideal gas. Explain each term involved in the equation. (Sep-20, Jun-23) Consider a closed system of gases which are chemically reacting to form gaseous products at constant temperature and pressure with V_i and V_f as the total volumes of the reactant and product gases respectively, and n_i and n_f as the number of moles of gaseous reactants and products, then, For reactants (initial state), $PV_i = n_i RT \dots\dots\dots (1)$ For products (final state), $PV_f = n_f RT \dots\dots\dots (2)$ eqn. (2) - eqn. (1), $P (V_f - V_i) = (n_f - n_i) RT$ $P\Delta V = \Delta n_g RT \dots\dots\dots (3)$ As we know, $\Delta H = \Delta U + P\Delta V \dots\dots\dots (4)$ Substituting eqn. (3) in eqn. (4), $\Delta H = \Delta U + \Delta n_g RT \dots\dots\dots (5)$
30	Suggest and explain an indirect method to calculate lattice enthalpy of sodium chloride crystal. - Let us use the Born - Haber cycle for determining the lattice enthalpy of NaCl as follows. - Since the reaction is carried out with reactants in elemental forms and products in their standard states, at 1 bar, the overall enthalpy change of the reaction is also the enthalpy of formation for NaCl. - Also, the formation of NaCl can be considered in 5 steps. - The sum of the enthalpy changes of these steps is equal to the enthalpy change for the overall reaction from which the lattice enthalpy of NaCl is calculated. - Let us calculate the lattice energy of sodium chloride using Born-Haber cycle <pre> graph TD A["Na(s) + 1/2 Cl2(g)"] -- "ΔHf" --> B["NaCl(s)"] A -- "ΔH1" --> C["Na(g)"] C -- "ΔH2" --> D["Na+(g)"] A -- "ΔH3" --> E["Cl(g)"] E -- "ΔH4" --> F["Cl-(g)"] D -- "U" --> B F -- "U" --> B </pre> ΔH_f = heat of formation of sodium chloride = $- 411.3 \text{ kJ mol}^{-1}$ ΔH_1 = heat of sublimation of Na(g) = $108.7 \text{ kJ mol}^{-1}$ ΔH_2 = ionisation energy of Na(g) = $495.0 \text{ kJ mol}^{-1}$ ΔH_3 = dissociation energy of $\text{Cl}_2(\text{g})$ = 244 kJ mol^{-1} ΔH_4 = Electron affinity of Cl(S) = $- 349.0 \text{ kJ mol}^{-1}$ U = lattice energy of NaCl $\Delta H_f = \Delta H_1 + \Delta H_2 + \frac{1}{2} \Delta H_3 + \Delta H_4 + U$

	$U = (\Delta H_f) - (\Delta H_1 + \Delta H_2 + \frac{1}{2} \Delta H_3 + \Delta H_4)$ $U = (-411.3) - (108.7 + 495.0 + 122 - 349)$ $U = (-411.3) - (376.7)$ $U = -788 \text{ kJ mol}^{-1}$ This negative sign in lattice energy indicates that the energy is released when sodium is formed from its constituent gaseous ions Na^+ and Cl^-.
31	How do you measure the heat change at constant pressure using a coffee cup calorimeter? 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 ($75.29 \text{ J K}^{-1} \text{ mol}^{-1}$.)

8. PHYSICAL AND CHEMICAL EQUILIBRIUM

1	If there is no change in concentration, why is the equilibrium state considered dynamic? - 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.
2	For a given reaction at a particular temperature, the equilibrium constant has constant value. Is the value of Q also constant? Explain. - 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. - At equilibrium Q is equal to K_c at a particular temperature. - Once the equilibrium is attained, there is no change in the Q value.
3	What is the relation between K_P and K_C. Give one example for which K_P is equal to K_C. $K_P = K_C (RT)^{\Delta n_g}$ $\Delta n_g = (n_P - n_R)$ If $n_P = n_R$ $\Delta n_g = 0$, so, $K_P = K_C$ Eg. $\text{H}_{2(g)} + \text{I}_{2(g)} \rightleftharpoons 2\text{HI}_{(g)}$ $\Delta n_g = 2 - 2 = 0$, so, $K_P = K_C$
4	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? If $Q > K_c$, the reaction will proceed in the reverse direction i.e., formation of reactants.

5	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. For a gaseous homogeneous reaction at equilibrium, if the number of moles of products are greater than the number of moles of reactants, K_C will be smaller than K_P. Eg. $\text{PCl}_{5(g)} \rightleftharpoons \text{PCl}_{3(g)} + \text{Cl}_{2(g)}$ $\Delta n_g = 2 - 1 = 1$, so, $K_P = K_C (RT)^1$ $\therefore K_P > K_C$
6	For the reaction, $\text{A}_{2(g)} + \text{B}_{2(g)} \rightleftharpoons 2\text{AB}_{(g)}$; ΔH - is -ve. the following molecular scenes represent different reaction mixture (A – green, B – blue) Closed ← System At equilibrium (x) (y) i) Calculate the equilibrium constant K_P and K_C. $K_C = \frac{[\text{AB}]^2}{[\text{A}_2][\text{B}_2]} = \frac{\left[\frac{4}{V}\right]^2}{\left[\frac{2}{V}\right]\left[\frac{2}{V}\right]} = \frac{16}{4} = 4$ $\Rightarrow K_P = K_C (RT)^{\Delta n_g}$ $K_P = 4 (RT)^0 = 4$ ii) For the reaction mixture represented by scene (x), (y) the reaction proceeds in which directions? i) At stage 'x': $Q = \frac{[\text{AB}]^2}{[\text{A}_2][\text{B}_2]} = \frac{\left[\frac{6}{V}\right]^2}{\left[\frac{2}{V}\right]\left[\frac{1}{V}\right]} = \frac{36}{2} = 18$ $K_C = 4$, $Q = 18$, $\therefore Q > K_C$ So, the reaction will proceed in the reverse direction. ii) At stage 'y': $Q = \frac{[\text{AB}]^2}{[\text{A}_2][\text{B}_2]} = \frac{\left[\frac{3}{V}\right]^2}{\left[\frac{3}{V}\right]\left[\frac{3}{V}\right]} = \frac{9}{9} = 1$ $K_C = 4$, $Q = 1$, $\therefore Q < K_C$ So, the reaction will proceed in the forward direction. iii) What is the effect of increase in pressure for the mixture at equilibrium. At equilibrium $n_P = n_r = 2$; $\therefore \Delta n_g = 2 - 2 = 0$ So, the pressure does not affect the reaction.
7	State Le-Chatelier principle. (Mar-19, Mar-23) It states that “If a system at equilibrium is disturbed, then the system shifts itself in a direction that nullifies the effect of that disturbance.”
8	State law of mass action. (Mar-23) “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”. $\text{Rate} \propto [\text{Reactant}]^x$ where, x is the stoichiometric coefficient of the reactant and the square bracket represents the active mass (concentration) of the reactants.

9	Consider the following reactions, a) $\text{H}_{2(g)} + \text{I}_{2(g)} \rightleftharpoons 2 \text{HI}$ b) $\text{CaCO}_{3(s)} \rightleftharpoons \text{CaO}_{(s)} + \text{CO}_{2(g)}$ c) $\text{S}_{(s)} + 3\text{F}_{2(g)} \rightleftharpoons \text{SF}_{6(g)}$ In each of the above reaction find out whether you have to increase (or) decrease the volume to increase the yield of the product. a) $\Delta n_g = 2 - 2 = 0$; So, there is no effect on changing the volume. b) $\Delta n_g = 2 - 1 = 1$; $\Delta n_g = +ve$ So, the increase in volume, favours the forward reaction to increase the yield of the product. c) $\Delta n_g = 1 - 4 = -3$; $\Delta n_g = -ve$ So, the decrease in volume, favours the forward reaction to increase the yield of the product.																				
10	Explain how will you predict the direction of an equilibrium reaction. The direction of the reaction can be predicted by comparing Q with K_C. • 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.																				
11	Derive a general expression for the equilibrium constant K_P and K_C for the reaction $3\text{H}_{2(g)} + \text{N}_{2(g)} \rightleftharpoons 2\text{NH}_{3(g)}$. (Jul-22) <table border="1"> <thead> <tr> <th></th><th>N_2</th><th>H_2</th><th>NH_3</th></tr> </thead> <tbody> <tr> <td>Initial number of moles</td><td>a</td><td>b</td><td>0</td></tr> <tr> <td>Number of moles reacted</td><td>x</td><td>3x</td><td>0</td></tr> <tr> <td>Number of moles at equilibrium</td><td>a - x</td><td>b - 3x</td><td>2x</td></tr> <tr> <td>Molar concentration at equilibrium</td><td>$\frac{a-x}{v}$</td><td>$\frac{b-3x}{v}$</td><td>$\frac{2x}{v}$</td></tr> </tbody> </table> Applying law of mass action, $K_C = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3} = \frac{\left(\frac{2x}{v}\right)^2}{\left(\frac{a-x}{v}\right)\left(\frac{b-3x}{v}\right)^3}$ $= \frac{\left(\frac{4x^2}{v^2}\right)}{\left(\frac{a-x}{v}\right)\left(\frac{b-3x}{v}\right)^3}$ $K_C = \frac{4x^2 v^2}{(a-x)(b-3x)^3}$ The equilibrium constant K_P can also be calculated as follows: $K_P = K_C (RT)^{\Delta n_g}$ Here, $\Delta n_g = n_P - n_r = 2 - 4 = -2$ $K_P = \frac{4x^2 v^2}{(a-x)(b-3x)^3} (RT)^{-2}$ Total number of moles at equilibrium, $n = a - x + b - 3x + 2x = a + b - 2x$ $K_P = \frac{4x^2 v^2}{(a-x)(b-3x)^3} \times \left[\frac{PV}{n}\right]^{-2}$		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	Molar concentration at equilibrium	$\frac{a-x}{v}$	$\frac{b-3x}{v}$	$\frac{2x}{v}$
	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																		
Molar concentration at equilibrium	$\frac{a-x}{v}$	$\frac{b-3x}{v}$	$\frac{2x}{v}$																		

	$K_P = \frac{4x^2 V^2}{(a-x)(b-3x)^3} \times \left[\frac{n}{PV} \right]^2$ $K_P = \frac{4x^2 V^2}{(a-x)(b-3x)^3} \times \left[\frac{a+b-2x}{PV} \right]^2$ $K_P = \frac{4x^2 V^2}{(a-x)(b-3x)^3} \times \frac{(a+b-2x)^2}{p^2 V^2}$ $K_P = \frac{4x^2 (a+b-2x)^2}{p^2 (a-x)(b-3x)^3}$
12	Write a balanced chemical equation for the equilibrium reaction for which the equilibrium constant is given by expression $K_C = \frac{[NH_3]^4 [O_2]^5}{[NO]^4 [H_2O]^6}$. $4NO + 6H_2O \rightleftharpoons 4NH_3 + 5O_2$
13	What is the effect of added inert gas on the reaction at equilibrium at constant volume. (Jun-19) - When an inert gas 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 are unchanged. - Hence at constant volume, addition of inert gas has no effect on equilibrium.
14	Derive the relation between K_P and K_C. (Jun-19, Sep-21) 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 $K_C = \frac{[C]^l [D]^m}{[A]^x [B]^y} \dots\dots\dots (1)$ and K_P is, $K_P = \frac{P_C^l \times P_D^m}{P_A^x \times P_B^y} \dots\dots\dots (2)$ The ideal gas equation is, $PV = nRT \quad (\text{or}) \quad P = \frac{n}{V} RT$ Since, Active mass = molar concentration = n/V $P = \text{active mass} \times (RT)$ $P_A^x = [A]^x (RT)^x$ $P_B^y = [B]^y (RT)^y$ $P_C^l = [C]^l (RT)^l$ $P_D^m = [D]^m (RT)^m$ On substitution in Eqn. 2, $K_P = \frac{[C]^l [RT]^l [D]^m [RT]^m}{[A]^x [RT]^x [B]^y [RT]^y} \dots\dots\dots (3)$ $K_P = \frac{[C]^l [D]^m (RT)^{l+m}}{[A]^x [B]^y (RT)^{x+y}}$

$$K_P = \frac{[C]^l [D]^m}{[A]^x [B]^y} (RT)^{(l+m)-(x+y)} \dots\dots (4)$$

By comparing equation (1) and (4), we get

$$K_P = K_C (RT)^{\Delta ng}$$

where, Δng 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. The following relations become immediately obvious. When $\Delta ng = 0$

$$K_P = K_C (RT)^0$$

$$K_P = K_C$$

When $\Delta ng = +ve$

$$K_P = K_C (RT)^{+ve}$$

$$K_P > K_C$$

When $\Delta ng = -ve$

$$K_P = K_C (RT)^{-ve}$$

$$K_P < K_C$$

15 Deduce the Vant Hoff equation. (Mar-24)

This equation gives the quantitative temperature dependence of equilibrium constant (K). The relation between standard free energy change (ΔG°) and equilibrium constant is

$$\Delta G^\circ = -RT \ln K \dots\dots\dots (1)$$

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ \dots\dots\dots (2)$$

Substituting (1) in equation (2)

$$-RT \ln K = \Delta H^\circ - T\Delta S^\circ$$

Rearranging,

$$\ln K = \frac{-\Delta H^\circ}{RT} + \frac{\Delta S^\circ}{R} \dots\dots\dots (3)$$

Differentiating equation (3) with respect to temperature,

$$\frac{d(\ln K)}{dT} = \frac{\Delta H^\circ}{RT^2} \dots\dots\dots (4)$$

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 .

$$\int_{K_1}^{K_2} d(\ln K) = \frac{\Delta H^\circ}{R} \int_{T_1}^{T_2} \frac{dT}{T^2}$$

$$[\ln K]_{K_1}^{K_2} = \frac{\Delta H^\circ}{R} \left[-\frac{1}{T} \right]_{T_1}^{T_2}$$

$$\ln K_2 - \ln K_1 = \frac{\Delta H^\circ}{R} \left[-\frac{1}{T_2} + \frac{1}{T_1} \right]$$

$$\ln \frac{K_2}{K_1} = \frac{\Delta H^\circ}{R} \left[\frac{T_2 - T_1}{T_2 T_1} \right]$$

$$\log \frac{K_2}{K_1} = \frac{\Delta H^\circ}{2.303 R} \left[\frac{T_2 - T_1}{T_2 T_1} \right] \dots\dots\dots (5)$$

Equation 5 is known as **integrated form of van't Hoff equation**.

- 16 Derive a general expression for the equilibrium constant K_P and K_C for the reaction $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$. (Mar-24)

	H_2	I_2	HI
Initial number of moles	a	b	0
Number of moles reacted	x	x	0
Number of moles at equilibrium	a - x	b - x	2x
Molar concentration at equilibrium	$\frac{a-x}{v}$	$\frac{b-x}{v}$	$\frac{2x}{v}$

Applying law of mass action,

$$K_C = \frac{[HI]^2}{[H_2][I_2]} = \frac{\left(\frac{2x}{v}\right)^2}{\left(\frac{a-x}{v}\right)\left(\frac{b-x}{v}\right)} = \frac{4x^2}{v^2} \times \frac{v^2}{(a-x)(b-x)} K_C = \frac{4x^2}{(a-x)(b-x)}$$

The equilibrium constant K_P can also be calculated as follows:

$$K_P = K_C (RT)^{\Delta n_g}$$

Here, $\Delta n_g = n_P - n_R = 2 - 2 = 0$

Hence, $K_P = K_C$

$$K_P = \frac{4x^2}{(a-x)(b-x)}$$

- 17 Derive a general expression for the equilibrium constant K_P and K_C for the reaction $PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$

	PCl_5	PCl_3	Cl_2
Initial number of moles	a	0	0
Number of moles reacted	x	0	0
Number of moles at equilibrium	a - x	x	x
Molar concentration at equilibrium	$\frac{a-x}{v}$	$\frac{x}{v}$	$\frac{x}{v}$

Applying law of mass action,

$$K_C = \frac{[PCl_3][Cl_2]}{[PCl_5]} = \frac{\left(\frac{x}{v}\right)\left(\frac{x}{v}\right)}{\left(\frac{a-x}{v}\right)} = \frac{x^2}{v^2} \times \frac{v}{a-x}$$

$$K_C = \frac{x^2}{(a-x)v}$$

The equilibrium constant K_P can also be calculated as follows:

$$K_P = K_C (RT)^{\Delta n_g}$$

Here, $\Delta n_g = n_P - n_R = 2 - 1 = 1$

Hence, $K_P = K_C (RT)^1$

We know that, $PV = nRT$

$$RT = \frac{PV}{n}$$

Where n is the total number of moles at equilibrium.

$$n = (a-x) + x + x = (a+x)$$

$$K_P = \frac{x^2}{(a-x)v} \frac{PV}{n}$$

$$K_P = \frac{x^2}{(a-x)v} \frac{PV}{(a+x)}$$

$$K_P = \frac{x^2 P}{(a-x)(a+x)}$$

18	What is Equilibrium constant? 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. $K_C = \frac{[C]^l [D]^m}{[A]^x [B]^y}$
19	What are the applications of equilibrium constant? The knowledge of equilibrium constant helps us to, 1. predict the direction in which the net reaction will take place 2. predict the extent of the reaction and 3. calculate the equilibrium concentrations of the reactants and products.
20	Define reaction quotient? (Sep-20, Jul-22, Jun-23) 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. $Q = \frac{[C]^l [D]^m_{\text{non-equilibrium condition}}}{[A]^x [B]^y_{\text{non-equilibrium condition}}}$
21	What is the effect of added catalyst on the reaction at equilibrium. • 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.
22	Using Le-Chatelier's Principle explain the effects of the following conditions at equilibrium? 1) Effect of concentration: According to Le Chatelier's principle, the effect of increase in concentration of a substance will shift the equilibrium in a direction that consumes the added substance. Eg: $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$ The addition of H_2 or I_2 to the equilibrium mixture, disturbs the equilibrium. To minimize the stress, the system shifts the reaction in a direction where H_2 and I_2 are consumed. 2) Effect of pressure: 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. Eg: $3H_{2(g)} + N_{2(g)} \rightleftharpoons 2NH_{3(g)}$ In this reaction, if we 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 reduce the pressure, the volume increases. It favours the decomposition of ammonia. 3) Effect of temperature: If the temperature of a system at equilibrium is changed, the system will shift the equilibrium in the direction that attempts to nullify the effect of temperature. Eg: $N_2(g) + 3H_2(g) \xrightleftharpoons[\text{endothermic}]{\text{exothermic}} 2NH_3(g) \quad \Delta H = -92.2 \text{ kJ}$ • In this equilibrium, the forward reaction is exothermic i.e. heat is liberated while the reverse reaction is endothermic i.e. heat is absorbed. • If the temperature is increased, the system responds by decomposing some of the ammonia molecules to nitrogen and hydrogen by absorbing the supplied heat energy. • Similarly, the system responds to a drop in the temperature by forming more ammonia molecules from nitrogen and hydrogen, which releases heat energy.

9. SOLUTIONS

1	Define molality? (Jun-23) It is defined as the number of moles of the solute dissolved in 1 kilogram of the solvent. $\text{Molality (m)} = \frac{\text{Number of moles of the solute}}{\text{Mass of the solvent (in kg)}}$
2	Define molarity? It is defined as the number of moles of the solute dissolved in 1 litre of the solution. $\text{Molarity (M)} = \frac{\text{Number of moles of the solute}}{\text{Volume of solution (in L)}}$
3	Define Normality? It is defined as the number of gram equivalents of the solute present in 1 litre of the solution. $\text{Normality (N)} = \frac{\text{Number of gram equivalents of solute}}{\text{Volume of solution (in L)}}$
4	Define mole fraction? $\text{Mole fraction (x)} = \frac{\text{Number of moles of the component}}{\text{Total number of moles of all the components present in solution}}$
5	Define formality? It is defined as the number of formula mass of the solute present in 1 litre of the solution. $\text{Normality (F)} = \frac{\text{Number of Formula mass of solute}}{\text{Volume of solution (in L)}}$
6	What is a vapour pressure of liquid? What is relative lowering of vapour pressure? (Jun-19) - The pressure exerted by the vapours above the liquid surface which is in equilibrium with the liquid at a given temperature is called vapour pressure of the liquid. - The difference between the vapour pressure of pure solvent and the solution is called as lowering of vapour pressure. $\Delta P = (P^\circ - P)$ - The relative lowering of vapour pressure is defined as the ratio of lowering of vapour pressure to the vapour pressure of pure solvent. $\frac{\Delta P}{P^\circ} = \frac{(P^\circ - P)}{P^\circ}$
7	State and explain Henry's law? "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". This statement is known as Henry's law. $P_{\text{solute}} \propto X_{\text{solute in solution}}$ $P_{\text{solute}} = K_H X_{\text{solute in solution}}$ $P_{\text{solute}} = \text{partial pressure of the gas in vapour state (vapour pressure)}$ $K_H = \text{empirical constant with the dimensions of pressure}$ $X_{\text{solute in solution}} = \text{mole fraction of solute in the solution}$
8	What are the limitations of Henry's law? - Henry's law is applicable at moderate temperature and pressure only. - Only the less soluble gases obey Henry's law - The gases reacting with the solvent do not obey Henry's law. Eg: ammonia or HCl. - The gases obeying Henry's law should not associate or dissociate while dissolving in the solvent.

9	What is solubility of the solute? Solubility of a solute is the maximum amount of solute that can be dissolved in a specific amount of solvent at a specified temperature.
10	What is molal depression constant? Does it depend on nature of the solute? The depression in freezing point is directly proportional to the molal concentration of the solute particles. Hence, $\Delta T_f \propto m$ (or) $\Delta T_f = K_f m$ Here, 'm' = is the molality of the solution K_f = molal freezing point depression constant or cryoscopic constant. The K_f is equal to the depression in freezing point for 1 molal solution. It depends on nature of the solute
11	State Raoult law (Mar-24) and obtain expression for lowering of vapour pressure when non-volatile solute is dissolved in solvent. Raoult's law (Mar-24) = "In the case of a solution of volatile liquids, the partial vapour pressure of each component of the solution is directly proportional to its mole fraction". $P_{\text{solution}} \propto X_A$ (1) (Where X_A is the mole fraction of the solvent) $P_{\text{solution}} = kX_A$ (2) When $X_A = 1$, $K = P^{\circ}_{\text{solvent}}$ ($P^{\circ}_{\text{solvent}}$ is the partial pressure of pure solvent) $P_{\text{solution}} = P^{\circ}_{\text{solvent}} X_A$ (3) $\frac{P_{\text{solution}}}{P^{\circ}_{\text{solvent}}} = X_A$ (4) subtract eqn (4) from one, $1 - \frac{P_{\text{solution}}}{P^{\circ}_{\text{solvent}}} = 1 - X_A$ (5) $\frac{P^{\circ}_{\text{solvent}} - P_{\text{solution}}}{P^{\circ}_{\text{solvent}}} = X_B$ (6) $\left[\frac{P^{\circ} - P}{P^{\circ}} = \frac{\Delta P}{P^{\circ}} = \text{relative lowering of vapour pressure} \right]$ $[X_A + X_B = 1]$ $X_B = 1 - X_A]$ Where X_B is the mole fraction of the solute Based on this expression, Raoult's Law can also be stated as "the relative lowering of vapour pressure of an ideal solution containing the non-volatile solute is equal to the mole fraction of the solute at a given temperature".
12	What is osmosis? Osmosis is a spontaneous process by which the solvent molecules pass through a semi permeable membrane from a solution of lower concentration to a solution of higher concentration.
13	What is osmotic pressure? (Mar-23) The pressure that must be applied to the solution to stop the influx of the solvent (to stop osmosis) through the semipermeable membrane is called osmotic pressure.
14	Define the term 'isotonic solution'? (Mar-19, May-22) - Two solutions having same osmotic pressure at a given temperature are called isotonic solutions. - 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.

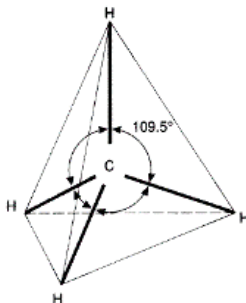
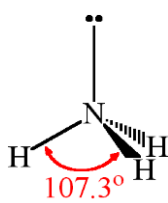
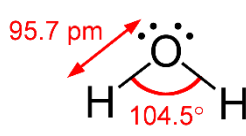
15	Define the term ‘hypotonic solution’? Too dilute solution of the two solutions separated by a semipermeable membrane is called hypotonic solution.										
16	Define the term ‘hypertonic solution’? Too concentrated solution of the two solutions separated by a semipermeable membrane is called hypertonic solution.										
17	You are provided with a solid ‘A’ and three solutions of A dissolved in water - one saturated, one unsaturated, and one super saturated. How would you determine which solution is which? The three solutions of the given solid ‘A’ can be determined by the following method. <table><tr><th>Substance dissolved in the given solution</th><th>Solubility</th><th>Type of solution</th></tr><tr><td rowspan="3">Large amount of solid ‘A’</td><td>Insoluble</td><td>saturated</td></tr><tr><td>Soluble</td><td>unsaturated</td></tr><tr><td>Insoluble and precipitated</td><td>super saturated</td></tr></table>	Substance dissolved in the given solution	Solubility	Type of solution	Large amount of solid ‘A’	Insoluble	saturated	Soluble	unsaturated	Insoluble and precipitated	super saturated
Substance dissolved in the given solution	Solubility	Type of solution									
Large amount of solid ‘A’	Insoluble	saturated									
	Soluble	unsaturated									
	Insoluble and precipitated	super saturated									
18	Explain the effect of pressure on the solubility. - Generally, the change in pressure does not have any significant effect in the solubility of solids and liquids as they are not compressible. However, the solubility of gases generally increases with increase of pressure. - Consider a saturated solution of a gaseous solute dissolved in a liquid solvent in a closed container. In such a system, the following equilibrium exists. Gas (in gaseous state) $\rightleftharpoons$ Gas (in solution) - According to Le-Chatelier principle, the increase in pressure will shift the equilibrium in the direction which will reduce the pressure. Therefore, more number of gaseous molecules dissolves in the solvent and the solubility increases.										
19	What is standard solution or a stock solution? What are its advantages. It is a solution whose concentration is accurately known. Advantages: - The error in weighing the solute can be minimised by using concentrated stock solution that requires large quantity of solute. - We can prepare working standards of different concentrations by diluting the stock solution, which is more efficient since consistency is maintained. - Some of the concentrated solutions are more stable and are less likely to support microbial growth than working standards used in the experiments.										
20	What is working standard? The solution with required concentration is prepared by diluting the stock solution is called as working standard.										
21	What are colligative properties? (or) write four colligative properties? (Jun-23) The properties that do not depend on the chemical nature of the solute but depends only on the number of solute particles (ions/molecules) present in the solution is called as colligative properties. Eg: i) Relative lowering of vapour pressure ii) Elevation of boiling point iii) Depression in freezing point iv) Osmotic pressure										

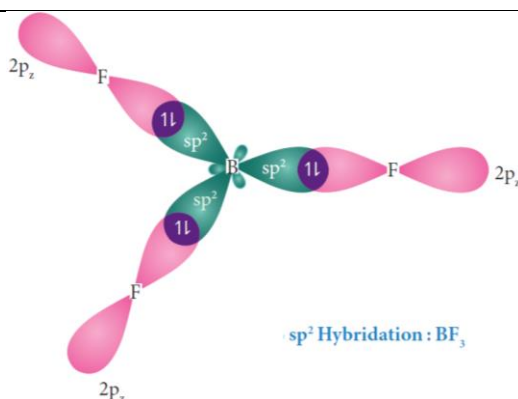
22	What is molal boiling point elevation? Molal boiling point elevation is equal to the elevation in boiling point for 1 molal solution. $\Delta T_b = K_b m ; m = 1$ $\therefore \Delta T_b = K_b$
23	Define boiling point and freezing point? - The boiling point of a liquid is the temperature at which its vapour pressure becomes equal to the atmospheric pressure (1 atm). - Freezing point is defined as “the temperature at which the solid and the liquid states of the substance have the same vapour pressure”.
24	Define ideal (Sep-21, Jul-22) and non-ideal solutions? - An ideal solution is a solution in which each component i.e. the solute as well as the solvent obeys the Raoult's law over the entire range of concentration. - The solutions which do not obey Raoult's law over the entire range of concentration, are called non-ideal solutions.
25	Explain the factors which are responsible for the solutions get deviation from Raoult's law? The deviation of solution from ideal behavior is attributed to the following factors. i) Solute-solvent interactions: For an ideal solution, the interaction between the solvent molecules (A-A), the solute molecules (B-B) and between the solvent & solute molecules (A-B) are expected to be similar. If these interactions are dissimilar, then there will be a deviation from ideal behavior. ii) Dissociation of solute: When a solute present in a solution dissociates to give its constituent ions, the resultant ions interact strongly with the solvent and cause deviation from Raoult's law. iii) Association of solute: Association of solute molecules can also cause deviation from ideal behaviour. For example, in solution, acetic acid exists as a dimer by forming intermolecular hydrogen bonds, and hence deviates from Raoult's law. iv) Temperature: An increase in temperature of the solution increases the average kinetic energy of the molecules present in the solution which causes decrease in the attractive force between them. As a result, the solution deviates from ideal behaviour. v) Pressure: At high pressure the molecules tend to stay close to each other and therefore there will be an increase in their intermolecular attraction. Thus, a solution deviates from Raoult's law at high pressure. vi) Concentration: If a solution is sufficiently dilute there is no pronounced solvent-solute interaction because the number of solute molecules are very low compared to the solvent. When the concentration is increased by adding solute, the solvent-solute interaction becomes significant. This causes deviation from the Raoult's law.
26	Prove elevation of boiling point is a colligative property? (Mar-22) - The boiling point of a liquid is the temperature at which its vapour pressure becomes equal to the atmospheric pressure (1 atm). - When a non-volatile solute is added to a pure solvent at its boiling point, the vapour pressure of the solution is lowered below 1 atm. To bring the vapour pressure again to 1 atm, the temperature of the solution has to be increased. - As a result, the solution boils at a higher temperature (T_b) than the boiling point of the pure solvent (T_b°). - This increase in the boiling point is known as elevation of boiling point. $\Delta T_b = T_b - T_b^\circ$

	- The elevation of boiling point is directly proportional to the concentration of the solute particles. $\Delta T_b \propto m$; $m = \text{molality}$ $\Delta T_b = K_b m$; $K_b = \text{molal boiling point elevation constant}$ $\Delta T_b = K_b \frac{n_2}{W_1 \text{ (kg)}}$ $\Delta T_b = K_b \frac{W_2}{M_2 W_1 \text{ (kg)}}$ - When a solute is dissolved in a pure solvent, evaporation of the solute molecules is inhibited due to increased solvent-solute interactions and the vapor pressure of the solution decreases. Hence its boiling point increases. So, the boiling point elevation is a colligative property as it depends on the number of solutes.
27	Prove depression in freezing point is a colligative property? (Sep-21) - The temperature at which the solid and the liquid states of the substance have the same vapour pressure is called freezing point. - At freezing point, the solid and liquid phases of the substance are in equilibrium. - When a non-volatile solute is added to water at its freezing point, the freezing point of the solution is lowered from 0 °c. - The lowering of the freezing point of the solvent when a solute is added is called depression in freezing point (ΔT_f). $\Delta T_f = T_f^\circ - T_f$ - The depression in freezing point is directly proportional to the concentration of the solute particles. $\Delta T_f \propto m$; $m = \text{molality}$ $\Delta T_f = K_f m$; $K_f = \text{molal depression in freezing point}$ $\Delta T_f = K_f \frac{n_2}{W_1 \text{ (kg)}}$ $\Delta T_f = K_f \frac{W_2}{M_2 W_1 \text{ (kg)}}$ - When a solute is dissolved in a pure solvent, evaporation of the solute molecules is inhibited due to increased solvent-solute interactions and the vapor pressure of the solution decreases. The attraction force between solvent - solute increases and freezes at lower temperature. The freezing point of the solution decreases. Hence the freezing point is a colligative property as it depends on the particle number of the solute.
28	Explain reverse osmosis? - It can be defined as a process in which a solvent passes through a semipermeable membrane in the opposite direction of osmosis, when subjected to a hydrostatic pressure greater than the osmotic pressure is called reverse osmosis. Eg: The pure water moves through the semipermeable membrane to the NaCl solution due to osmosis. This process can be reversed by applying pressure greater than the osmotic pressure to the solution side. Now the pure water moves from the solution side to the solvent side and this process is called reverse osmosis. Uses: Reverse osmosis is used in the desalination of sea water and also in the purification of drinking water. - There are different types of semipermeable membranes used in this process like, cellulose acetate and polyamide membranes.

29	Why the carbonated drinks show effervescence when opened? - The carbonated beverages contain carbon dioxide dissolved in them. To dissolve the carbon dioxide in these drinks, the CO₂ gas is bubbled through them under high pressure. - These containers are sealed to maintain the pressure. When we open these containers at atmospheric pressure, the pressure of the CO₂ drops to the atmospheric level and hence bubbles of CO₂ rapidly escape from the solution and show effervescence.
30	Write van't Hoff equation and explain? For dilute solutions, the osmotic pressure is directly proportional to the molar concentration of the solute and the temperature of the solution. $\pi = CRT$ Here, C = Concentration of the solution in molarity, T = Temperature and R = Gas constant
31	Define van't Hoff factor? It is defined as the ratio of the actual molar mass to the abnormal (calculated) molar mass of the solute. $i = \frac{\text{Normal actual molar mass}}{\text{Observed abnormal molar mass}}$
32	Explain how does the van't Hoff factor value varies for different solutes? - For a solute that does not dissociate or associate the van't Hoff factor is equal to 1 (i = 1) and the molar mass will be close to the actual molar mass. - For the solutes that associate to form higher oligomers in solution the van't Hoff factor will be less than one (i < 1) and the observed molar mass will be greater than the actual molar mass. - For solutes that dissociates into their constituent ions the van't Hoff factor will be more than one (i > 1) and the observed molar mass will be less than the normal molar mass.
33	Calculate the molality of the solution containing 90 g of glucose dissolved in 2 kg of water? $\text{Molality} = \frac{\text{No. of moles of solute}}{\text{Mass of the solvent (in Kg)}} = \frac{90/180}{2} = 0.25 \text{ m}$

10. CHEMICAL BONDING

1	Define the following i) Bond order (Sep-21): The number of covalent bonds between the two combining atoms is called bond order. $\text{Bond order} = \frac{N_b - N_a}{2}$ Where, N_b = Total number of electrons present in the bonding molecular orbitals N_a = Total number of electrons present in the antibonding molecular orbitals ii) Hybridisation: It is the process of mixing of atomic orbitals of the same atom with comparable energy to form equal number of new equivalent orbitals with same energy. iii) σ- bond (Jun-23): When two atomic orbitals overlap linearly along the axis, the resultant bond is called a sigma (σ) bond.													
2	What is a pi bond? (Jun-23, Mar-24) When two atomic orbitals overlap sideways, the resultant covalent bond is called a pi (π) bond.													
3	In CH_4, NH_3 and H_2O, the central atom undergoes sp^3 hybridisation - yet their bond angles are different. why? Methane (CH_4):  Tetrahedral (AB_4 type) No lone pair (lp) electrons present in it. So, the bond angle is $109^\circ 28'$ (or) 109.5°. Ammonia (NH_3):  Pyramidal shape (AB_3L type) Number of lone pair (lp) electrons = 1 $lp - bp$ repulsive force exists. So, the bond angle is decreased to 107° Water (H_2O):  Bent shaped - V Shaped (AB_2L_2 type) Number of lone pair (lp) electrons = 2 $lp - lp$ and $lp - bp$ repulsive force exists. So, the bond angle is decreased to 104.5°													
4	Explain sp^2 hybridisation in BF_3? (Sep-20) Electronic configuration of boron ($Z = 5$) In ground state <table style="margin-left: auto; margin-right: auto; border-collapse: collapse;"> <tr> <td style="text-align: center;">$1s^2$</td> <td style="text-align: center;">$2s^2$</td> <td style="text-align: center;">$2p^1$</td> </tr> <tr> <td style="text-align: center; border: 1px solid black; padding: 2px;">$1\downarrow$</td> <td style="text-align: center; border: 1px solid black; padding: 2px;">$1\downarrow$</td> <td style="text-align: center; border: 1px solid black; padding: 2px;">1 </td> </tr> </table> In excited state <table style="margin-left: auto; margin-right: auto; border-collapse: collapse;"> <tr> <td style="text-align: center;">$1s^2$</td> <td style="text-align: center;">$2s^1$</td> <td style="text-align: center;">$2p^2$</td> </tr> <tr> <td style="text-align: center; border: 1px solid black; padding: 2px;">$1\downarrow$</td> <td style="text-align: center; border: 1px solid black; padding: 2px;">1</td> <td style="text-align: center; border: 1px solid black; padding: 2px;">1 1 </td> </tr> </table> sp^2 hybridisation		$1s^2$	$2s^2$	$2p^1$	$1\downarrow$	$1\downarrow$	1 	$1s^2$	$2s^1$	$2p^2$	$1\downarrow$	1	1 1
$1s^2$	$2s^2$	$2p^1$												
$1\downarrow$	$1\downarrow$	1 												
$1s^2$	$2s^1$	$2p^2$												
$1\downarrow$	1	1 1 												

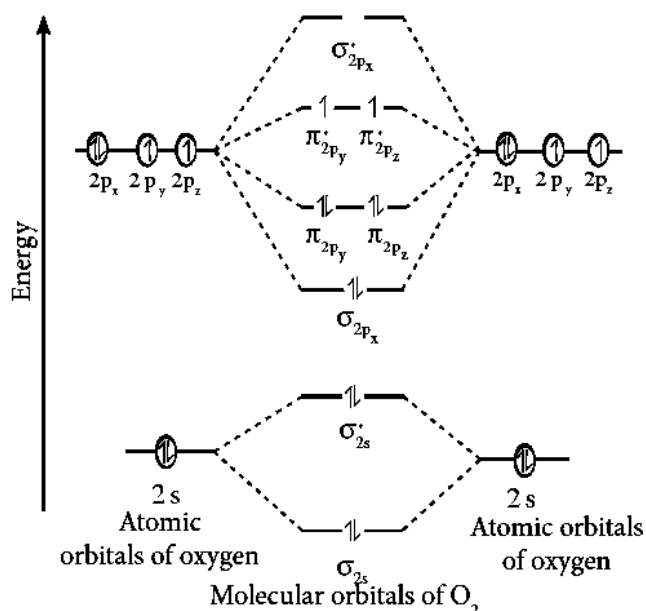


- In the ground state boron has only one unpaired electron in the valence shell.
- In order to form three covalent bonds with fluorine atoms, three unpaired electrons are required.
- To achieve this, one of the paired electrons in the 2s orbital is promoted to the 2p orbital in the excited state.
- In boron, the s orbital and two p orbitals in the valence shell hybridise, to generate three equivalent sp^2 orbitals
- The three sp^2 hybridised orbitals of boron now overlap with the 2p orbitals of 3 fluorine atoms along the axis to form 3 covalent bonds as shown in the figure.

5 **What do you understand by Linear combination of atomic orbitals in MO theory.**

- The wave functions for the molecular orbitals can be obtained by solving Schrödinger wave equation for the molecule.
- Since solving the Schrödinger equation is too complex, approximation methods are used to obtain the wave function for molecular orbitals. The most common method is the linear combination of atomic orbitals (LCAO).
- The atomic orbitals are represented by the wave function ψ .
- Let us consider two atomic orbitals represented by the wave function ψ_A and ψ_B with comparable energy, combine to form two molecular orbitals.
- $\psi_{\text{bonding}} = \psi_A + \psi_B$
- $\psi_{\text{antibonding}} = \psi_A - \psi_B$

6 **Draw the M.O diagram for oxygen molecule calculate its bond order and show that O_2 is paramagnetic. (Jun-19, Jul-22)**

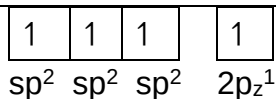


	Electronic configuration of Oxygen atom = $1s^2 2s^2 2p^4$ Electronic configuration of O₂ molecule = $\sigma_{1s}^2, \sigma_{1s}^{*2}, \sigma_{2s}^2, \sigma_{2s}^{*2}, \sigma_{2p_x}^2, \pi_{2p_y}^2, \pi_{2p_z}^2, \pi_{2p_y}^{*1}, \pi_{2p_z}^{*1}$ Bond order = $\frac{N_b - N_a}{2} = \frac{10 - 6}{2} = 2$. O₂ Molecule has two unpaired electrons. Hence, it is paramagnetic.
7	Draw MO diagram of CO and calculate its bond order. Electronic configuration of Carbon atom = $1s^2 2s^2 2p^2$ Electronic configuration of Oxygen atom = $1s^2 2s^2 2p^4$ Electronic configuration of CO molecule = $\sigma_{1s}^2, \sigma_{1s}^{*2}, \sigma_{2s}^2, \sigma_{2s}^{*2}, \pi_{2p_y}^2, \pi_{2p_z}^2, \sigma_{2p_x}^2$ Bond order = $\frac{N_b - N_a}{2} = \frac{10 - 4}{2} = 3$. Molecule has no unpaired electrons. Hence, it is diamagnetic.
8	Discuss the formation of N₂ molecule using MO Theory? (Jun-23, Mar-24)

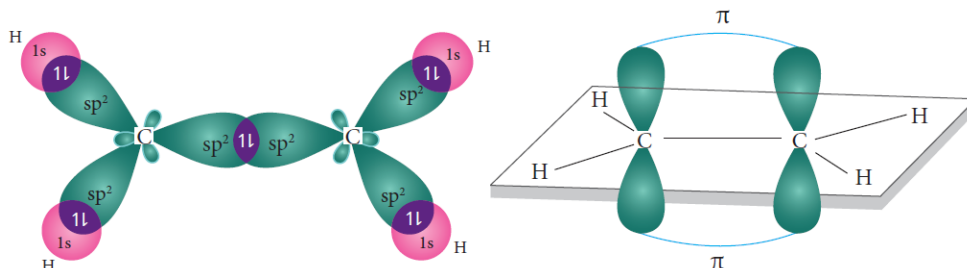
	Electronic configuration of Nitrogen atom = $1s^2 2s^2 2p^3$ Electronic configuration of N_2 molecule = $\sigma_{1s}^2, \sigma_{1s}^{*2}, \sigma_{2s}^2, \sigma_{2s}^{*2}, \pi_{2p_y}^2, \pi_{2p_z}^2, \sigma_{2p_x}^2$ Bond order = $\frac{N_b - N_a}{2} = \frac{10 - 4}{2} = 3$. Molecule has no unpaired electrons. Hence, it is diamagnetic.												
9	What is dipolemoment? The polarity of a covalent bond can be measured in terms of dipole moment which is defined as $\mu = q \times 2d$ Where, μ is the dipole moment, q is the charge and $2d$ is the distance between the two charges. • The dipole moment is a vector • The direction of dipole moment vector points from the negative charge to positive charge. • The unit for dipole moment is columb meter (Cm).												
10	Linear form of carbondioxide molecule has two polar bonds. Yet the molecule has Zero dipolement why? (Jun-19) In CO_2, the dipole moments of two polar bonds (CO) are equal in magnitude but have opposite direction. $\begin{array}{c} \text{O}=\text{C}=\text{O} \\ \xrightarrow{\mu_1} \quad \xleftarrow{\mu_2} \end{array}$ Hence, the net dipole moment of the $CO_2 = 0$ In this case, $\mu = \vec{\mu}_1 + \vec{\mu}_2$ $= \vec{\mu}_1 + (-\vec{\mu}_1) = 0$												
11	Draw the Lewis structures for the following species. i) NO_3^- : Nitrate ion ii) SO_4^{2-} : Sulphate ion iii) HNO_3 (Mar-23) : Nitric acid iv) O_3 : Ozone												
12	Explain the bond formation in $BeCl_2$ and $MgCl_2$. Bond formation in $BeCl_2$: Electronic configuration of beryllium ($Z = 4$) In ground state <table style="margin-left: auto; margin-right: auto; text-align: center;"> <tr> <td>$1s^2$</td> <td>$2s^2$</td> <td>$2p^0$</td> </tr> <tr> <td> 1↓ </td> <td> 1↓ </td> <td> </td> </tr> </table> In excited state <table style="margin-left: auto; margin-right: auto; text-align: center;"> <tr> <td>$1s^2$</td> <td>$2s^1$</td> <td>$2p^1$</td> </tr> <tr> <td> 1↓ </td> <td> 1 </td> <td> 1 </td> </tr> </table> sp hybridisation Each sp hybridized orbital of beryllium linearly overlap with 3p orbital of the chlorine to form a covalent bond.	$1s^2$	$2s^2$	$2p^0$	1↓	1↓		$1s^2$	$2s^1$	$2p^1$	1↓	1	1
$1s^2$	$2s^2$	$2p^0$											
1↓	1↓												
$1s^2$	$2s^1$	$2p^1$											
1↓	1	1											

	Bond formation in $MgCl_2$: Electronic configuration of Magnesium ($Z = 4$) In ground state $3s^2$ 1↓ $3p^0$ In excited state $3s^1$ 1 $3p^1$ 1 $\underbrace{\hspace{10em}}$ sp hybridisation Each sp hybridized orbital of magnesium linearly overlap with 3p orbital of the chlorine to form a covalent bond.
13	Which bond is stronger σ or π? Why? - When two atomic orbitals overlap linearly along the axis, the resultant bond is called a sigma (σ) bond and when two atomic orbitals overlap sideways, the resultant covalent bond is called a pi (π) bond. - sigma (σ) bond is stronger between these two bonds because, head-on overlap is stronger than side by side overlap.
14	Define bond energy. (May-22) - The bond energy is defined as the minimum amount of energy required to break one mole of a particular bond in molecules in their gaseous state. - The unit of bond enthalpy is kJ mol^{-1}.
15	Hydrogen gas is diatomic whereas inert gases are monoatomic – explain on the basis of MO theory. According to MO theory, - Electronic configuration of hydrogen = $1s^1$ - Electronic configuration of hydrogen molecule = $\sigma^2 1s$ - Bond order = $\frac{N_b - N_a}{2} = \frac{2 - 0}{2} = 1$. - The bond order of hydrogen molecule is 1 so it can form the molecule. - But the electronic configuration of inert gas = $ns^2 np^6$ - Bond order of inert gas is zero so, it can't form the molecule and exist as monoatomic.
16	What is polar covalent bond? explain with example. In the case of covalent bond formed between atoms having different electronegativities, the atom with higher electronegativity will have greater tendency to attract the shared pair of electrons more towards itself than the other atom. So, the atom with high electronegativity will get partially negative charge and the other atom gets partially positive charge. It is called as polar covalent bond. Eg: HF molecule. $H^{\delta+} - F^{\delta-}$ (The electronegativities of hydrogen and fluorine on Pauling's scale are 2.1 and 4 respectively)
17	Considering x- axis as molecular axis, which out of the following will form a sigma bond i) 1s and 2py: 1s orbital overlaps with 2py orbital along the axis, so it forms σ bond. ii) 2Px and 2Px: 2Px orbital overlaps with 2Px orbital along the axis, so it forms σ bond. iii) 2px and 2pz: 2Px orbital overlaps with 2Pz orbital along sideways, so it forms π bond. iv) 1s and 2pz: 1s orbital overlaps with 2pz orbital along the axis, so it forms σ bond.

In hybridised state



- Each carbon atom undergoes hybridisation resulting in three equivalent sp^2 hybridised orbitals lying in the xy plane at an angle of 120° to each other. The unhybridised $2p_z$ orbital lies perpendicular to the xy plane.
- One of the sp^2 hybridised orbitals of each carbon lying on the molecular axis (x-axis) linearly overlaps with each other resulting in the formation a C-C sigma bond.
- Other two sp^2 hybridised orbitals of both carbons linearly overlap with the four $1s$ orbitals of four hydrogen atoms leading to the formation of two C-H sigma bonds on each carbon.

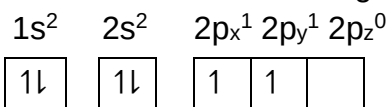


- The unhybridised $2p_z$ orbital of both carbon atoms can overlap only sideways as they are not in the molecular axis. This lateral overlap results in the formation a pi(π) bond between the two carbon atoms.

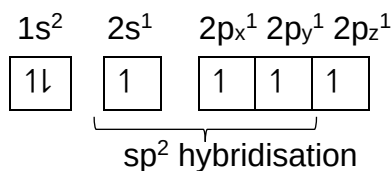
Bond formation in acetylene:

Molecular formula of ethylene is C_2H_2 . Electronic configuration of carbon,

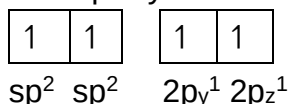
In ground state



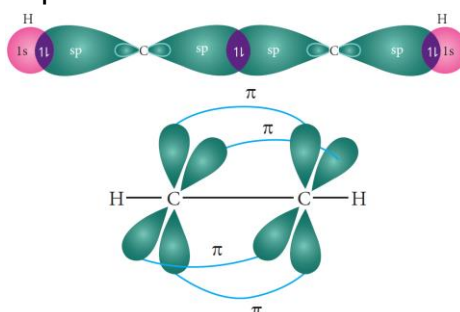
In excited state

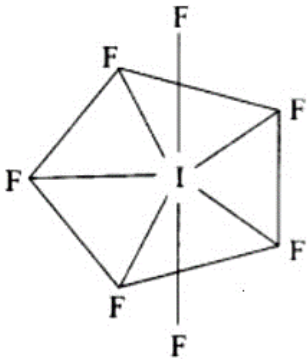
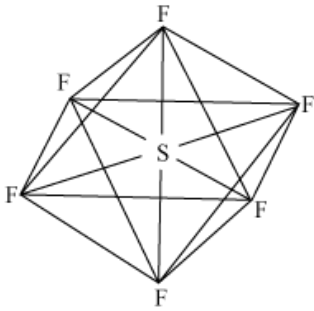
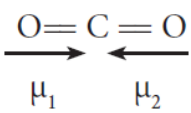


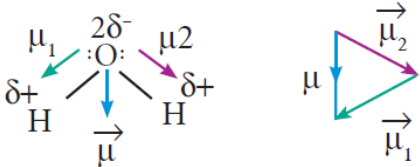
In hybridised state



- Each carbon atom undergoes hybridisation resulting in equivalent sp hybridised orbitals lying in a straight line along the molecular axis (x-axis). The unhybridised $2p_y$ and $2p_z$ orbitals lie perpendicular to the molecular axis.
- One of the two sp hybridised orbitals of each carbon linearly overlaps with each other resulting in the formation a C-C sigma bond.
- The other sp hybridised orbital of both carbons linearly overlap with the two $1s$ orbitals of two hydrogen atoms leading to the formation of one C-H sigma bonds on each carbon.
- The unhybridised $2p_y$ and $2p_z$ orbitals of each carbon overlap sideways. This lateral overlap results in the formation of two pi bonds between the two carbon atoms



20	What type of hybridisations are possible in the following geometries? a) Octahedral = $sp^3 d^2$ b) Tetrahedral = sp^3 c) Square planer = dsp^2
21	Explain VSEPR theory. Applying this theory to predict the shapes of IF_7, and SF_6. Important principles of VSEPR Theory: The shape of the molecules depends on the number of valence shell electron pair around the central atom. There are two types of electron pairs namely bond pairs and lone pairs. The bond pair of electrons are those shared between two atoms the lone pairs are the valence electron pairs that are not involved in bonding. Each pair of valence electrons around the central atom repels each other and hence, they are located as far away as possible in three-dimensional space to minimize the repulsion between them. The repulsive interaction between the different types of electron pairs is in the following order $lp - lp > lp - bp > bp - bp$ where, lp - lone pair bp- bond pair Shape of IF_7:  • It is the type of molecule that has a central atom with no lone pair of electrons. • It belongs to AB_7 type • In this shape I present in the center and there are seven bonding electron pairs around it. • The molecule has a regular pentagonal bipyramidal shape Shape of SF_6:  • It is the type of molecule that has a central atom with no lone pair of electrons. • It belongs to AB_6 type • In this shape there are six bonding electron pairs around central sulphur atom. • The molecule has a regular octahedral shape
22	CO_2 and H_2O both are triatomic molecule but their dipole moment values are different. Why? • The linear form of carbon dioxide has zero dipole moment, even though it has two polar bonds. • In CO_2, the dipole moments of two polar bonds (CO) are equal in magnitude but have opposite direction. Hence, the net dipole moment of the CO_2 is zero. $\mu = \mu_1 + \mu_2 = \mu_1 + (-\mu_1) = 0$ 

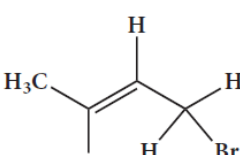
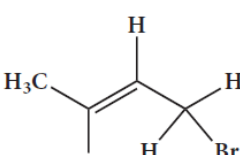
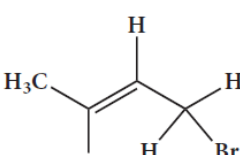
	- In case of water net dipole moment is the vector sum of $\mu_1 + \mu_2$ as shown.  - Dipole moment in water is found to be 1.85D
23	Which one of the following has highest bond order? N_2, N_2^+ or N_2^- - Bond order = $\frac{N_b - N_a}{2}$ - Bond order of $N_2 = \frac{10 - 4}{2} = 3$. - Bond order of $N_2^+ = \frac{9 - 4}{2} = 2.5$. - Bond order of $N_2^- = \frac{10 - 5}{2} = 2.5$. - So, N_2 as highest bond order.
24	Explain the covalent character in ionic bond. - Like the partial ionic character in covalent compounds, ionic compounds show partial covalent character. - Eg: LiCl is an ionic compound but shows partial covalent character and is soluble in organic solvents such as ethanol. - The positively charged cation attracts the valence electrons of anion while repelling the nucleus. - This causes a distortion in the electron cloud of the anion and its electron density drifts towards the cation - It results in some sharing of the valence electrons between these ions. Thus, a partial covalent character is developed between them. This phenomenon is called polarisation. - 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.
25	Describe fajan's rule. (Jul-22, Jun-23) - The extent of polarisation in an ionic compound is given by the Fajans rules - 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 - The smaller cation and larger anion show greater covalent character due to the greater extent of polarisation. - 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.
26	Define octet rule? Octet rule states that, the atoms transfer or share electrons so that all atoms involved in chemical bonding obtain 8 electrons in their outer shell (valence shell).
27	Define covalent bond? The mutual sharing of one or more pairs of electrons between two combining atoms results in the formation of a chemical bond called a covalent bond. Eg: H_2, O_2

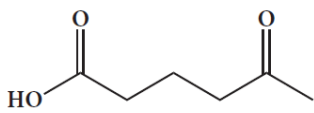
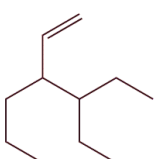
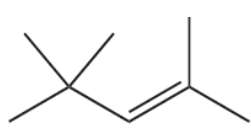
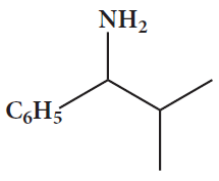
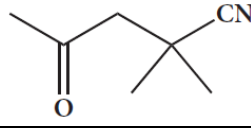
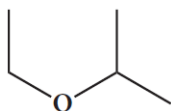
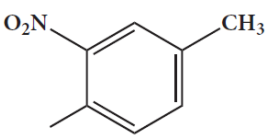
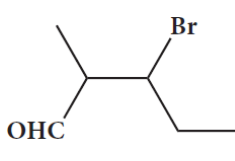
28	How does the extent of ionic character in a covalent bond is calculated? The extent of ionic character in a covalent bond can be related to the electro negativity difference to the bonded atoms. In a typical polar molecule, $A^{\delta-}-B^{\delta+}$, the electronegativity difference ($\chi_A - \chi_B$) can be used to predict the percentage of ionic character as follows. If the electronegativity difference ($\chi_A - \chi_B$), is If $(\chi_A - \chi_B) = 1.7$, then the bond A-B has 50% ionic character if $(\chi_A - \chi_B) > 1.7$, then the bond A-B has more than 50% ionic character, if $(\chi_A - \chi_B) < 1.7$, then the bond A-B has less than 50% ionic character.
29	Explain the exceptions to octet rule with examples? • Molecules with electron deficient central atoms Eg: BF_3. • Molecules containing odd electrons Eg: NO_2. • Molecules with expanded valence shells Eg: PCl_5.
30	Define ionic bond? The complete transfer of electrons between the two combining atoms leads to the formation of a cation and an anion. Both these ions are held together by the electrostatic attractive force which is known as ionic bond. Eg: HCl, NaCl
31	How does the bond length depends on the size of the atom and the number of bonds between the combining atoms? • Greater the size of the atom, greater will be the bond length. • Eg: carbon-carbon single bond length ($1.54 \text{ \AA}$) is longer than the carbon-nitrogen single bond length ($1.43 \text{ \AA}$). • Increase in the number of bonds between the two atoms decreases the bond length. • Eg: The length of carbon-carbon single bond = $1.54 \text{ \AA}$ • The length of carbon-carbon double bond = $1.33 \text{ \AA}$ • The length of carbon-carbon triple bond = $1.20 \text{ \AA}$.
32	Define hybridisation? (Sep-20) Hybridisation is the process of mixing of atomic orbitals of the same atom with comparable energy to form equal number of new equivalent orbitals with same energy. The resultant orbitals are called hybridised orbitals
33	Define bond length? (Mar-19, May-22) The distance between the nuclei of the two covalently bonded atoms is called bond length.
34	Write the salient features of Molecular orbital Theory? (Sep-20, Mar-23) • When atoms combine to form molecules, their individual atomic orbitals lose their identity and forms new orbitals called molecular orbitals. • The shapes of molecular orbitals depend upon the shapes of combining atomic orbitals. • The number of molecular orbitals formed is the same as the number of combining atomic orbitals. • Half the number of molecular orbitals formed will have lower energy than the corresponding atomic orbital, while the remaining molecular orbitals will have higher energy. The molecular orbital with lower energy is called bonding molecular orbital and the one with higher energy is called anti-bonding molecular orbital. • The bonding molecular orbitals are represented as σ (Sigma), π (pi), δ (delta) and the corresponding antibonding orbitals are denoted as σ^*, π^* and δ^*.

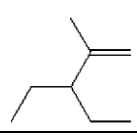
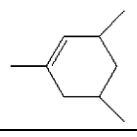
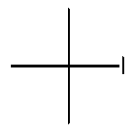
	- The electrons in a molecule are accommodated in the newly formed molecular orbitals. The filling of electrons in these orbitals follows Aufbau's principle, Pauli's exclusion principle and Hund's rule as in the case of filling of electrons in atomic orbitals. - Bond order gives the number of covalent bonds between the two combining atoms. $\text{Bond order} = \frac{N_b - N_a}{2}$ Here, N_b = Total number of electrons present in the bonding molecular orbitals N_a = Total number of electrons present in the antibonding molecular orbitals.
35	Give the salient features of VB Theory? (Sep-21) - When half-filled orbitals of two atoms overlap, a covalent bond will be formed between them. - The resultant overlapping orbital is occupied by the two electrons with opposite spins. - The strength of a covalent bond depends upon the extent of overlap of atomic orbitals. - Each atomic orbital has a specific direction (except s-orbital which is spherical) and hence orbital overlap takes place in the direction that maximizes overlap
36	Write the hybridisation present in the following compounds? (Mar-24) a) BF_3 - SP^2 b) CH_4 - SP^3 c) PCl_5 - SP^3d d) SF_6 - SP^3d^2

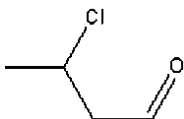
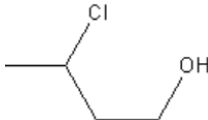
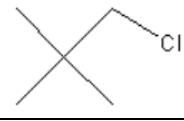
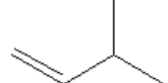
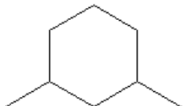
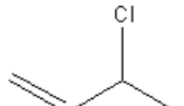
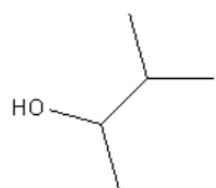
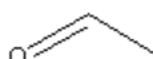
11. FUNDAMENTALS OF ORGANIC CHEMISTRY

1	Give the general characteristics of organic compounds? (Mar-23) • They are covalent compounds of carbon • They are generally insoluble in water • They are readily soluble in organic solvent such as benzene, toluene, ether, chloroform etc • Many of the organic compounds are inflammable (except CCl_4). • They possess low boiling and melting points due to their covalent nature • Organic compounds are characterised by functional groups. • They exhibit isomerism which is a unique phenomenon.
2	Describe the classification of organic compounds based on their structure. (Jun-23) <pre> graph TD OC[Organic Compounds] --> AC[Acyclic or open chain or aliphatic compounds Example : CH₃-CH₂-CH₃ (propane)] OC --> C[Cyclic compounds] C --> HC[Homocyclic compounds] C --> H[Heterocyclic compounds] HC --> AC1[Alicyclic Compounds or carbocyclic Cyclopropane] HC --> A1[Aromatic compounds Phenol] H --> AC2[Alicyclic compounds THF] H --> A2[Aromatic compounds Pyridine] A1 --> NB[Non-Benzenoid compounds also aromatic homocyclic azulene] </pre>
3	Write a note on homologous series. (Sep-21, Mar-24) Series of organic compounds each containing a characteric functional group and the successive members differ from each other in molecular formula by a CH_2 group is called homologous series. Compounds of the homologous series are represented by a general formula Alkanes – $\text{C}_n\text{H}_{2n+2}$ Alkenes – C_nH_{2n} Alkynes – $\text{C}_n\text{H}_{2n-2}$
4	Write the molecular formula of the first six members of homologous series of nitro alkanes. i) CH_3NO_2 ii) $\text{C}_2\text{H}_5\text{NO}_2$ iii) $\text{C}_3\text{H}_7\text{NO}_2$ iv) $\text{C}_4\text{H}_9\text{NO}_2$ v) $\text{C}_5\text{H}_{11}\text{NO}_2$ vi) $\text{C}_6\text{H}_{13}\text{NO}_2$

5	What is meant by a functional group? Identify the functional group in the following compounds. (a) acetaldehyde (b) oxalic acid (c) di methyl ether (d) methylamine A functional group is an atom or a specific combination of bonded atoms that react in a characteristic way, irrespective of the organic molecule in which it is present. <table><tr><th></th><th>Compound</th><th>Compound</th><th>Functional group</th></tr><tr><td>a</td><td>Acetaldehyde</td><td>CH_3CHO</td><td>- CHO</td></tr><tr><td>b</td><td>Oxalic acid</td><td>$\begin{array}{c} \text{COOH} \\ \\ \text{COOH} \end{array}$</td><td>- COOH</td></tr><tr><td>c</td><td>Di methyl ether</td><td>$\text{CH}_3 - \text{O} - \text{CH}_3$</td><td>- O -</td></tr><tr><td>d</td><td>Methylamine</td><td>$\text{CH}_3 - \text{NH}_2$</td><td>- NH_2</td></tr></table>		Compound	Compound	Functional group	a	Acetaldehyde	CH_3CHO	- CHO	b	Oxalic acid	$\begin{array}{c} \text{COOH} \\ \\ \text{COOH} \end{array}$	- COOH	c	Di methyl ether	$\text{CH}_3 - \text{O} - \text{CH}_3$	- O -	d	Methylamine	$\text{CH}_3 - \text{NH}_2$	- NH_2	
	Compound	Compound	Functional group																			
a	Acetaldehyde	CH_3CHO	- CHO																			
b	Oxalic acid	$\begin{array}{c} \text{COOH} \\ \\ \text{COOH} \end{array}$	- COOH																			
c	Di methyl ether	$\text{CH}_3 - \text{O} - \text{CH}_3$	- O -																			
d	Methylamine	$\text{CH}_3 - \text{NH}_2$	- NH_2																			
6	Give the general formula for the following classes of organic compounds (a) Aliphatic monohydric alcohol = $\text{R} - \text{OH}$ (b) Aliphatic ketones. = $\text{R} - \text{CO} - \text{R}$ (c) Aliphatic amines. = $\text{R} - \text{NH}_2$																					
7	Write the molecular and possible structural formula of the first four members of homologous series of carboxylic acids. <table><tr><th></th><th>Molecular formula</th><th>Structural formula</th></tr><tr><td>1</td><td>CH_2O_2</td><td>$\text{H} - \text{COOH}$</td></tr><tr><td>2</td><td>$\text{C}_2\text{H}_4\text{O}_2$</td><td>$\text{CH}_3 - \text{COOH}$</td></tr><tr><td>3</td><td>$\text{C}_3\text{H}_6\text{O}_2$</td><td>$\text{CH}_3 - \text{CH}_2 - \text{COOH}$</td></tr><tr><td>4</td><td>$\text{C}_4\text{H}_8\text{O}_2$</td><td>$\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{COOH}$</td></tr></table>		Molecular formula	Structural formula	1	CH_2O_2	$\text{H} - \text{COOH}$	2	$\text{C}_2\text{H}_4\text{O}_2$	$\text{CH}_3 - \text{COOH}$	3	$\text{C}_3\text{H}_6\text{O}_2$	$\text{CH}_3 - \text{CH}_2 - \text{COOH}$	4	$\text{C}_4\text{H}_8\text{O}_2$	$\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{COOH}$						
	Molecular formula	Structural formula																				
1	CH_2O_2	$\text{H} - \text{COOH}$																				
2	$\text{C}_2\text{H}_4\text{O}_2$	$\text{CH}_3 - \text{COOH}$																				
3	$\text{C}_3\text{H}_6\text{O}_2$	$\text{CH}_3 - \text{CH}_2 - \text{COOH}$																				
4	$\text{C}_4\text{H}_8\text{O}_2$	$\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{COOH}$																				
8	Give the IUPAC names of the following compounds. <table><tr><td>i</td><td>$(\text{CH}_3)_2\text{CH}-\text{CH}_2-\text{CH}(\text{CH}_3)-\text{CH}(\text{CH}_3)_2$</td><td>2,3,5-trimethylhexane</td></tr><tr><td>ii</td><td>$\begin{array}{c} \text{CH}_3-\text{CH}-\text{CH}-\text{CH}_3 \\ \quad \\ \text{CH}_3 \text{ Br} \end{array}$</td><td>2-bromo-3-methylbutane</td></tr><tr><td>iii</td><td>$\text{CH}_3-\text{O}-\text{CH}_3$</td><td>Methoxymethane</td></tr><tr><td>iv</td><td>$\begin{array}{c} \text{CH}_3-\text{CH}_2-\text{CH}-\text{CHO} \\ \\ \text{OH} \end{array}$</td><td>2-hydroxybutanal</td></tr><tr><td>v</td><td>$\text{CH}_2 = \text{CH}-\text{CH}=\text{CH}_2$</td><td>Buta-1,3-diene</td></tr><tr><td>vi</td><td>$\begin{array}{c} \text{CH}_3-\text{C}\equiv\text{C}-\text{CH}-\text{CH}_3 \\ \\ \text{Cl} \end{array}$</td><td>4-chloropent-2-yne</td></tr><tr><td>vii</td><td></td><td>1-bromobut-2-ene</td></tr></table>	i	$(\text{CH}_3)_2\text{CH}-\text{CH}_2-\text{CH}(\text{CH}_3)-\text{CH}(\text{CH}_3)_2$	2,3,5-trimethylhexane	ii	$\begin{array}{c} \text{CH}_3-\text{CH}-\text{CH}-\text{CH}_3 \\ \quad \\ \text{CH}_3 \text{ Br} \end{array}$	2-bromo-3-methylbutane	iii	$\text{CH}_3-\text{O}-\text{CH}_3$	Methoxymethane	iv	$\begin{array}{c} \text{CH}_3-\text{CH}_2-\text{CH}-\text{CHO} \\ \\ \text{OH} \end{array}$	2-hydroxybutanal	v	$\text{CH}_2 = \text{CH}-\text{CH}=\text{CH}_2$	Buta-1,3-diene	vi	$\begin{array}{c} \text{CH}_3-\text{C}\equiv\text{C}-\text{CH}-\text{CH}_3 \\ \\ \text{Cl} \end{array}$	4-chloropent-2-yne	vii		1-bromobut-2-ene
i	$(\text{CH}_3)_2\text{CH}-\text{CH}_2-\text{CH}(\text{CH}_3)-\text{CH}(\text{CH}_3)_2$	2,3,5-trimethylhexane																				
ii	$\begin{array}{c} \text{CH}_3-\text{CH}-\text{CH}-\text{CH}_3 \\ \quad \\ \text{CH}_3 \text{ Br} \end{array}$	2-bromo-3-methylbutane																				
iii	$\text{CH}_3-\text{O}-\text{CH}_3$	Methoxymethane																				
iv	$\begin{array}{c} \text{CH}_3-\text{CH}_2-\text{CH}-\text{CHO} \\ \\ \text{OH} \end{array}$	2-hydroxybutanal																				
v	$\text{CH}_2 = \text{CH}-\text{CH}=\text{CH}_2$	Buta-1,3-diene																				
vi	$\begin{array}{c} \text{CH}_3-\text{C}\equiv\text{C}-\text{CH}-\text{CH}_3 \\ \\ \text{Cl} \end{array}$	4-chloropent-2-yne																				
vii		1-bromobut-2-ene																				

viii		5-oxohexanoic acid
ix		3-ethyl-4-ethenylheptane
x		2,4,4-trimethylpent-2-ene
xi		2-methyl-1-phenylpropan-1-amine
xii		2,2-dimethyl-4-oxopentanenitrile
xiii		2-ethoxypropane
xiv		1-fluoro-4-methyl-2-nitrobenzene
xv		3-bromo-2-methylpentanal

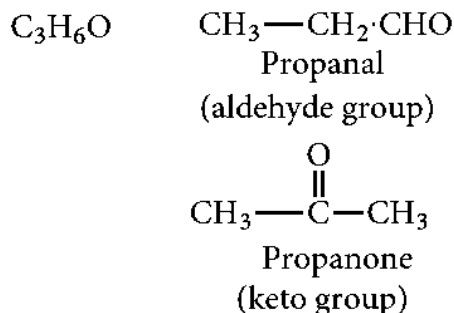
9	Give the structure for the following compound.	
i	3- ethyl - 2 methyl -1-pentene	
ii	1,3,5- Trimethyl cyclohex - 1 -ene	
iii	tertiary butyl iodide	

	iv	3 - Chlorobutanal	
	v	3 - Chlorobutanol	
	vi	2 - Chloro - 2- methyl propane	
	vii	2,2-dimethyl-1-chloropropane	
	viii	3 - methylbut -1- ene	
	ix	Butan - 2, 2 - diol	
	x	Octane - 1,3- diene	
	xi	1,3- Dimethylcyclohexane	
	xii	3-Chlorobut - 1 - ene	
	xiii	3 - methylbutan - 2 - ol	
	xiv	acetaldehyde	
10	Describe the reactions involved in the detection of nitrogen in an organic compound by Lassaigne method. (Mar-19) - If nitrogen is present, it gets converted to sodium cyanide which reacts with freshly prepared ferrous sulphate and ferric ion followed by conc. HCl and gives a Prussian blue colour or green colour or precipitate. It confirms the presence of nitrogen. - HCl is added to dissolve the greenish precipitate of ferrous hydroxide produced by the excess of NaOH on FeSO₄ which would otherwise mark the Prussian blue precipitate.		

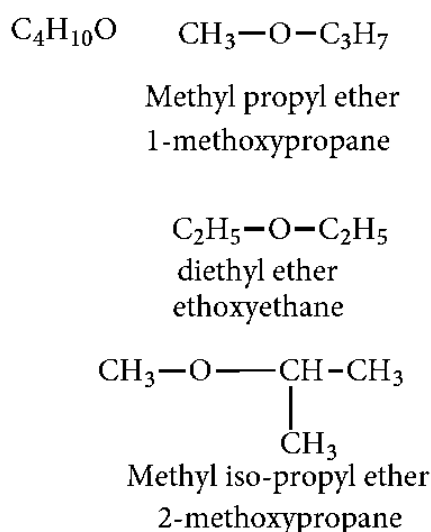
	The following reaction takes part in the formation of Prussian blue. $\text{Na} + \text{C} + \text{N} \longrightarrow \text{NaCN}$ (from organic compounds) $\text{FeSO}_4 + 2\text{NaOH} \longrightarrow \text{Fe(OH)}_2 + \text{Na}_2\text{SO}_4$ (from excess of sodium) $6\text{NaCN} + [\text{Fe(OH)}_2] \longrightarrow \text{Na}_4[\text{Fe(CN)}_6] + 2\text{NaOH}$ Sodium ferrocyanide $\text{Na}_4[\text{Fe(CN)}_6] + 4\text{FeCl}_3 \longrightarrow \text{Fe}_4[\text{Fe(CN)}_6]_3 + 12\text{NaCl}$ ferric ferrocyanide Prussian blue or green ppt Incase if both N & S are present, a blood red colour is obtained due to the following reactions. $\text{Na} + \text{C} + \text{N} + \text{S} \xrightarrow{\text{Heat}} \text{NaCNS}$ sodium sulphocyanide $3\text{NaCNS} + \text{FeCl}_3 \longrightarrow \text{Fe(CNS)}_3 + 3\text{NaCl}$ ferric sulphocyanide (Blood red colour)
11	Give the principle involved in the estimation of halogen in an organic compound by carius method. Estimation of halogens (carius method): A known mass of the organic compound is heated with fuming HNO_3 and AgNO_3. C,H &S get oxidized to CO_2, H_2O & SO_2 and halogen combines with AgNO_3 to form a precipitate of silver halide. $\text{X} \xrightarrow[\text{AgNO}_3]{\text{fum.HNO}_3} \text{AgX} \downarrow$ The ppt of AgX is filtered, washed, dried and weighed. From the mass of AgX and the mass of the organic compound taken, percentage of halogens are calculated.
12	Give a brief description of the principles of i) Fractional distillation (Jul-19): - This is one method to purify and separate liquids present in the mixture having their boiling point close to each other. - In this method, a fractionating column is fitted with distillation flask and a condenser. - A thermometer is fitted in the fractionating column near the mouth of the condenser. This will enable to record the temperature of vapour passing over the condenser. - The process of separation of the components in a liquid mixture at their respective boiling points in the form of vapours and the subsequent condensation of those vapours is called fractional distillation. - If necessary, the process of fractional distillation is repeated. - This method is very useful in distillation of petroleum, coal-tar and crude oil. ii) Column Chromatography - This is the simplest chromatographic method carried out in long glass column having a stop cock near the lower end. - This method involves separation of a mixture over a column of adsorbent (Stationery phase) packed in a column.

	- In the column a plug of cotton or glass wool is placed at the lower end of the column to support the adsorbent powder. The tube is uniformly packed with suitable adsorbent constitute the stationary phase. (Activated aluminum oxides (alumina), Magnesium oxide, starch are also used as adsorbents). - The mixture to be separated is placed on the top of the adsorbent column. Eluent which is a liquid or a mixture of liquids is allowed to flow down the column slowly. - Different components are eluted depending upon the degree to which the components are adsorbed and complete separation takes place. The most readily adsorbed are retained near the top and others come down to various distances in the column.			
13	Explain paper chromatography - It is an example of partition chromatography. - A strip of paper acts as an adsorbent. This method involves continuous differential portioning of components of a mixture between stationary and mobile phase. - In this method, a special quality paper known as chromatography paper is used. This paper act as a stationary phase. - A strip of chromatographic paper spotted at the base with the solution of the mixture is suspended in a suitable solvent which act as the mobile phase. The solvent rises up and flows over the spot. - The paper selectively retains different components according to their different partition in the two phases where a chromatogram is developed. - The spots of the separated colored compounds are visible at different heights from the position of initial spots on the chromatogram. - The spots of the separated colorless compounds may be observed either under ultraviolet light or by the use of an appropriate spray reagent.			
14	Explain various types of constitutional isomerism (structural isomerism) in organic compounds. (Jul-22) This type of isomers has same molecular formula but differ in their bonding sequence. (a) Chain or nuclear or skeletal isomerism: These isomers differ in the way in which the carbon atoms are bonded to each other in a carbon chain or in other words isomers have similar molecular formula but differ in the nature of the carbon skeleton (ie. Straight or branch) <table border="1" style="width: 100%; text-align: center;"> <tr> <td style="width: 33%;"> $\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_3$ n-Pentane </td> <td style="width: 33%;"> $\begin{array}{c} \text{CH}_3-\text{CH}-\text{CH}_2-\text{CH}_3 \\ \\ \text{CH}_3 \end{array}$ Isopentane 2-methyl butane </td> <td style="width: 33%;"> $\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3-\text{C}-\text{CH}_3 \\ \\ \text{CH}_3 \end{array}$ Neopentane 2,2-dimethyl propane </td> </tr> </table> (b) Position isomerism: If different compounds belonging to same homologous series with the same molecular formula and carbon skeleton, but differ in the position of substituent or functional group or an unsaturated linkage are said to exhibit position isomerism. Molecular formula C_5H_{10} $\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}=\text{CH}_2$ Pent-1-ene and $\text{CH}_3-\text{CH}_2-\text{CH}=\text{CH}-\text{CH}_3$ Pent-2-ene	$\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_3$ n-Pentane	$\begin{array}{c} \text{CH}_3-\text{CH}-\text{CH}_2-\text{CH}_3 \\ \\ \text{CH}_3 \end{array}$ Isopentane 2-methyl butane	$\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3-\text{C}-\text{CH}_3 \\ \\ \text{CH}_3 \end{array}$ Neopentane 2,2-dimethyl propane
$\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_3$ n-Pentane	$\begin{array}{c} \text{CH}_3-\text{CH}-\text{CH}_2-\text{CH}_3 \\ \\ \text{CH}_3 \end{array}$ Isopentane 2-methyl butane	$\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3-\text{C}-\text{CH}_3 \\ \\ \text{CH}_3 \end{array}$ Neopentane 2,2-dimethyl propane		

(c) Functional isomerism: Different compounds having same molecular formula but different functional groups are said to exhibit functional isomerism.

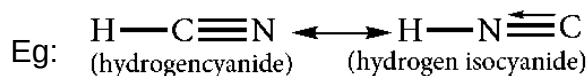


(d) Metamerism: This type of isomerism is a special kind of structural isomerism arises due to the unequal distribution of carbon atoms on either side of the functional group or different alkyl groups attached to the either side of the same functional group and having same molecular formula.

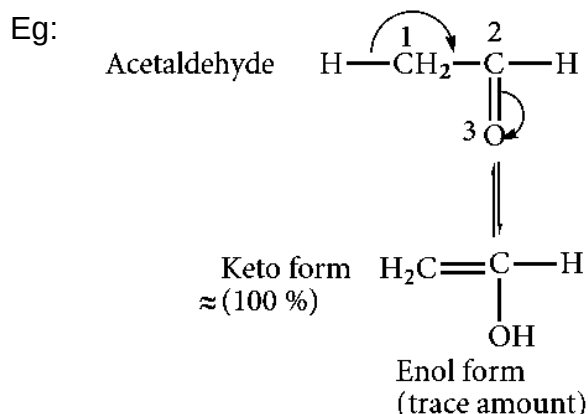


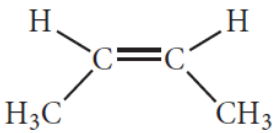
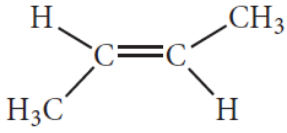
(e) Tautomerism: It is a special type of functional isomerism in which a single compound exists in two readily inter convertible structures that differ markedly in the relative position of atleast one atomic nucleus, generally hydrogen. The two different structures are known as tautomers. There are two important types are dyad and triad systems.

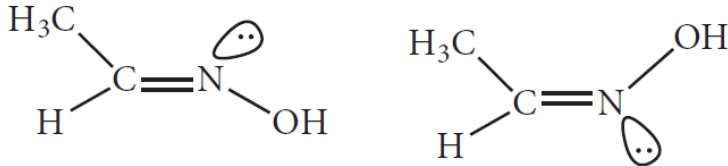
(i) Dyad system: In this system hydrogen atom oscillates between two directly linked polyvalent atoms.



(ii) Triad system: In this system hydrogen atom oscillates between three polyvalent atoms. It involves 1,3 migration of hydrogen atom from one polyvalent atom to other within the molecule. The most important type of triad system is keto–enol tautomerism and the two groups of tautomers are ketoform and enol-form.



	(f) Ring chain isomerism: The compounds having same molecular formula but differ in terms of bonding of carbon atom to form open chain and cyclic structures. eg: C_3H_6 $H_3C-CH=CH_2$ and $\begin{array}{c} CH_2 \\ \diagup \quad \diagdown \\ H_2C-CH_2 \end{array}$ Propene Cyclopropane
15	Describe optical isomerism with suitable example. (May-22) - 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. - Glucose has the ability to rotate the plane of the plane polarized light and they are said to be optically active compounds and this property of a compound is called optical activity. - The optical isomer, which rotates the plane of the plane polarised light to the right or in clockwise direction is said to be dextro rotatory denoted by the sign (+), - The compound which rotates to the left or anticlockwise is said to be leavo rotatory denoted by sign (-). - Dextrorotatory compounds are represented as 'd' or by sign (+) and leavorotatory compounds are represented as 'l' or by sign (-).
16	Briefly explain geometrical isomerism in alkene by considering 2- butene as an example. (Sep-20) $CH_3-CH=CH-CH_3$ - Geometrical isomers are the stereoisomers which have different arrangement of groups or atoms around a rigid frame work of double bonds. - This type of isomerism occurs due to restricted rotation of double bonds, or about single bonds in cyclic compounds. - The carbon-carbon double bond consists of a σ bond and a π bond. Rotation around $C=C$ bond is not possible. This restriction of rotation about $C-C$ double bond is responsible for geometrical isomerism in alkenes.  <i>cis</i> - 2-butene  <i>Trans</i> 2-butene - The <i>cis</i> isomer is one in which two similar groups are on the same side of the double bond. The <i>trans</i> isomer is that in which the two similar groups are on the opposite side of the double bond, hence this type of isomerism is often called <i>cis-trans</i> isomerism. - The <i>cis</i>-isomer can be converted to <i>trans</i> isomer or vice versa is only if either isomer is heated to a high temperature or absorbs light. - The heat supplies the energy (about 62kcal/ mole) to break the π bond so that rotation about σ bond becomes possible. - Upon cooling, the reformation of the π bond can take place in two ways giving a mixture both <i>cis</i> and <i>trans</i> forms of <i>trans</i>-2-butene and <i>cis</i>-2-butene.
17	Which is more stable in <i>cis</i> and <i>trans</i> isomers. - The <i>trans</i> isomer is more stable than the corresponding <i>cis</i> isomers. - This is because in the <i>cis</i> isomer, the bulky groups are on the same side of the double bond. - The steric repulsion of the groups makes the <i>cis</i> isomers less stable than the <i>trans</i> isomers in which bulky groups are on the opposite side.

18	Explain oximes and azo compounds? - Restricted rotation around C=N (oximes) gives rise to geometrical isomerism in oximes. Here 'syn' and 'anti' are used instead of cis and trans respectively. - In the syn isomer the H atom of a doubly bonded carbon and –OH group of doubly bonded nitrogen lie on the same side of the double bond, while in the anti-isomer, they lie on the opposite side of the double bond.  syn (cis) acetaldoxime anti (trans) acetaldoxime
19	Define Catenation? The tendency of an atom to form a chain of bonds with the atoms of the same element is called catenation.
20	Define isomerism? It represents the existence of two or more compounds with the same molecular formula but different structure and properties is called isomerism.
21	What are enantiomers? An optically active substance may exist in two or more isomeric forms which have same physical and chemical properties but differ in terms of direction of rotation of plane polarized light, such optical isomers which rotate the plane of polarized light with equal angle but in opposite direction are known as enantiomers.
22	Give the conditions for optical isomerism? A molecule should possess, 1) chiral carbon (carbon atom whose tetra valency is satisfied by four different atoms or groups). 2) A molecule possessing non-super imposable to its own mirror image
23	Explain the preparation of lassaigue's extract? - 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 lassaigue's extract or sodium fusion extract and it used for detection of nitrogen, sulfur and halogens present in organic compounds.
24	Define Sublimation? - Few substances like benzoic acid, naphthalene and camphor when heated pass directly from solid to vapor without melting (ie liquid). On cooling the vapours will give back solids. Such phenomenon is called sublimation. It is a useful technique to separate volatile and non-volatile solid. - Substances to be purified is taken in a beaker. It is covered with a watch glass. The beaker is heated for a while and the resulting vapours condense on the bottom of the watch glass. Then the watch glass is removed and the crystals are collected.

25	Define Crystallization? (Sep-20) Selection of solvent: Most of the organic substances being covalent do not dissolve in polar solvents like water, hence selection of solvent (suitable) becomes necessary. Hence the powdered organic substance is taken in a test tube and the solvent is added little by little with constant stirring and heating, till the amount added is just sufficient to dissolve the solute (ie) organic compound. If the solid dissolves upon heating and throws out maximum crystals on cooling, then the solvent is suitable. This process is repeated with other solvents like benzene, ether, acetone and alcohol till the most suitable one is sorted out. Preparation of solution: The organic substance is dissolved in a minimum quantity of suitable solvent. Small amount of animal charcoal can be added to decolorize any coloured substance. The heating may be done over a wire gauze or water bath depending upon the nature of liquid. Filtration of hot solution: The hot solution so obtained is filtered through a fluted filter paper placed in a funnel. Crystallization: The hot filtrate is then allowed to cool. Most of the impurities are removed on the filter paper, the pure solid substance separates as crystal. When copious amount of crystal has been obtained, then the crystallization is complete. If the rate of crystallization is slow, it is induced either by scratching the walls of the beaker with a glass rod or by adding a few crystals of the pure compounds to the solution. Isolation and drying of crystals: The crystals are separated from the mother liquor by filtration. Filtration is done under reduced pressure using a Bucher funnel. When the whole of the mother liquor has been drained into the filtration flask, the crystals are washed with small quantities of the pure cold solvent and then dried.
26	Explain Differential extraction? • The process of removing a substance from its aqueous solution by shaking with a suitable organic solvent is termed extraction. • When an organic substance present as solution in water can be recovered from the solution by means of a separating funnel. • The aqueous solution is taken in a separating funnel with little quantity of ether or chloroform (CHCl_3). The organic solvent immiscible with water will form a separate layer and the contents are shaken gently. • The solute being more soluble in the organic solvent is transferred to it. The solvent layer is then separated by opening the tap of the separating funnel, and the substance is recovered.
27	Explain Thin layer chromatography? • This method is possible to separate even minute quantities of mixtures. • A sheet of a glass is coated with a thin layer of adsorbent (cellulose, silica gel or alumina). This sheet of glass is called chromoplate or thin layer chromatography plate. • After drying the plate, a drop of the mixture is placed just above one edge and the plate is then placed in a closed jar containing eluent (solvent). The eluent is drawn up the adsorbent layer by capillary action. • The components of the mixture move up along with the eluent to different distances depending upon their degree of adsorption of each component of the mixture. • It is expressed in terms of its retention factor (i.e.) R_f value $R_f = \frac{\text{Distance moved by the substance from base line (x)}}{\text{Distance moved by the solvent from base line (y)}}$

28	Explain briefly about simple distillation? The process of distillation involves the impure liquid when boiled gives out vapour and the vapour so formed is collected and condensed to give back the pure liquid in the receiver. This method is called simple distillation. Liquids with large difference in boiling point (about 40k) and do not decompose under ordinary pressure can be purified by simply distillation Eg. The mixture of $C_6H_5NO_2$ (b.p 484k) & C_6H_6(354k) and mixture of diethyl ether (b.p 308k) and ethyl alcohol (b.p 351k)
29	Explain Steam distillation? - This method is applicable for solids and liquids. If the compound to be steam distilled the it should not decompose at the steam temperature, should have a fairly high vapour pressure at 373k, it should be insoluble in water and the impurities present should be non-volatile. - The impure liquid along with little water is taken in a round-bottom flask which is connected to a boiler on one side and water condenser on the other side, the flask is kept in a slanting position so that no droplets of the mixture will enter into the condenser on the brisk boiling and bubbling of steam. - The mixture in the flask is heated and then a current of steam passed in to it. The vapours of the compound mix up with steam and escape into the condenser. The condensate obtained is a mixture of water and organic compound which can be separated. - This method is used to recover essential oils from plants and flowers, also in the manufacture of aniline and turpentine oil.
30	Explain Azeotropic Distillation? - These are the mixture of liquids that cannot be separated by fractional distillation. The mixtures that can be purified only by azeotropic distillation are called as azeotropes. - These azeotropes are constant boiling mixtures, which distil as a single component at a fixed temperature. For example, ethanol and water in the ratio of 95.87 : 4.13. - In this method the presence of a third component like C_6H_6, CCl_4, ether, glycerol, glycol which act as a dehydrating agent depress the partial pressure of one component of azeotropic mixture and raises the boiling point of that component and thus other component will distil over. - Substances like C_6H_6, CCl_4 have low boiling points and reduce the partial vapour pressure of alcohol more than that of water while substances like glycerol & glycol etc. have high boiling point and reduce the partial vapour pressure of water more than that of alcohol.
31	Describe the method to estimate carbon and hydrogen present in organic compound? Both carbon and hydrogen are estimated by the same method. A known weight of the organic substance is burnt in excess of oxygen and the carbon and hydrogen present in it are oxidized to carbon dioxide and water, respectively. The weight of carbon dioxide and water thus formed are determined and the amount of carbon and hydrogen in the organic substance is calculated. Procedure: The combustion tube is heated strongly to dry its content. It is then cooled slightly and connected to the absorption apparatus. The other end of the combustion tube is open for a while and the boat containing weighed organic substance is introduced. The tube is again heated strongly till the substance in the boat is burnt away. This takes about 2 hours. Finally, a strong current of oxygen is passed through the combustion tube to sweep away any traces of carbon dioxide or moisture which may be left in it. The U-tube and the potash bulbs are then detached and the increase in weight of each of them is determined.

	Calculation: Weight of the organic substance taken = w g Increase in weight of H₂O = x g Increase in weight of CO₂ = y g 18 g of H₂O contains 2g of hydrogen ∴ x g of H₂O contains $\left(\frac{2x}{18}\right)$ g of hydrogen Percentage of hydrogen = $\left(\frac{2x}{18} \times \frac{x}{w} \times 100\right) \%$ 44g of CO₂ contains 12g of carbon ∴ y g of CO₂ contains $\left(\frac{12y}{44}\right)$ g of carbon Percentage of Carbon = $\left(\frac{12y}{44} \times \frac{y}{w} \times 100\right) \%$
32	Describe the method to estimate sulphur present in organic compound? Carius method: A known mass of the organic substance is heated strongly with fuming HNO₃. C & H get oxidized to CO₂ & H₂O while sulphur is oxidized to sulphuric acid as per the following reaction. $\begin{array}{l} \text{C} \xrightarrow{\text{fum. HNO}_3} \text{CO}_2 \\ 2\text{H} \xrightarrow{\text{fum. HNO}_3} \text{H}_2\text{O} \\ \text{S} \longrightarrow \text{SO}_2 \xrightarrow{\text{O} + \text{H}_2\text{O}} \text{H}_2\text{SO}_4 \end{array}$ The resulting solution is treated with excess of BaCl₂ solution H₂SO₄ present in the solution is quantitatively converted into BaSO₄, from the mass of BaSO₄, the mass of sulphur and hence the percentage of sulphur in the compound can be calculated. Procedure: A known mass of the organic compound is taken in clean carius tube and added a few mL of fuming HNO₃. The tube is the sealed. It is then placed in an iron tube and heated for about 5 hours. The tube is allowed to cool to room temperature and a small hole is made to allow gases produced inside to escape. The carius tube is broken and the content collected in a beaker. Excess of BaCl₂ is added to the beaker contains H₂SO₄ acid as a result of the reaction is converted to BaSO₄. The precipitate of BaSO₄ is filtered, washed, dried and weighed. From the mass of BaSO₄, percentage of S is found. Mass of the organic compound = w g Mass of the BaSO₄ formed = x g 233g of BaSO₄ contains 32 g of Sulphur ∴ x g of BaSO₄ contains $\left(\frac{32}{233} x\right)$ g of S Percentage of Sulphur = $\left(\frac{32}{233} \times \frac{x}{w} \times 100\right) \%$

33	Describe the method to estimate halogens present in organic compound? - A known mass of the substance is taken along with fuming HNO_3 and AgNO_3 is taken in a clean carius tube. - The open end of the Carius tube is sealed and placed in a iron tube for 5 hours in the range at 530- 540 K Then the tube is allowed to cool and a small hole is made in the tube to allow gases produced to escape. The tube is broken and the ppt is filtered, washed, dried and weighed. - From the mass of AgX obtained, percentage of halogen in the organic compound is calculated. Weight of the organic compound = w g ➤ Weight of AgCl precipitate = a g ➤ 143.5 g of AgCl contains 35.5 g of Cl ➤ $\therefore$ a g of AgCl contains = $\frac{35.5}{143.5} \times a$ ➤ w g Organic compound gives a g AgCl ➤ Percentage of Cl in w g = $\left(\frac{35.5}{143.5} \times \frac{a}{w} \times 100 \right)$ % organic compound ○ Let Weight of silver Bromide be 'b'g ○ 188g of AgBr contains 80 g of Br ○ $\therefore$ b g of AgBr contains $\left(\frac{80b}{188} \right)$ g of Br ○ w g Organic compound gives b g AgBr ○ Percentage of Br in w g = $\left(\frac{80}{188} \times \frac{b}{w} \times 100 \right)$ % organic compound • Let Weight of silver Iodide be 'c'g • 235g of AgI contains 127 g of I • $\therefore$ C g of AgI contains $\left(\frac{127c}{235} \right)$ g of I • w g Organic compound gives c g AgI • Percentage of I in w g = $\left(\frac{127}{235} \times \frac{c}{w} \times 100 \right)$ % organic compound
34	Describe carius method to estimate phosphorus present in organic compound? - A known mass of the organic compound (w) containing phosphorous is heated with fuming HNO_3 in a sealed tube where C is converted into CO_2 and H to H_2O. phosphorous present in organic compound is oxidized to phosphoric acid which is precipitated, as ammonium phosphomolybdate by heating with Conc. HNO_3 and then adding ammonium molybdate. - The precipitate of ammonium phosphomolybdate thus formed is filtered washed, dried and weighed. Mass of organic compound is wg Weight of ammonium phosphomolybdate = x g Mole mass of $(\text{NH}_4)_3\text{PO}_4 \cdot 12\text{MoO}_3$ is =1877g

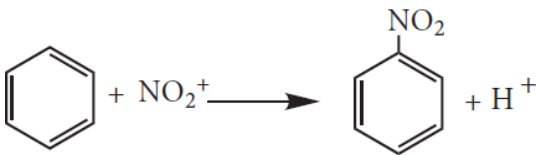
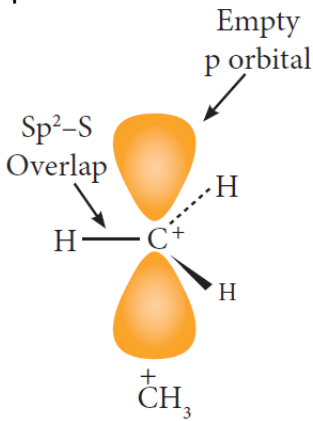
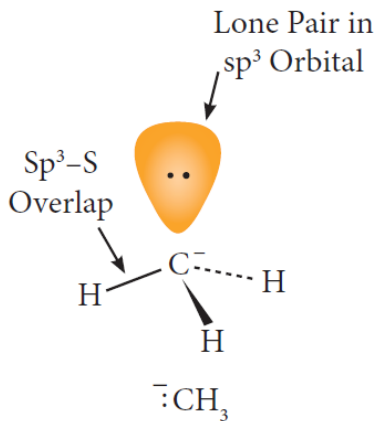
	1877g of $(\text{NH}_4)_3\text{PO}_4 \cdot 12\text{MoO}_3$ contains 31g of P xg of $(\text{NH}_4)_3\text{PO}_4 \cdot 12\text{MoO}_3$ in w g of organic compound contains $\left(\frac{31}{1877} \times \frac{x}{w}\right)$ of phosphorous Percentage of Phosphorous = $\left(\frac{31}{1877} \times \frac{x}{w} \times 100\right) \%$
35	Describe the method to estimate phosphorus using phosphoric acid or magnesia mixture? - The phosphoric acid is precipitated as magnesium-ammonium phosphate by adding magnesia mixture (a mixture containing MgCl_2, NH_4Cl and ammonia) This ppt is washed, dried and ignited to get magnesium pyrophosphate which is washed, dried and weighed. - By knowing the mass of the organic compound and the mass of magnesium pyrophosphate formed, the percentage of P is calculated. Mass of organic compound is wg Weight of magnesium pyrophosphate = y g Molar mass of $\text{Mg}_2\text{P}_2\text{O}_7$ is 222 g 222 of $\text{Mg}_2\text{P}_2\text{O}_7$ contains 62 g of P Y g of $\text{Mg}_2\text{P}_2\text{O}_7$ in w g of Organic compound contains $\left(\frac{62}{222} \times \frac{y}{w}\right)$ of P. Percentage Phosphorous = $\left(\frac{62}{222} \times \frac{y}{w} \times 100\right) \%$
36	Describe Dumas method to estimate nitrogen present in organic compound? Procedure: To start with the tap of nitro meter is left open. CO_2 is passed through the combustion tube to expel the air in it. - When the gas bubbles rising through, the potash solution fails to reach the top of it and is completely absorbed it shows that only CO_2 is coming and that all air has been expelled from the combustion tube. The nitrometer is then filled with KOH solution by lowering the reservoir and the tap is closed. - The combustion tube is now heated in the furnace and the temperature rises gradually. - The nitrogen set free from the compound collects in the nitro meter. When the combustion is complete a strong current of CO_2 is sent through, the apparatus in order to sweep the last trace of nitrogen from it. - The volume of the gas gets collected is noted after adjusting the reservoir so that the solution in it and the graduated tube is the same. The atmospheric pressure and the temperature are also recorded. Calculations: Weight of the substance taken = wg Volume of nitrogen = V_1 L Room Temperature = T_1 K Atmospheric Pressure = P mm of Hg Aqueous tension at room temperature = P_1 mm of Hg Pressure of dry nitrogen = $(P - P_1) = P_1$ mm of Hg.

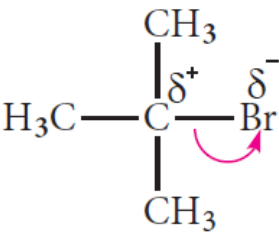
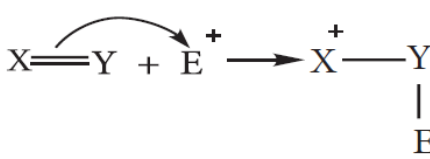
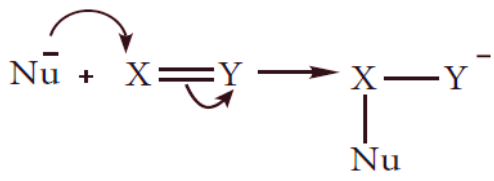
	Let p_0, V_0 and T_0 be the pressure, Volume and temperature respectively of dry nitrogen at STP, $\frac{P_0 V_0}{T_0} = \frac{P_1 V_1}{T_1}$ $\therefore V_0 = \frac{P_1 V_1}{T_1} \times \frac{T_0}{P_0}$ $V_0 = \left(\frac{P_1 V_1}{T_1} \times \frac{273 \text{ K}}{760} \right) \text{ mm of Hg}$ Calculation of percentage of nitrogen. 22.4 L of N_2 at STP weigh 28g of N_2 $\therefore V_0 \text{ L of } N_2 \text{ at S.T.P weigh } \left(\frac{28}{22.4} \times V_0 \right)$ Wg of Organic compound contain $\left(\frac{28}{22.4} \times \frac{V_0}{w} \right)$ g of nitrogen $\therefore \text{Percentage of nitrogen} = \left(\frac{28}{22.4} \times \frac{V_0}{w} \right) \times 100$
37	Describe the Kjeldahls method to estimate nitrogen present in organic compound? Procedure: A weighed quantity of the substance (0.3 to 0.5 g) is placed in a special long – necked Kjeldahl flask made of pyrex glass. About 25 mL of Conc. H_2SO_4 together with a little K_2SO_4 and $CuSO_4$ (catalyst) are added to it the flask is loosely stoppered by a glass bulb and heated gently in an inclined position. The heating is continued till the brown color of the liquid first produced, disappears leaving the contents clear as before. At this point all the nitrogen in the substance is converted to $(NH_4)_2SO_4$. The Kjeldahl flask is then cooled and its contents are diluted with distilled water and then carefully transferred into a 1 lit round bottom flask. An excess NaOH solution is poured down the side of the flask and it is fitted with a Kjeldahl trap and a water condenser. The lower end of the condenser dips in a measured volume of excess the $\frac{N}{20}$ H_2SO_4 solution. The liquid in the round bottom flask is then heated and the liberated ammonia is distilled into sulphuric acid. The Kjeldahl trap serves to retain any alkali splashed up on vigorous boiling. When no more ammonia passes over (test the distillate with red litmus) the receiver is removed. The excess of acid is then determined by titration with alkali, using phenolphthalein as the indicator. Calculation: Weight of the substance = Wg. Volume of H_2SO_4 required for the complete neutralisation of evolved NH_3 = V mL. Strength of H_2SO_4 used to neutralise NH_3 = N Let the Volume and the strength of NH_3 formed are V_1 and N_1 respectively we know that $V_1 N_1 = VN$ The amount of nitrogen present in the w g of Organic Compound = $\frac{14 \times NV}{1 \times 1000 \times W}$ Percentage of Nitrogen = $\left(\frac{14 \times NV}{1000 \times W} \right) \times 100 \%$

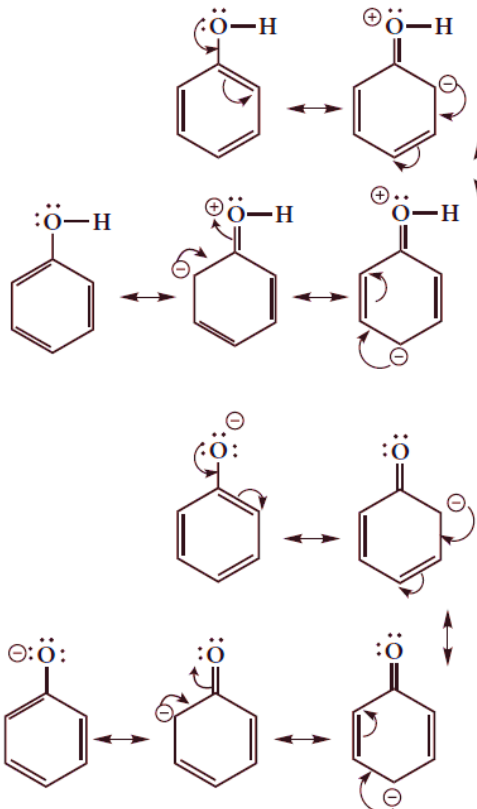
12. BASIC CONCEPTS OF ORGANIC REACTIONS

1	Write short notes on (a) Resonance (Sep-21): - 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 and this phenomenon is called resonance. This phenomenon is also called mesomerism or mesomeric effect. (b) Hyperconjugation: - The delocalisation of electrons of σ bond is called as hyper conjugation. - It is a special stabilising effect that results due to the interaction of electrons of a σ-bond (usually C-H or C-C) with the adjacent, empty non-bonding p-orbital or an anti-bonding σ^* or π^*-orbitals resulting in an extended molecular orbital. - Unlike electromeric effect, hyper conjugation is a permanent effect.				
2	What are electrophiles and nucleophiles? (Mar-19, May-22) Give suitable examples for each. (or) Differentiate electrophiles and nucleophiles? (Mar-24) <table border="1"> <thead> <tr> <th>Nucleophiles:</th><th>Electrophiles:</th></tr> </thead> <tbody> <tr> <td> - They are reagents that has high affinity for electro positive centers. - They possess an atom has an unshared pair of electrons - They are usually negatively charged ions or electron rich neutral molecules - All Lewis bases act as nucleophiles - They are electrons donors. - Eg: NH_3, H_2S, Cl^-, CN^- </td><td> - They are reagents that are attracted towards negative charge or electron rich center. - They are either positively charged ions or electron deficient neutral molecules. - All Lewis acids act as electrophiles - They are electron acceptors - Eg: CO_2, $^+\text{NO}_2$, H^+ </td></tr> </tbody> </table>	Nucleophiles:	Electrophiles:	- They are reagents that has high affinity for electro positive centers. - They possess an atom has an unshared pair of electrons - They are usually negatively charged ions or electron rich neutral molecules - All Lewis bases act as nucleophiles - They are electrons donors. - Eg: NH_3, H_2S, Cl^-, CN^-	- They are reagents that are attracted towards negative charge or electron rich center. - They are either positively charged ions or electron deficient neutral molecules. - All Lewis acids act as electrophiles - They are electron acceptors - Eg: CO_2, $^+\text{NO}_2$, H^+
Nucleophiles:	Electrophiles:				
- They are reagents that has high affinity for electro positive centers. - They possess an atom has an unshared pair of electrons - They are usually negatively charged ions or electron rich neutral molecules - All Lewis bases act as nucleophiles - They are electrons donors. - Eg: NH_3, H_2S, Cl^-, CN^-	- They are reagents that are attracted towards negative charge or electron rich center. - They are either positively charged ions or electron deficient neutral molecules. - All Lewis acids act as electrophiles - They are electron acceptors - Eg: CO_2, $^+\text{NO}_2$, H^+				
3	Show the heterolysis of covalent bond by using curved arrow notation and complete the following equations. Identify the nucleophile is each case. i) $\text{CH}_3 - \text{Br} + \text{KOH} \longrightarrow \text{CH}_3 - \text{OH} + \text{KBr}$ Here OH^- is the nucleophile. Step-1: $\text{CH}_3 - \text{Br} \longrightarrow ^+\text{CH}_3 + \text{Br}^-$ Step-2: $^+\text{CH}_3 + \text{K}^+ - \text{OH}^- \longrightarrow \text{CH}_3 - \text{OH} + \text{KBr}$ ii) $\text{CH}_3 - \text{OCH}_3 + \text{HI} \longrightarrow \text{CH}_3\text{OH} + \text{CH}_3 - \text{I}$ Here I^- is the nucleophile. Step-1: $\text{CH}_3 - \text{OCH}_3 \longrightarrow ^+\text{CH}_3 + ^-\text{OCH}_3$ Step-2: $^+\text{CH}_3 + \text{I}^- \longrightarrow \text{CH}_3 - \text{I}$				
4	Explain inductive effect with suitable example. (Mar-23) - Inductive effect is defined as the change in the polarisation of a covalent bond due to the presence of adjacent bonds, atoms or groups in the molecule. This is a permanent phenomenon. - Let us explain the inductive effect by considering ethane and ethylchloride as examples.				

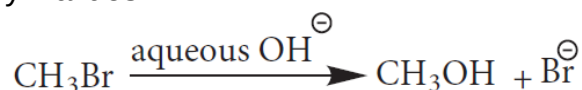
	- The C-C bond in ethane is non polar while the C-C bond in ethyl chloride is polar. - We know that chlorine is more electronegative than carbon, hence it attracts the shared pair of electrons between C-Cl in ethyl chloride towards itself. This develops a slight negative charge on chlorine and a slight positive charge on carbon to which chlorine is attached. - To compensate it, the C₁ draws the shared pair of electrons between itself and C₂. - This polarisation effect is called inductive effect. This effect is greatest for the adjacent bonds, but they also be felt farther away. - However, the magnitude of the charge separation decreases rapidly, as we move away from C₁ and is observed maximum for 2 carbons and almost insignificant after 4 bonds from the active group. $\overset{\delta\delta+}{\text{CH}_3} \xrightarrow{2} \overset{\delta+}{\text{CH}_2} \xrightarrow{1} \overset{\delta-}{\text{Cl}}$
5	Explain electromeric effect. - Electromeric is a temporary effect which operates in unsaturated compounds (containing >C=C<, >C=O, etc...) in the presence of an attacking reagent. - Let us consider two different compounds (i) compounds containing carbonyl group (>C=O) and (ii) unsaturated compounds such as alkenes (>C=C<). - When a nucleophile approaches the carbonyl compound, the π electrons between C and O is instantaneously shifted to the more electronegative oxygen. - This makes the carbon electron deficient and thus facilitating the formation of a new bond between the incoming nucleophile and the carbonyl carbon atom. $\text{CN}^- + \text{>C=O} \rightarrow \text{NC-C-O}^-$ - On the other hand, when an electrophile such as H⁺ approaches an alkene molecule, the π electrons are instantaneously shifted to the electrophile and a new bond is formed between carbon and hydrogen. - This makes the other carbon electron deficient and hence it acquires a positive charge. $\text{H}_2\text{C=CH}_2 + \text{H}^+ \rightarrow \left[\overset{\delta+}{\text{H}_2\text{C}} - \overset{\delta-}{\text{CH}_2} + \text{H}^+ \right] \rightarrow \text{H}_2\text{C}^+ - \text{CH}_3$
6	Give examples for the following types of organic reactions (i) β - elimination (Mar-24) n-Propyl bromide on reaction with alcoholic KOH gives propene. In this reaction hydrogen and Br are eliminated. $\text{CH}_3 - \overset{\beta}{\text{CH}} - \overset{\alpha}{\text{CH}_2} - \text{Br} \xrightarrow{\text{Alcoholic OH}^-} \text{CH}_3 - \text{CH} = \text{CH}_2 + \text{H}_2\text{O} + \text{Br}^-$ (ii) Electrophilic substitution.

	Nitration of Benzene is an example for electrophilic substitution.  Here, NO_2^+ acts as an electrophile.
7	Why does a cutted apple turns brown when kept in air? - Apples contain an enzyme called polyphenol oxidase (PPO), also known as tyrosinase. - Cutting an apple exposes its cells to the atmospheric oxygen and oxidizes the phenolic compounds present in apples. - This is called the enzymatic browning that turns a cutted apple brown.
8	Write a short note on hybridisation of carbon in carbocation? In a carbocation, the carbon bearing positive charge is sp^2 hybridised and hence it has a planar structure. In the reaction involving such a carbocation, the attack of a negatively charged species (nucleophiles) take place on either side of the carbocation as shown below.  Relative stability carbocations: $^+\text{C}(\text{CH}_3)_3 > ^+\text{CH}(\text{CH}_3)_2 > ^+\text{CH}_2\text{CH}_3 > ^+\text{CH}_3$
9	Write a short note on hybridisation of carbon in carbanion? The carbanions are generally pyramidal in shape and the lone pair occupies one of the sp^3 hybridised orbitals. An alkyl free radical may be either pyramidal or planar.  Relative stability of carbanions: $^-\text{C}(\text{CH}_3)_3 > ^-\text{CH}(\text{CH}_3)_2 > ^-\text{CH}_2\text{CH}_3 > ^-\text{CH}_3$
10	Explain +I effect and -I effect with example? (Jun-19) +I effect: - Highly electropositive atoms and atoms are groups which carry a negative charge are electron donating or +I group. - Eg: Alkali metals, alkyl groups such as methyl, ethyl, negatively charged groups such as CH_3O^-, $\text{C}_2\text{H}_5\text{O}^-$, COO^- etc. - Lesser the electronegativity of the elements, greater is the +I effect.

	-I effect: - Highly electronegative atoms and groups with an atom carrying a positive charge are electron withdrawing groups or –I groups. - Eg: -F, -Cl, -COOH, -NO₂, -NH₂ - Higher the electronegativity of the substituent, greater is the -I effect.
11	Explain the change in reactivity of organic compound and acidity of carboxylic acids due to induction effect? - When a highly electronegative atom such as halogen is attached to a carbon then it makes the C-X bond polar. - In such cases the -I effect of halogen facilitates the attack of an incoming nucleophile at the polarised carbon, and hence increases the reactivity.  - If a -I group is attached nearer to a carbonyl carbon, it decreases the availability of electron density on the carbonyl carbon, and hence increases the rate of the nucleophilic addition reaction. Acidity of carboxylic acids: - When a halogen atom is attached to the carbon which is nearer to the carboxylic acid group, its -I effect withdraws the bonded electrons towards itself and makes the ionisation of H⁺ easy. - The acidity of various chloro acetic acid is in the following order. $\text{CCl}_3\text{COOH} > \text{CHCl}_2\text{COOH} > \text{CH}_2\text{ClCOOH} > \text{CH}_3\text{COOH}$ - The strength of the acid increases with increase in the -I effect of the group attached to the carboxyl group.
12	Explain +E effect and -E effect with suitable example? +E effect: When the π electron is transferred towards the attacking reagent, it is called + E (positive electromeric) effect.  The addition of H⁺ to alkene as shown above is an example of +E effect. - E effect: When the π electron is transferred away from the attacking reagent, it is called, -E (negative electromeric) effect.  The attack of CN⁻ on a carbonyl carbon, as shown above, is an example of -E effect.

13	Explain the acidity of phenol using resonance effect? 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.
14	Define Positive Mesomeric Effect and Negative Mesomeric Effect? Positive Mesomeric Effect: • 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. • Eg: -OH, -SH, -OR, -SR, -NH₂, -O- etc. Negative Mesomeric Effect: • Negative resonance effect occurs, when the electrons move towards the substituent attached to the conjugated system. • It occurs if the electron withdrawing substituents are attached to the conjugated system. • In such cases, the attached group has a tendency to withdraw electrons through resonance. These electron withdrawing groups are usually denoted as -R or -M groups. • Eg: NO₂, >C=O, -COOH, -C≡N etc
15	Explain the following substitution reactions with example? i) Nucelophilic substituion: This reaction can be represented as,  Here Y⁻ is the incoming nucleophile or and attacking species and X⁻ is the leaving group.

Example: Hydrolysis of alkyl halides.



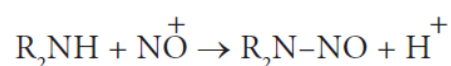
Aliphatic nucleophilic substitution reactions take places either by S_N^1 or S_N^2 mechanism.

ii) Free radical substitution:



Aliphatic electrophilic substitution

A general aliphatic electrophilic substitution is represented as,



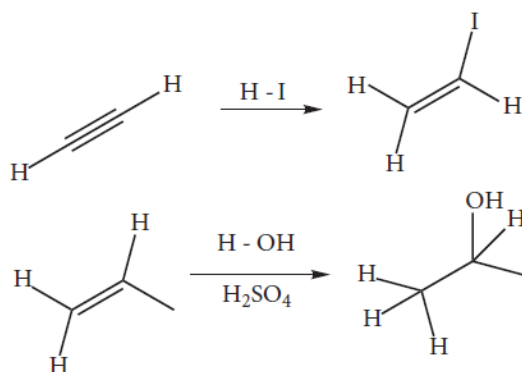
16 **Explain the following substitution reactions with example?**

i) Electrophilic Addition reaction

ii) Nucleophilic addition reaction

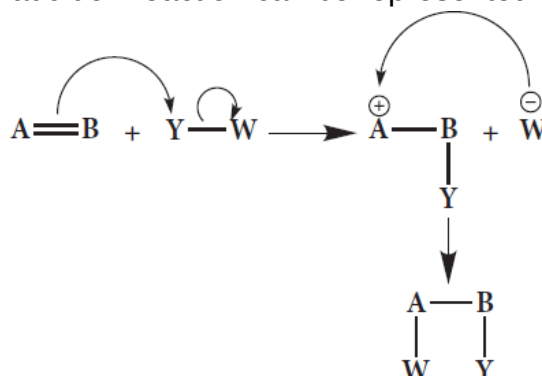
iii) Free radical addition Reaction

- It is a characteristic reaction of an unsaturated compound (compounds containing C-C localised double or triple bond).
- In this reaction two molecules combine to give a single product.
- Like substitution this reaction also can be classified as nucleophilic, electrophilic and free radical addition reactions depending the type of reagent which initiates the reaction.
- During the addition reaction the hybridisation of the substrate changes (from $\text{sp}^2 \rightarrow \text{sp}^3$ in the addition reaction of alkenes or $\text{sp} \rightarrow \text{sp}^2$ in the addition reaction of alkynes) as only one bond breaks and two new bonds are formed.

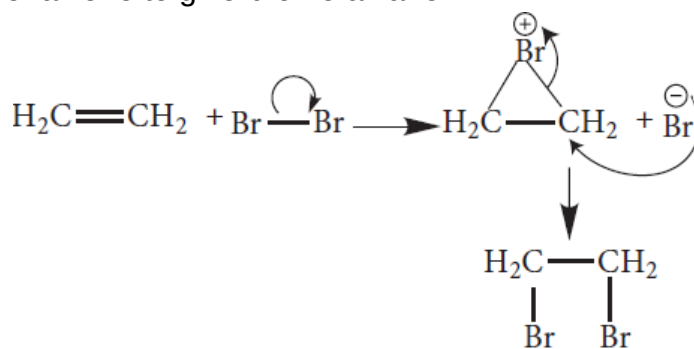


i) Electrophilic Addition reaction:

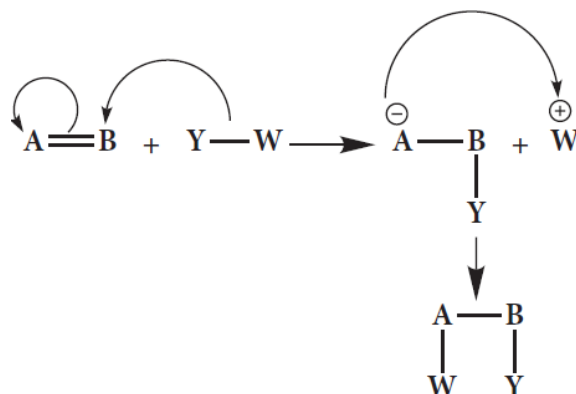
A general electrophilic addition reaction can be represented as below.



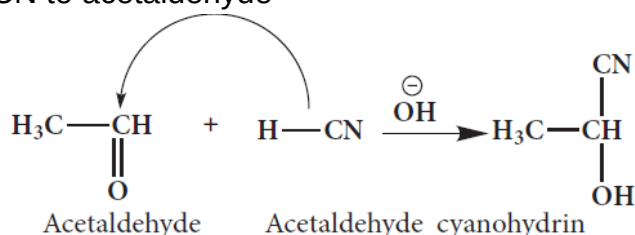
Example: Bromination of alkene to give bromo alkane.



ii) Nucleophilic addition reaction:

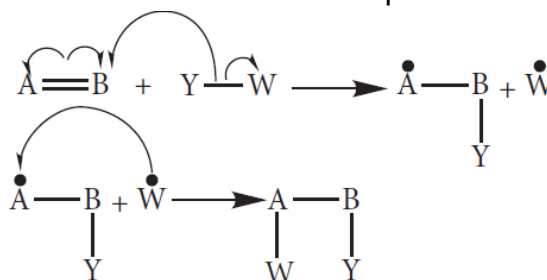


Example: Addition of HCN to acetaldehyde

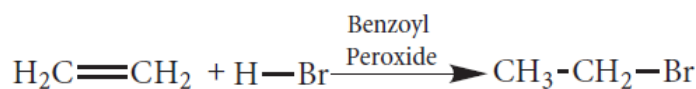


iii) Free radical addition Reaction:

A General free radical addition reaction can be represented as below.



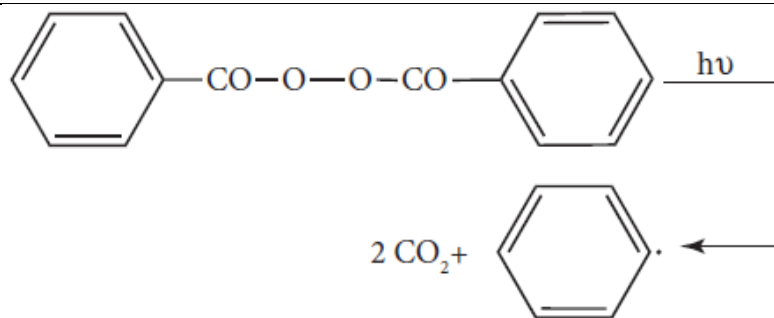
Example:



In the above reaction, Benzoyl peroxide acts as a radical initiator. The mechanism involves free radicals.

17 **Briefly explain about free radicals?**

- Homolytic cleavage of covalent bonds results into free radicals.
- They are short lived and are highly reactive.
- The type of reagents that promote homolytic cleavage in substrate are called as free radical initiators.
- For example, Azobisisobutyronitrile (AIBN) and peroxides such as benzoyl peroxide are used as free radical initiators in polymerisation reactions.



- As a free radical with an unpaired electron is neutral and unstable, it has a tendency to gain an electron to attain stability.
- Organic reactions involve homolytic fission of C-C bonds to form alkyl free radicals.
- The stability of alkyl free radicals is in the following order

$$C(CH_3)_3 > CH(CH_3)_2 > CH_2CH_3 > CH_3$$

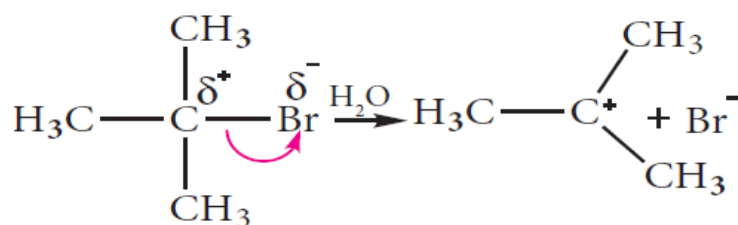
18 Explain Homolytic Cleavage and Heterolytic Cleavage?

Homolytic Cleavage:

- Homolytic cleavage is the process in which a covalent bond breaks symmetrically in such way that each of the bonded atoms retains one electron.
- It is denoted by a half-headed arrow (fish hook arrow).
- This type of cleavage occurs under high temperature or in the presence of UV light in a compound containing non polar covalent bond formed between atoms of similar electronegativity.
- In such molecules, the cleavage of bonds results into free radicals.
- Eg: $CH_3 - CH_3 \xrightarrow[\text{UV light}]{\text{high temperature}} 2\dot{C}H_3$

Heterolytic Cleavage:

- In this process a covalent bond breaks unsymmetrically such that one of the bonded atoms retains the bond pair of electrons.
- It results in the formation of a cation and an anion.
- Of the two bonded atoms, the most electronegative atom becomes the anion and the other atom becomes the cation.
- The cleavage is denoted by a curved arrow pointing towards the more electronegative atom.



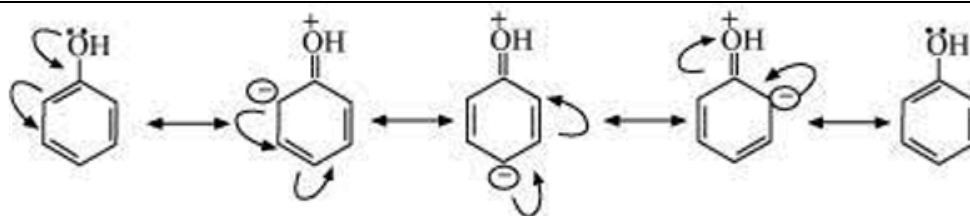
19 Explain the structure of 1,3-butadiene using resonance effect? (Jun-19)

- In 1,3-butadiene, it is expected that the bond between C_1-C_2 and C_3-C_4 should be shorter than that of C_2-C_3 , but the observed bond lengths are of same.
- This property cannot be explained by a simple structure in which two π bonds localised between C_1-C_2 and C_3-C_4 . Actually, the π electrons are delocalised as shown below.

	- These resonating structures are called canonical forms and the actual structure lies between these three resonating structures, and is called a resonance hybrid. - The resonance hybrid is represented as below. $\text{H}_2\text{C} \text{---} \text{C} \text{---} \text{C} \text{---} \text{CH}_2$ H H
20	Explain Hyper conjugation effect (or) Baker-Nathan effect? (S-20,J-22) - It requires an α-CH group or a lone pair on atom like N, O adjacent to a π bond (sp^2 hybrid carbon). - It occurs by the overlapping of the σ-bonding orbital or the orbital containing a lone pair with the adjacent π-orbital or p-orbital. - In propene, the σ-electrons of C-H bond of methyl group can be delocalised into the π-orbital of doubly bonded carbon as represented above. - In the above structure the sigma bond is involved in resonance and breaks in to supply electrons for delocalisation giving rise to 3 new canonical forms. - In the contributing canonical structures: (II), (III) & (IV) of propene, there is no bond between an α-carbon and one of the hydrogen atoms. - Hence the hyperconjugation is also known as “no bond resonance” or “Baker-Nathan effect”. - The structures (II), (III) & (IV) are polar in nature.
21	What are the effects of free radicals in human body and give the methods to reduce its effect? - Human body produces free radicals when it is exposed to x-rays, cigarette smoke, industrial chemicals and air pollutants. - Free radicals can disrupt cell membranes, increase the risk of many forms of cancer, damage the interior lining of blood vessels and lead to a high risk of heart disease and stroke. Methods to decrease the effect of free radicals: - Body uses vitamins and minerals to counter the effects of free radicals. - Fruits contains antioxidants which decrease the effects of free radicals.

13. HYDROCARBONS

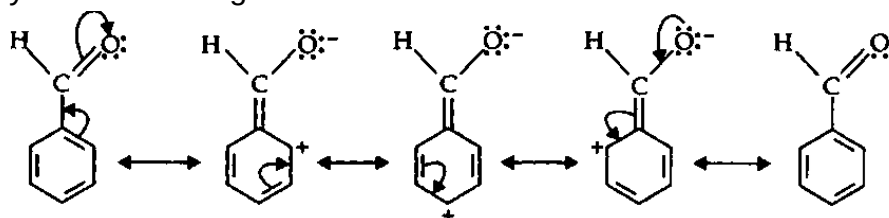
1	Give IUPAC names for the following compounds 1) $\text{CH}_3 - \text{CH} = \text{CH} - \text{CH} = \text{CH} - \text{C} \equiv \text{C} - \text{CH}_3$: octa – 2, 4 – diene – 6 – yne 2) $\begin{array}{c} \text{C}_2\text{H}_5 \quad \text{CH}_3 \\ \quad \\ \text{CH}_3 - \text{C} - \text{C} - \text{C} \equiv \text{C} - \text{CH}_3 \\ \quad \\ \text{CH}_3 \quad \text{H} \end{array}$: 5 – ethyl – 4, 5 – dimethyl – 2 – hexyne 3) $(\text{CH}_3)_3 \text{C} - \text{C} \equiv \text{C} - \text{CH} (\text{CH}_3)_3$: 2, 2, 5 – trimethyl – 3 – hexyne 4) ethyl isopropyl acetylene : 2 – methyl – 3 – hexyne $(\text{CH}_3)_2 - \text{CH} - \text{C} \equiv \text{C} - \text{CH}_2 \text{CH}_3$ 5) $\text{CH} \equiv \text{C} - \text{C} \equiv \text{C} - \text{C} \equiv \text{CH}$: hexa – 1, 3, 5 – triyne
2	Identify the compound A, B, C and D in the following series of reactions $\text{CH}_3 - \text{CH}_2 - \text{Br} \xrightarrow{\text{alc. KOH}} \text{A} \xrightarrow{\text{Cl}_2 / \text{CCl}_4} \text{B}$ $\downarrow \begin{array}{l} \text{i) O}_3 \\ \text{ii) Zn/H}_2\text{O} \end{array}$ C $\downarrow \text{NaNH}_2$ D Ans: $\text{CH}_3 - \text{CH}_2 - \text{Br} \xrightarrow[\text{-HBr}]{\text{alc. KOH}} \text{CH}_2 = \text{CH}_2 \xrightarrow{\text{Cl}_2 / \text{CCl}_4} \begin{array}{c} \text{CH}_2 - \text{CH}_2 \\ \quad \\ \text{Cl} \quad \text{Cl} \end{array}$ Ethylene (A) $\downarrow \begin{array}{l} \text{i) O}_3 \quad \text{ii) Zn / H}_2\text{O} \end{array}$ 2 HCHO + H₂O₂ Formaldehyde (C) Ethylene dichloride (B) $\downarrow \text{NaNH}_2$ CH $\equiv$ CH Acetylene (D)
3	Write short notes on ortho, para directors in aromatic electrophilic substitution reactions. - When mono substituted benzene undergoes an electrophilic substitution reaction, the rate of the reaction and the site of attack of the incoming electrophile depends on the functional group already attached to it. - Some groups increase the reactivity of benzene ring and are known as activating groups. - Some groups which decrease the reactivity are known as deactivating groups. - We further divide these groups into two categories depending on the way they influence the orientation of attack by the incoming groups. - Those which increases electron density at 'ortho' and 'para' position are known as ortho-para directors - while those which increase electron density at 'meta' position is known as meta-directors. Ortho and para directing groups: - All the activating groups are 'ortho-para' directors. - Eg: –OH, –NH₂, –NHR, –NHCOCH₃, –OCH₃, –CH₃, –C₂H₅ etc. - Let us consider the directive influences of phenolic (–OH) group. Phenol is the resonance hybrid of following structures.



- In these resonance structures, the (-) charge residue is present on ortho and para position of ring structure.
- Therefore, phenolic group activates the benzene ring for electrophilic attack at 'ortho' and 'para' positions and hence -OH group is an ortho-para director and activator.

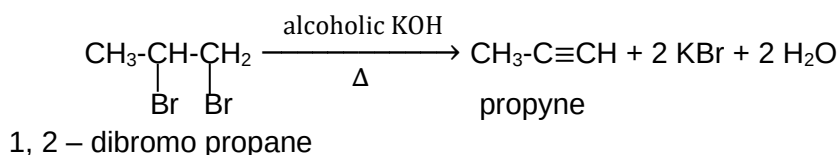
Meta directing groups:

- Generally, all deactivating groups are meta-directors.
- Eg: $-\text{NO}_2$, $-\text{CN}$, $-\text{CHO}$, $-\text{COR}$, $-\text{COOH}$, $-\text{COOR}$, $-\text{SO}_3\text{H}$ etc.
- Let us consider the directive influence of aldehyde ($-\text{CHO}$) group. Benzaldehyde is the resonance hybrid of following structures.



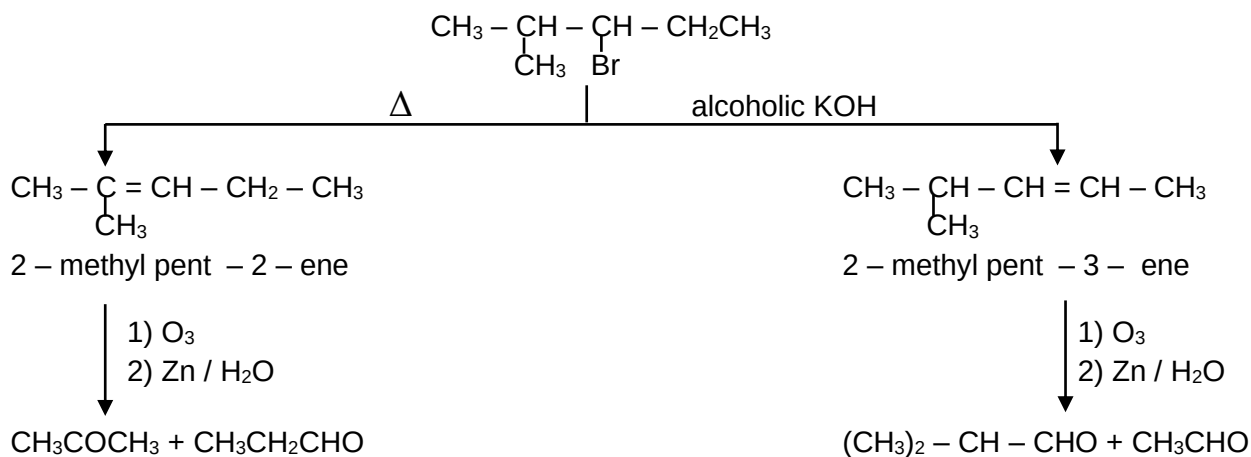
- Here overall density of benzene ring decreases due to -I effect of $-\text{CHO}$ group there by deactivating the benzene for electrophilic attack.
- However resonating structure shows that electron density is more in meta position, compared to o & p-position. Hence $-\text{CHO}$ group is a meta-director and deactivator.

4 How is propyne prepared from an alkylene dihalide?

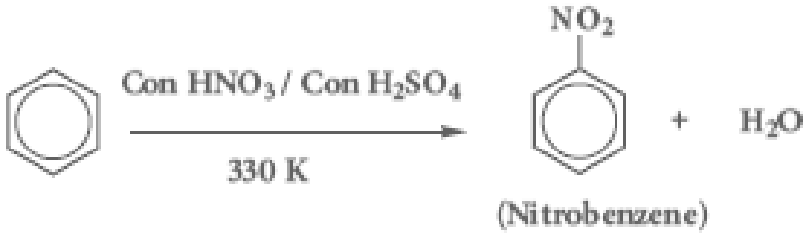
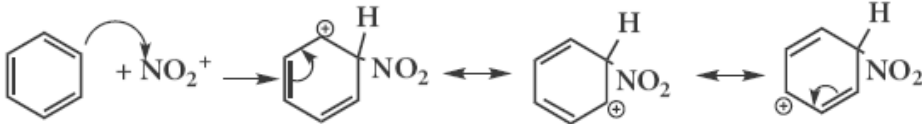
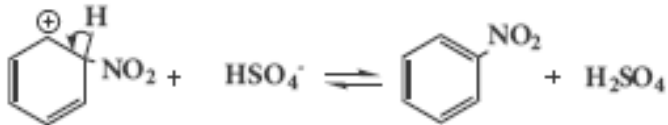
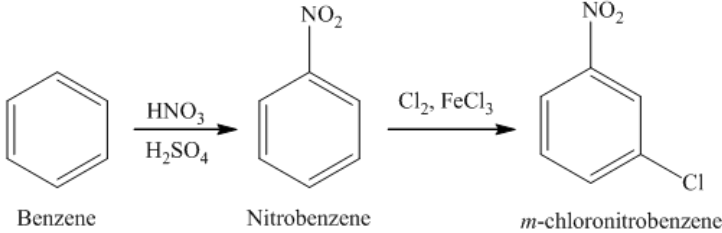
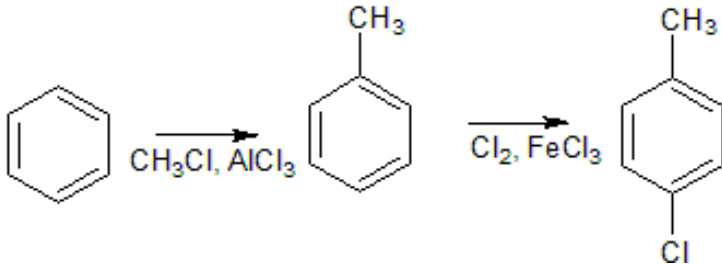
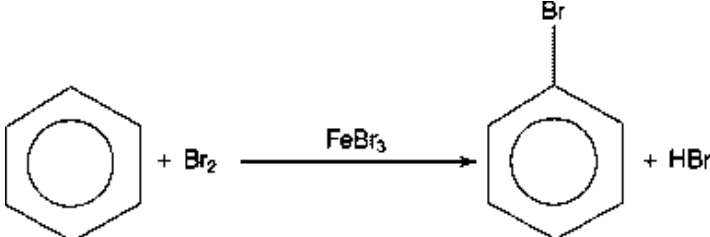


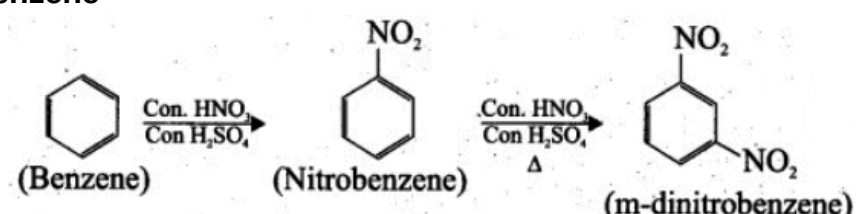
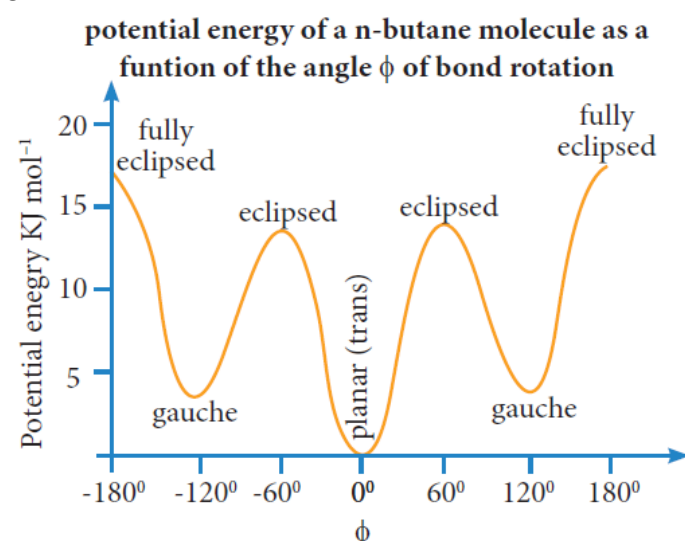
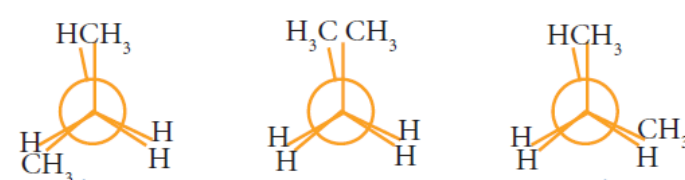
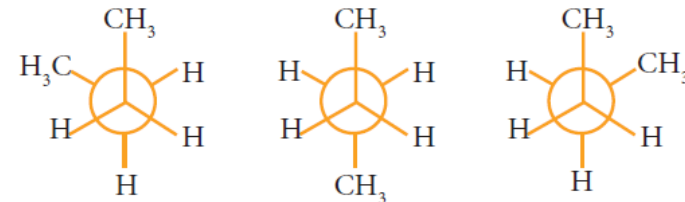
5 An alkylhalide with molecular formula $\text{C}_6\text{H}_{13}\text{Br}$ on dehydro halogenation gave two isomeric alkenes X and Y with molecular formula C_6H_{12} . On reductive ozonolysis, X and Y gave four compounds CH_3COCH_3 , CH_3CHO , $\text{CH}_3\text{CH}_2\text{CHO}$ and $(\text{CH}_3)_2\text{CHCHO}$. Find the alkylhalide.

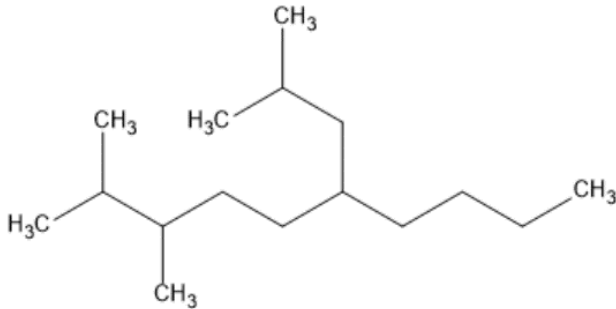
An alkylhalide with molecular formula $\text{C}_6\text{H}_{13}\text{Br}$

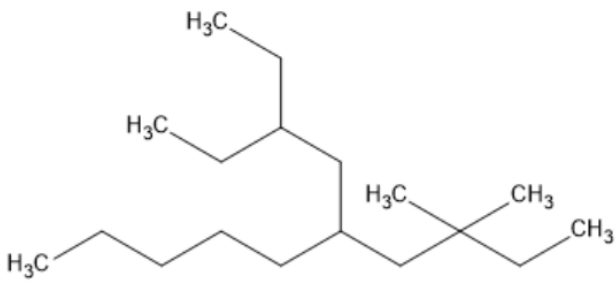
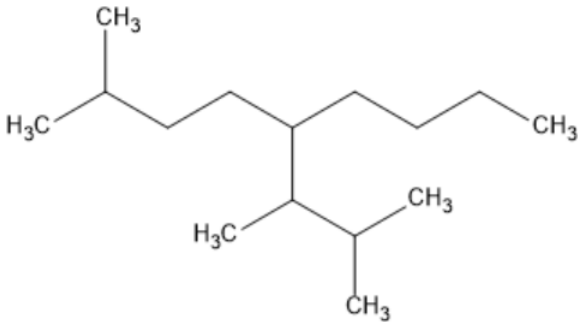
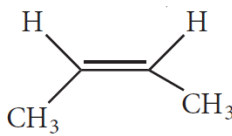
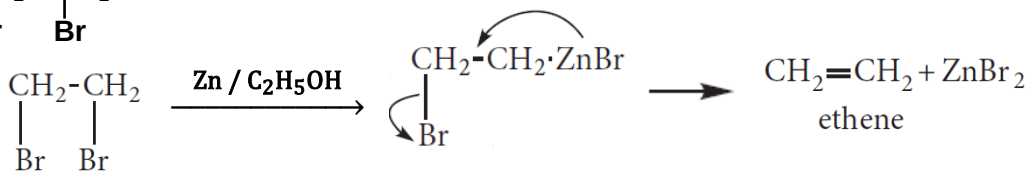


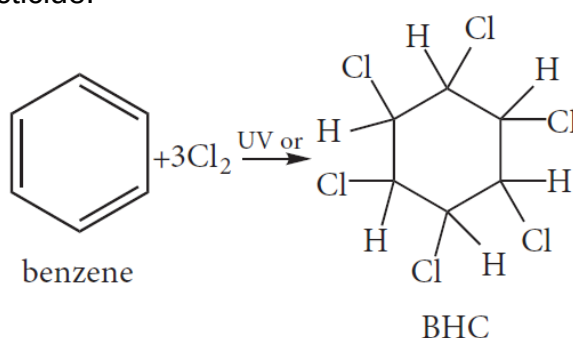
So, the alkyl halide is 3 – bromo – 2 – methyl propane.

6	Describe the mechanism of nitration of benzene.  (Nitrobenzene) Reagents: Conc.HNO₃ / Conc. H₂SO₄ ; Electrophile: NO₂⁺ (Nitronium ion) Mechanism: Step – 1: $\text{HNO}_3 + \text{H}_2\text{SO}_4 \longrightarrow \text{NO}_2^+ + \text{HSO}_4^- + \text{H}_2\text{O}$ Step – 2:  Step – 3: 
7	How does Huckel rule help to decide the aromatic character of a compound. (Sep-21, Jun-23) A compound may be aromatic, if it obeys the following rules (i) The molecule must be co-planar (ii) Complete delocalization of π electron in the ring (iii) Presence of $(4n+2)$ π electrons in the ring where n is an integer ($n=0,1,2,\dots$) This is known as Huckel's rule.
8	Suggest the route for the preparation of the following from benzene. 1) 3 – chloro nitrobenzene  Benzene Nitrobenzene <i>m</i>-chloronitrobenzene 2) 4 – chlorotoluene  3) Bromo benzene 

	4) m - dinitro benzene  (Benzene) $\xrightarrow[\text{Con. H}_2\text{SO}_4]{\text{Con. HNO}_3}$ (Nitrobenzene) $\xrightarrow[\Delta]{\text{Con. HNO}_3, \text{Con. H}_2\text{SO}_4}$ (m-dinitrobenzene)
9	Suggest a simple chemical test to distinguish propane and propene. - Propene decolourises reddish brown colour of bromine water, but propane does not decolourise bromine water. - Propene decolourises pink coloured acidified KMnO_4 solution but propane does not decolourise it.
10	Describe the conformers of n - butane. (Jun-19) n-Butane may be considered as a derivative of ethane, as one hydrogen on each carbon is replaced by a methyl group Eclipsed conformation: In this conformation, the distance between the two-methyl group is minimum. So, there is maximum repulsion between them and it is the least stable conformer. Anti or staggered form In this conformation, the distance between the two methyl groups is maximum and so there is minimum repulsion between them. And it is the most stable conformer. The following potential energy diagram shows the relative stabilities of various conformers of n-butane.  potential energy of a n-butane molecule as a function of the angle ϕ of bond rotation eclipsed conformations  

11	What happens when isobutylene is treated with acidified potassium permanganate? $ \begin{array}{ccc} \text{CH}_3 & & \text{CH}_3 \\ & & \\ \text{CH}_3-\text{C}=\text{CH}_2 & \xrightarrow[\text{-CO}_2, \text{-H}_2\text{O}]{\text{KMnO}_4/\text{H}^+} & \text{CH}_3-\text{C}=\text{O} \\ \text{2-methylprop-1-ene} & & \text{propan-2-one} \end{array} $
12	How will you convert ethyl chloride in to i) ethane $ \text{CH}_3\text{CH}_2\text{Cl} \xrightarrow[2[\text{H}]]{\text{Zn / HCl}} \text{CH}_3-\text{CH}_3 + \text{HCl} $ Ethane ii) n – butane $ \text{CH}_3\text{CH}_2\text{Cl} + \text{ClCH}_2\text{CH}_3 + 2\text{Na} \xrightarrow{\text{dry ether}} \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 $ n – butane
13	Explain Markownikoff's rule with suitable example. “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: $ \begin{array}{c} \text{CH}_3-\text{CH}=\text{CH}_2 + \text{HBr} \\ \text{Propene} \\ \swarrow \quad \searrow \\ \begin{array}{cc} \text{CH}_3-\text{CH}-\text{CH}_3 & \text{CH}_3-\text{CH}_2-\text{CH}_2-\text{Br} \\ & \text{1-Bromo Propane} \\ \text{Br} & \text{(minor product)} \\ \text{2-Bromo Propane} & \\ \text{(major product)} & \end{array} \end{array} $
14	Write the chemical equations for combustion of propane. $ \text{CH}_3-\text{CH}_2-\text{CH}_3 + 5\text{O}_2 \longrightarrow 3\text{CO}_2 + 4\text{H}_2\text{O} + \text{Energy} $
15	What happens when ethylene is passed through cold dilute alkaline potassium permanganate. $ \text{CH}_2=\text{CH}_2 + \text{H}_2\text{O} \xrightarrow[\text{H}_2\text{O} + [\text{O}]]{\text{Cold dilute alkaline KMnO}_4} \begin{array}{c} \text{CH}_2 - \text{CH}_2 + \text{MnO}_2 \\ \quad \\ \text{OH} \quad \text{OH} \end{array} $ Ethylene glycol
16	Write the structures of folowing alkanes. 1) 2, 3 – Dimethyl – 6 – (2 – methyl propyl) decane 

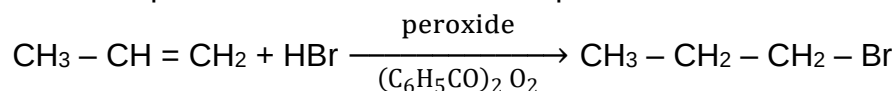
	2) 5 – (2 – Ethyl butyl) – 3, 3 – dimethyldecane  3) 5 – (1, 2 – Dimethyl propyl) – 2 – methylnonane 
17	How will you prepare propane from a sodium salt of fatty acid? $\text{CH}_3\text{CH}_2\text{CH}_2\text{COONa} \xrightarrow[\Delta]{\text{NaOH / CaO}} \text{CH}_3\text{CH}_2\text{CH}_3 + \text{Na}_2\text{CO}_3$ Sodium butyrate Propane
18	$\text{CH}_3 - \text{CH}(\text{CH}_3) - \text{CH}(\text{OH}) - \text{CH}_3 \xrightarrow{\text{H}^+ / \text{Heat}}$ (A) major product $\xrightarrow{\text{HBr}}$ (B) major product. Identify A and B.
19	Complete the following: i) 2 – butyne $\xrightarrow{\text{Lindlar Catalyst}}$ $\text{CH}_3 - \text{C} \equiv \text{C} - \text{CH}_3 + \text{H}_2 \xrightarrow{\text{Lindlar Catalyst}}$  cis-2-butene ii) $\text{CH}_2 = \text{CH}_2 \xrightarrow{\text{I}_2} ?$ $\text{CH}_2 = \text{CH}_2 \xrightarrow{\text{I}_2} \left[\begin{array}{c} \text{CH}_2 - \text{CH}_2 \\ \quad \\ \text{I} \quad \text{I} \end{array} \right] \xrightarrow{-\text{I}_2} \text{CH}_2 = \text{CH}_2$ ethene ethene iii) $\text{CH}_2 - \text{CH}_2 \xrightarrow{\text{Zn / C}_2\text{H}_5\text{OH}} ?$  $\text{CH}_2 = \text{CH}_2 + \text{ZnBr}_2$ ethene iv) $\text{CaC}_2 \xrightarrow{\text{H}_2\text{O}} ?$ (Jun-23) $\text{Ca} \begin{array}{c} \diagup \quad \diagdown \\ \text{C} \equiv \text{C} \end{array} + 2\text{H}_2\text{O} \longrightarrow \text{CH} \equiv \text{CH} + \text{Ca}(\text{OH})_2$

20	How will you distinguish 1 – butyne and 2 – butyne? 1 – butyne and 2 – butyne can be distinguished by treating it with ammonical silver nitrate. 1 – butyne gives white precipitate with ammoniated silver nitrate and gives red precipitate with ammoniated cuprous chloride, but 2 – butyne does not reacts with ammonical AgNO₃ solution. $\text{CH}_3\text{-CH}_2\text{-C}\equiv\text{CH} + \text{AgNO}_3 + \text{NH}_4\text{OH} \longrightarrow \text{CH}_3\text{-CH}_2\text{-C}\equiv\text{C-Ag} \downarrow$ But-1-yne Silver butynide $+ \text{NH}_4\text{NO}_3 + \text{H}_2\text{O}$ $2\text{CH}_3\text{-CH}_2\text{-C}\equiv\text{CH} + \text{Cu}_2\text{Cl}_2 + 2\text{NH}_4\text{OH} \longrightarrow 2\text{CH}_3\text{-CH}_2\text{-C}\equiv\text{C-Cu} \downarrow$ But-1-yne Copper butynide $+ 2\text{NH}_4\text{Cl} + 2\text{H}_2\text{O}$ $\text{CH}_3\text{-C}\equiv\text{C-CH}_3 + \text{AgNO}_3 + \text{NH}_4\text{OH} \longrightarrow$ But-2-yne No Reaction due to absence of acidic hydrogen
21	Write a short note on corey – House mechanism? An alkyl halide and lithium di alkyl copper are reacted to give higher alkane. $\text{CH}_3\text{CH}_2\text{Br} + (\text{CH}_3)_2\text{LiCu} \longrightarrow \text{CH}_3\text{CH}_2\text{CH}_3 + \text{CH}_3\text{Cu} + \text{LiBr}$
22	What are hydrocarbons present in LPG? Give its uses. A mixture of propane and butane present in LPG. It is used as fuel for household cooking purpose.
23	Define polymerisation? (Jun-19) A polymer is a large molecule formed by the combination of larger number of small molecules. The process is known as polymerisation. Eg: $n\text{CH}_2 = \text{CH}_2 \xrightarrow[873\text{K}]{\text{Red hot iron tube}} \text{-(CH}_2 - \text{CH}_2\text{)}_n$
24	How does polystyrene prepared from styrene? Give its uses. $n\text{CH}_2 = \text{CH} \xrightarrow{\text{free radical polymerisation}} \text{-(CH}_2 - \text{CH}_2\text{)}_n$ Uses: it is used to prepare disposable plates, mugs, insulators in refrigerators, freezers, etc
25	What is BHC? How is it prepared (May-22)? Give its uses. (or) how benzene is converted into BHC? (May-24) Benzene reacts with three molecules of Cl₂ in the presence of sun light or UV light to yield Benzene Hexa Chloride (BHC) C₆H₆Cl₆. This is known as gammaxane or Lindane. Uses: it is a powerful insecticide.  benzene +3Cl₂ $\xrightarrow{\text{UV or}}$ BHC

26	How does acetylene react with ozone? (Jul-19) $\text{CH}\equiv\text{CH} \xrightarrow{\text{O}_3} \begin{array}{c} \text{O} \\ \diagup \quad \diagdown \\ \text{CH} \quad \text{CH} \\ \diagdown \quad \diagup \\ \text{O} \quad \text{O} \end{array} \xrightarrow{\text{HOH}} \begin{array}{c} \text{H} \quad \text{C} \quad \text{C} \quad \text{H} \\ \parallel \quad \parallel \\ \text{O} \quad \text{O} \end{array} \xrightarrow{\text{H}_2\text{O}_2} 2\text{HCOOH}$ Acetylene Glyoxal Methanoic acid
27	Give the uses of acetylene? - Acetylene is used in oxy acetylene torch used for welding and cutting metals. - It is used for manufacture of PVC, polyvinyl acetate, polyvinyl ether, orlon and neoprene rubbers.
28	What happens when acetylene is passed through red hot iron tube? (Mar-19, Sep-21) (or) How does benzene prepared from the following? (Mar-24) a) Acetylene: (Mar-19, Mar-24) Ethyne undergoes cyclic polymerization on passing through red hot iron tube. Three molecules of ethyne polymerises to benzene. $3 \text{ CH}\equiv\text{CH} \xrightarrow[873 \text{ K}]{\text{Red Hot Iron tube}} \text{C}_6\text{H}_6$ Benzene b) Phenol: (Mar-19, Mar-24) $\text{C}_6\text{H}_5\text{OH} + \text{Zn} \longrightarrow \text{C}_6\text{H}_6 + \text{ZnO}$ Phenol
29	Define Friedel Craft's Alkylation? (or) How does toluene prepared from benzene? (Mar-19, Mar-23) $\text{C}_6\text{H}_6 + \text{CH}_3\text{Cl} \xrightarrow{\text{Anhydrous AlCl}_3} \text{C}_6\text{H}_5\text{CH}_3 + \text{HCl}$ toluene
30	Define Friedel Craft's Acylation (Acetylation)? (Mar-23) $\text{C}_6\text{H}_6 + \text{CH}_3\text{COCl} \xrightarrow{\text{Anhydrous AlCl}_3} \text{C}_6\text{H}_5\text{COCH}_3 + \text{HCl}$ acetophenone
31	Define Birch reduction? (Jul-22) $\text{C}_6\text{H}_6 \xrightarrow[2) \text{R-OH}]{1) \text{Na / Li}, \text{Liq. NH}_3} \text{C}_6\text{H}_8$ Benzene Cyclohexa-1,4-diene

32 **Explain Anti-Markovnikoff's Rule (or) Peroxide Effect (or) Kharasch Addition?**

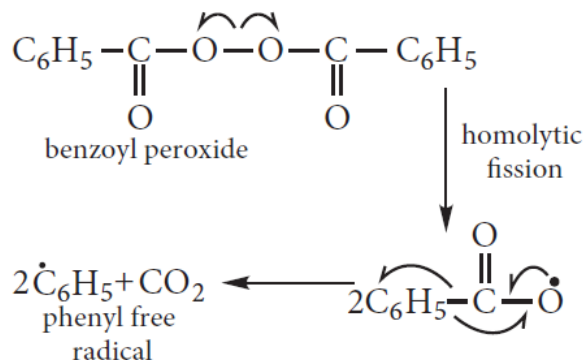
The addition of HBr to an alkene in the presence of organic peroxide, gives the anti Markovnikoff's product. This effect is called peroxide effect.



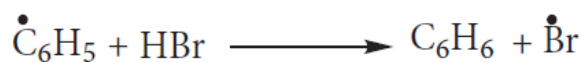
Mechanism:

The reaction proceeds via free radical mechanism.

Step:1

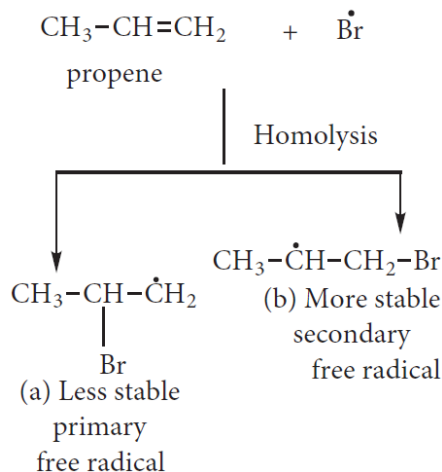


Step:2

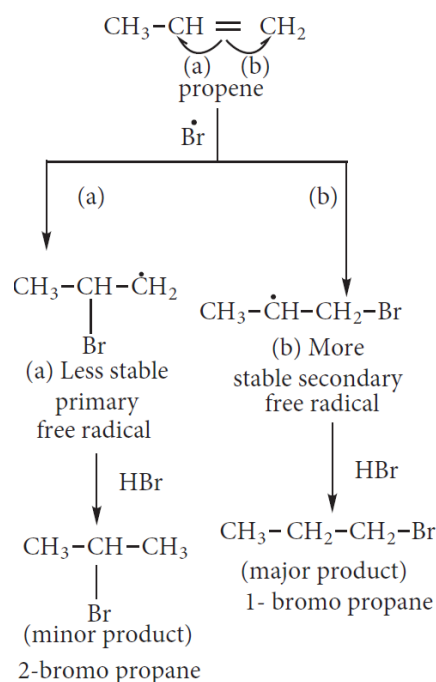


Step:3

The Bromine radical adds to the double bond in the way to form more stable alkyl free radical.

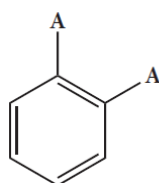


Step:4

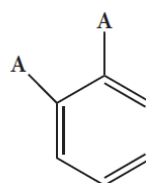


33 **Explain the structure of benzene?**

1. Elemental Analysis and molecular weight determination have proved that the molecular formula of benzene is C_6H_6 . This indicates that benzene is a highly unsaturated compound.
2. Benzene could be constructed as a straight chain or ring compound but it not feasible since it does not show the properties of alkenes or alkynes.
3. Benzene reacts with bromine in the presence of $AlCl_3$ to form mono bromo benzene. It indicates that all the six hydrogen atoms in benzene were identical. This is possible only if it has a cyclic structure of six carbons each containing one hydrogen.
4. Benzene can add on to three moles of hydrogen in the presence of nickel catalyst to give cyclohexane. This confirms cyclic structure of benzene and the presence of three carbon-carbon double bond.
5. In 1865, August Kekule suggested that benzene consists of a cyclic planar structure of six carbon with alternate single and double bonds. There were two objections:
(i) Benzene forms only one ortho disubstituted products whereas the Kekule's structure predicts two o-di substituted products as shown below.



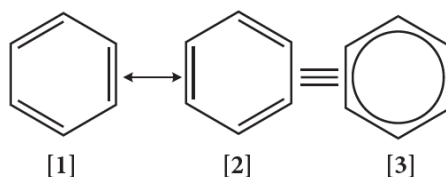
Presence of
double bond
between the
substituents



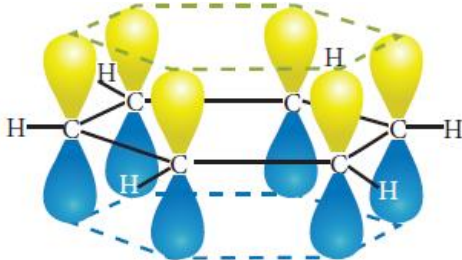
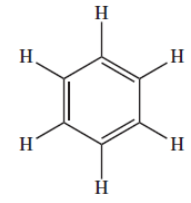
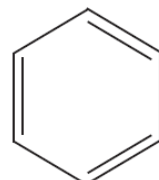
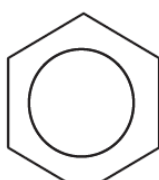
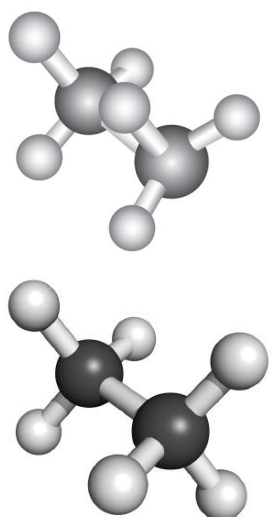
Presence of
single bond
between the
substituents

(ii) Kekule's structure failed to explain why benzene with three double bonds did not give addition reactions like other alkenes.

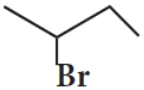
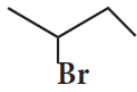
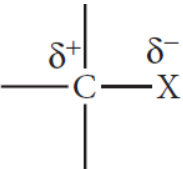
6. The phenomenon in which two or more structures can be written for a substance which has identical position of atoms is called resonance. The actual structure of the molecule is said to be resonance hybrid of various possible alternative structures. In benzene, Kekule's structures I & II represented the resonance structure, and structure III is the resonance hybrid of structure I & II



7. Spectroscopic measurements show that benzene is planar and all of its carbon-carbon bonds are of equal length $1.40\text{\AA}$. This value lies between carbon-carbon single bond length $1.54\text{\AA}$ and carbon-carbon double bond length $1.34\text{\AA}$.
8. All the six carbon atoms of benzene are sp^2 hybridized. six sp^2 hybrid orbitals of carbon linearly overlap with six $1s$ orbitals of hydrogen atoms to form six C - H sigma bonds. Overlap between the remaining sp^2 hybrid orbitals of carbon forms six C-C sigma bonds.
9. All the σ bonds in benzene lie in one plane with bond angle 120° . Each carbon atom in benzene possesses an unhybridized p-orbital containing one electron. The lateral overlap of their p-orbital produces 3 π - bond The six electrons of the p-orbitals cover all the six carbon atoms and are said to be delocalised. Due to delocalization, strong π -bond is formed which makes the molecule stable.

	10. Hence unlike alkenes and alkynes benzene undergoes substitution reactions rather addition reactions under normal conditions.  11. Hence, there are three ways in which benzene can be represented.  Expanded form  Kekule structure  Short hand representation
34	Explain the conformations of ethane? The two tetrahedral methyl groups can rotate about the carbon – carbon bond axis yielding several arrangements called conformers. The extreme conformations are staggered and eclipsed conformation. There can be number of other arrangements between staggered and eclipsed forms and their arrangements are known as skew forms. Eclipsed conformation: - In this conformation, the hydrogen's of one carbon are directly behind those of the other. - The repulsion between the atoms is maximum and it is the least stable conformer. Staggered conformation: - In this conformation, the hydrogens of both the carbon atoms are far apart from each other. - The repulsion between the atoms is minimum and it is the most stable conformer. Skew Conformation: The infinite numbers of possible intermediate conformations between the two extreme conformations are referred as skew conformations. 
35	Write Sabatier- Sendersens reaction? $\text{CH}_2 = \text{CH}_2 + \text{H}_2 \xrightarrow[298 \text{ K}]{\text{Ni}} \text{CH}_3 - \text{CH}_3$
36	Write wurtz reaction? $\text{CH}_3 - \text{Br} + 2\text{Na} + \text{Br} - \text{CH}_3 \xrightarrow{\text{dry ether}} \text{CH}_3 - \text{CH}_3 + 2\text{NaBr}$
37	Write Wurtz – Fittig Reaction? $\text{C}_6\text{H}_5\text{Br} + 2\text{Na} + \text{CH}_3\text{I} \xrightarrow{\text{ether}} \text{C}_6\text{H}_5\text{CH}_3 + \text{NaBr} + \text{NaI}$
38	Write Friedel Craft's Reaction? $\text{C}_6\text{H}_6 + \text{CH}_3\text{Cl} \xrightarrow{\text{anhydrous AlCl}_3} \text{C}_6\text{H}_5\text{CH}_3 + \text{HCl}$

14. HALOALKANES AND HALOARENES

1	Differentiate the following compounds into alkyl, allylic, vinyl and benzylic halide? i) $\text{CH}_3 - \text{CH} = \text{CH} - \text{Cl}$: vinyl halide ii) $\text{C}_6\text{H}_5\text{CH}_2\text{I}$: benzylic halide iii) $\text{CH}_3 - \underset{\text{Br}}{\text{CH}} - \text{CH}_3$: alkyl halide iv) $\text{CH}_2 = \text{CH} - \text{Cl}$: vinyl halide
2	Why chlorination of methane is not possible in dark? This reaction is a free radical substitution reaction. The energy required to form free radical by homolytic cleavage can't be received from dark. So, this reaction is not possible in dark.
3	How will you prepare n-propyl iodide from n-propyl bromide? It can be prepared by Finkelstein reaction. $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br} + \text{NaI} \xrightarrow[\Delta]{\text{Acetone}} \text{CH}_3\text{CH}_2\text{CH}_2\text{I} + \text{NaBr}$ n-propyl bromide n-propyl iodide
4	Which alkyl halide from the following pair is i) chiral ii) undergoes faster S_N^2 reaction?   i) chiral molecule:  (Secondary butyl bromide) ii) undergoes faster S_N^2 reaction:  (n-butyl chloride)
5	How does chlorobenzene react with sodium in the presence of ether? What is the name of the reaction? Haloarenes react with sodium metal in dry ether, two aryl groups combine to give biaryl products. This reaction is called Fittig reaction. $\text{C}_6\text{H}_5\text{Cl} + 2\text{Na} + \text{Cl} - \text{C}_6\text{H}_5 \xrightarrow[\Delta]{\text{Ether}} \text{C}_6\text{H}_5 - \text{C}_6\text{H}_5 + 2\text{NaCl}$
6	Give reasons for polarity of C-X bond in halo alkane. Carbon halogen bond is a polar bond as halogens are more electro negative than carbon. The carbon atom exhibits a partial positive charge (δ^+) and halogen atom a partial negative charge (δ^-). 
7	Why is it necessary to avoid even traces of moisture during the use of Grignard reagent? Grignard reagents react with water to form alkanes. Even traces of water is enough to form alkanes. So, all the reagents used should be dry. $\text{RMgX} + \text{H}_2\text{O} \longrightarrow \text{RH} + \text{MgX (OH)}$

8	What happens when acetyl chloride is treated with excess of CH₃MgI? Acetyl chloride reacts with Grignard reagent to form ketones. However, with excess of Grignard reagent it forms tertiary alcohol. $\text{CH}_3 - \overset{\text{O}}{\parallel} \text{C} - \text{Cl} + \text{CH}_3\text{MgI} \longrightarrow \text{CH}_3 - \overset{\text{OMgI}}{\underset{\text{CH}_3}{\text{C}}} - \text{Cl} \xrightarrow{\text{H}_2\text{O} / \text{H}^+} \text{CH}_3 - \overset{\text{O}}{\parallel} \text{C} - \text{CH}_3 + \text{MgI}(\text{Cl}) \xrightarrow{\text{CH}_3\text{MgI}} \text{CH}_3 - \overset{\text{OH}}{\underset{\text{CH}_3}{\text{C}}} - \text{CH}_3$																																						
9	Arrange the following alkyl halide in increasing order of bond enthalpy of RX. CH₃Br, CH₃F, CH₃Cl, CH₃I increasing order of bond enthalpy: CH ₃ I < CH ₃ Br < CH ₃ Cl < CH ₃ F																																						
10	What happens when chloroform reacts with oxygen in the presence of sunlight? $\text{CHCl}_3 + \frac{1}{2} \text{O}_2 \xrightarrow[\text{Sunlight}]{\text{Air}} \text{COCl}_2 + \text{HCl}$ Phosgene																																						
11	Write down the possible isomers of C₅H₁₁Br and give their IUPAC and common names. <table><tr><th></th><th>possible isomers</th><th>IUPAC Name</th><th>Common Name</th></tr><tr><td>1</td><td>CH₃CH₂CH₂CH₂CH₂Br</td><td>1 – Bromo pentane</td><td>n – pentyl bromide</td></tr><tr><td>2</td><td>CH₃CH₂CH₂ Br CH – CH₃</td><td>2 - Bromo pentane</td><td>2 – pentyl bromide</td></tr><tr><td>3</td><td>CH₃CH₂ Br CH – CH₂CH₃</td><td>3 - Bromo pentane</td><td>3 – pentyl bromide</td></tr><tr><td>4</td><td>CH₃CH – CH₂CH₂Br CH₃</td><td>1 - Bromo – 3 – methyl butane</td><td>isopentyl bromide</td></tr><tr><td>5</td><td>CH₃ – CH – CH – CH₃ CH₃ Br</td><td>2 - Bromo – 3 – methyl butane</td><td>2 - Bromo – 3 – methyl butane</td></tr><tr><td>6</td><td>CH₃ – CH₂ – CH – CH₂Br CH₃</td><td>1 - Bromo – 2 – methyl butane</td><td>2 – methyl butyl bromide</td></tr><tr><td>7</td><td>CH₃ – CH₃ – C – CH₂ – CH₃ Br</td><td>2 - Bromo – 2 – methyl butane</td><td>Tertiary pentyl bromide</td></tr><tr><td>8</td><td>CH₃ – CH₃ – C – CH₂ – Br CH₃</td><td>1 - Bromo – 2, 2 – dimethyl propane</td><td>Neo-pentyl bromide</td></tr></table>				possible isomers	IUPAC Name	Common Name	1	CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ Br	1 – Bromo pentane	n – pentyl bromide	2	CH ₃ CH ₂ CH ₂ Br CH – CH ₃	2 - Bromo pentane	2 – pentyl bromide	3	CH ₃ CH ₂ Br CH – CH ₂ CH ₃	3 - Bromo pentane	3 – pentyl bromide	4	CH ₃ CH – CH ₂ CH ₂ Br CH ₃	1 - Bromo – 3 – methyl butane	isopentyl bromide	5	CH ₃ – CH – CH – CH ₃ CH ₃ Br	2 - Bromo – 3 – methyl butane	2 - Bromo – 3 – methyl butane	6	CH ₃ – CH ₂ – CH – CH ₂ Br CH ₃	1 - Bromo – 2 – methyl butane	2 – methyl butyl bromide	7	CH ₃ – CH ₃ – C – CH ₂ – CH ₃ Br	2 - Bromo – 2 – methyl butane	Tertiary pentyl bromide	8	CH ₃ – CH ₃ – C – CH ₂ – Br CH ₃	1 - Bromo – 2, 2 – dimethyl propane	Neo-pentyl bromide
	possible isomers	IUPAC Name	Common Name																																				
1	CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ Br	1 – Bromo pentane	n – pentyl bromide																																				
2	CH ₃ CH ₂ CH ₂ Br CH – CH ₃	2 - Bromo pentane	2 – pentyl bromide																																				
3	CH ₃ CH ₂ Br CH – CH ₂ CH ₃	3 - Bromo pentane	3 – pentyl bromide																																				
4	CH ₃ CH – CH ₂ CH ₂ Br CH ₃	1 - Bromo – 3 – methyl butane	isopentyl bromide																																				
5	CH ₃ – CH – CH – CH ₃ CH ₃ Br	2 - Bromo – 3 – methyl butane	2 - Bromo – 3 – methyl butane																																				
6	CH ₃ – CH ₂ – CH – CH ₂ Br CH ₃	1 - Bromo – 2 – methyl butane	2 – methyl butyl bromide																																				
7	CH ₃ – CH ₃ – C – CH ₂ – CH ₃ Br	2 - Bromo – 2 – methyl butane	Tertiary pentyl bromide																																				
8	CH ₃ – CH ₃ – C – CH ₂ – Br CH ₃	1 - Bromo – 2, 2 – dimethyl propane	Neo-pentyl bromide																																				
13	Reagents and the conditions used in the reactions are given below. Complete the table by writing down the product and the name of the reaction. <table><tr><th>Reaction</th><th>Product</th><th>Name of the reaction</th></tr><tr><td>CH₃CH₂OH + SOCl₂ $\xrightarrow{\text{pyridine}}$ CH₃CH₂Cl + SO₂ + HCl</td><td>CH₃CH₂Cl Ethyl chloride</td><td>Darzen's reaction</td></tr><tr><td>CH₃CH₂Br + AgF $\longrightarrow$ CH₃CH₂F + AgBr</td><td>CH₃CH₂F Ethyl fluoride</td><td>Swarts reaction</td></tr><tr><td>2C₆H₅Cl + 2Na $\xrightarrow{\text{ether}}$ C₆H₅ – C₆H₅ + 2NaCl</td><td>C₆H₅ – C₆H₅ Biphenyl</td><td>Fittig reaction</td></tr></table>			Reaction	Product	Name of the reaction	CH ₃ CH ₂ OH + SOCl ₂ $\xrightarrow{\text{pyridine}}$ CH ₃ CH ₂ Cl + SO ₂ + HCl	CH ₃ CH ₂ Cl Ethyl chloride	Darzen's reaction	CH ₃ CH ₂ Br + AgF $\longrightarrow$ CH ₃ CH ₂ F + AgBr	CH ₃ CH ₂ F Ethyl fluoride	Swarts reaction	2C ₆ H ₅ Cl + 2Na $\xrightarrow{\text{ether}}$ C ₆ H ₅ – C ₆ H ₅ + 2NaCl	C ₆ H ₅ – C ₆ H ₅ Biphenyl	Fittig reaction																								
Reaction	Product	Name of the reaction																																					
CH ₃ CH ₂ OH + SOCl ₂ $\xrightarrow{\text{pyridine}}$ CH ₃ CH ₂ Cl + SO ₂ + HCl	CH ₃ CH ₂ Cl Ethyl chloride	Darzen's reaction																																					
CH ₃ CH ₂ Br + AgF $\longrightarrow$ CH ₃ CH ₂ F + AgBr	CH ₃ CH ₂ F Ethyl fluoride	Swarts reaction																																					
2C ₆ H ₅ Cl + 2Na $\xrightarrow{\text{ether}}$ C ₆ H ₅ – C ₆ H ₅ + 2NaCl	C ₆ H ₅ – C ₆ H ₅ Biphenyl	Fittig reaction																																					
12	Mention any three methods of preparation of haloalkanes from alcohols. 1) Reaction with hydrogen halide: $\text{CH}_3\text{CH}_2\text{OH} + \text{HCl} \xrightarrow[\Delta]{\text{anhydrous ZnCl}_2} \text{CH}_3\text{CH}_2\text{Cl} + \text{H}_2\text{O}$																																						

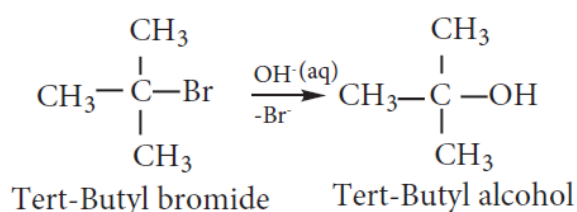
	2) Reaction with phosphorus halide: $\text{CH}_3\text{CH}_2\text{OH} + \text{PCl}_5 \longrightarrow \text{CH}_3\text{CH}_2\text{Cl} + \text{POCl}_3 + \text{HCl}$ 3) Reaction with thionyl chloride: $\text{CH}_3\text{CH}_2\text{OH} + \text{SOCl}_2 \xrightarrow{\text{pyridine}} \text{CH}_3\text{CH}_2\text{Cl} + \text{SO}_2\uparrow + \text{HCl}\uparrow$																											
14	Compare S_N¹ and S_N² reaction mechanisms. <table><tr><th></th><th>S_N¹ reaction</th><th>S_N² reaction</th></tr><tr><td>1</td><td>The rate of the following S_N¹ reaction depends upon the concentration of alkyl halide (RX) and is independent of the concentration of the nucleophile (OH⁻).</td><td>The rate of S_N² reaction depends upon the concentration of both alkyl halide and the nucleophile.</td></tr><tr><td>2</td><td>Rate of the reaction = k [alkyl halide]</td><td>Rate of reaction = k₂ [alkylhalide] [nucleophile]</td></tr><tr><td>3</td><td>It follows first order kinetics</td><td>It follows second order kinetics</td></tr><tr><td>4</td><td>It occurs in two steps.</td><td>It occurs in one step.</td></tr><tr><td>5</td><td>Nucleophile attacks alkyl halide from both the sides</td><td>The attack of nucleophile occurs from the back side</td></tr><tr><td>6</td><td>Carbocation is formed</td><td>No carbocation formation</td></tr><tr><td>7</td><td>Tertiary alkyl halide undergoes this reaction</td><td>Primary alkyl halide undergoes this reaction</td></tr><tr><td>8</td><td>If halo alkane substrate is optically active then, the product obtained will be optically inactive racemic mixture.</td><td>S_N² reaction of an optically active haloalkane is always accompanied by inversion of configuration at the asymmetric centre.</td></tr></table>		S _N ¹ reaction	S _N ² reaction	1	The rate of the following S _N ¹ reaction depends upon the concentration of alkyl halide (RX) and is independent of the concentration of the nucleophile (OH ⁻).	The rate of S _N ² reaction depends upon the concentration of both alkyl halide and the nucleophile.	2	Rate of the reaction = k [alkyl halide]	Rate of reaction = k ₂ [alkylhalide] [nucleophile]	3	It follows first order kinetics	It follows second order kinetics	4	It occurs in two steps.	It occurs in one step.	5	Nucleophile attacks alkyl halide from both the sides	The attack of nucleophile occurs from the back side	6	Carbocation is formed	No carbocation formation	7	Tertiary alkyl halide undergoes this reaction	Primary alkyl halide undergoes this reaction	8	If halo alkane substrate is optically active then, the product obtained will be optically inactive racemic mixture.	S _N ² reaction of an optically active haloalkane is always accompanied by inversion of configuration at the asymmetric centre.
	S _N ¹ reaction	S _N ² reaction																										
1	The rate of the following S _N ¹ reaction depends upon the concentration of alkyl halide (RX) and is independent of the concentration of the nucleophile (OH ⁻).	The rate of S _N ² reaction depends upon the concentration of both alkyl halide and the nucleophile.																										
2	Rate of the reaction = k [alkyl halide]	Rate of reaction = k ₂ [alkylhalide] [nucleophile]																										
3	It follows first order kinetics	It follows second order kinetics																										
4	It occurs in two steps.	It occurs in one step.																										
5	Nucleophile attacks alkyl halide from both the sides	The attack of nucleophile occurs from the back side																										
6	Carbocation is formed	No carbocation formation																										
7	Tertiary alkyl halide undergoes this reaction	Primary alkyl halide undergoes this reaction																										
8	If halo alkane substrate is optically active then, the product obtained will be optically inactive racemic mixture.	S _N ² reaction of an optically active haloalkane is always accompanied by inversion of configuration at the asymmetric centre.																										
15	Discuss the aromatic nucleophilic substitution reaction of chlorobenzene. Halo arenes do not undergo nucleophilic substitution reaction readily. This is due to C–X bond in aryl halide is short and strong and also the aromatic ring is a centre of high electron density. The halogen of haloarenes can be substituted by OH⁻, NH₂⁻, or CN⁻ with appropriate nucleophilic reagents at high temperature and pressure. Eg: Dow's Process $\begin{array}{ccc} \text{C}_6\text{H}_5\text{Cl} + \text{NaOH} & \xrightarrow[300 \text{ atm}]{350^\circ\text{C}} & \text{C}_6\text{H}_5\text{OH} + \text{NaCl} \\ \text{Chlorobenzene} & & \text{Phenol} \end{array}$ $\begin{array}{ccc} \text{C}_6\text{H}_5\text{Cl} + 2\text{NH}_3 & \xrightarrow[50 \text{ atm}]{250^\circ\text{C}} & \text{C}_6\text{H}_5\text{NH}_2 + \text{NH}_4\text{Cl} \\ \text{Chlorobenzene} & & \text{Aniline} \end{array}$ $\begin{array}{ccc} \text{C}_6\text{H}_5\text{Cl} + \text{CuCN} & \xrightarrow[\text{Pyridine}]{250^\circ\text{C}} & \text{C}_6\text{H}_5\text{CN} + \text{CuCl} \\ \text{Chlorobenzene} & & \text{Phenyl cyanide} \end{array}$																											
16	Account for the following (i) t-butyl chloride reacts with aqueous KOH by S_N¹ mechanism while n-butyl chloride reacts with S_N² mechanism. tertiary butyl chloride readily loses Cl⁻ to form stable tertiary butyl carbocation and reacts with aqueous KOH by S_N¹ mechanism but n-butyl chloride does not undergoes ionisation to form n-butyl carbocation because it is not stable. So it prefers to undergo reaction by S_N² mechanism.																											

	(ii) p-dichloro benzene has higher melting point than those of o-and m-dichloro benzene. The higher melting point of p-isomer is due to its, ➤ Symmetry ➤ Close packing of its molecules in the crystal lattice ➤ Strong intermolecular attractive force.
17	In an experiment ethyl iodide in ether is allowed to stand over magnesium pieces. Magnesium dissolves and product is formed a) Name the product and write the equation for the reaction. Methyl magnesium iodide is formed. $\text{CH}_3\text{I} + \text{Mg} \xrightarrow{\text{Ether}} \text{CH}_3\text{MgI}$ b) Why all the reagents used in the reaction should be dry? Explain. All the reagents used in the reaction should be dry because the moisture present in the reagents will decompose ethyl iodide to form alkane. c) How is acetone prepared from the product obtained in the experiment. $\begin{array}{c} \text{O} \\ \parallel \\ \text{CH}_3 - \text{C} - \text{Cl} + \text{CH}_3\text{MgI} \end{array} \rightarrow \begin{array}{c} \text{OMgI} \\ \\ \text{CH}_3 - \text{C} - \text{Cl} \\ \\ \text{CH}_3 \end{array} \xrightarrow{\text{H}_2\text{O}/\text{H}^+} \begin{array}{c} \text{O} \\ \parallel \\ \text{CH}_3 - \text{C} - \text{CH}_3 \end{array} + \begin{array}{c} \text{I} \\ \\ \text{Mg} \\ \\ \text{Cl} \end{array}$ Acetyl chloride Acetone
18	Write a chemical reaction useful to prepare the following: i) Freon-12 from Carbon tetrachloride $\begin{array}{c} \text{CCl}_4 + 2\text{HF} \xrightarrow{\text{SbCl}_5} 2\text{HCl} + \text{CCl}_2\text{F}_2 \\ \text{Carbon} \qquad \qquad \qquad \text{Freon - 12} \\ \text{tetrachloride} \end{array}$ ii) Carbon tetrachloride from carbon disulphide $\begin{array}{c} \text{CS}_2 + 3\text{Cl}_2 \xrightarrow[\text{AlCl}_3]{\text{anhydrous}} \text{CCl}_4 + \text{S}_2\text{Cl}_2 \\ \text{carbon disulphide} \qquad \qquad \qquad \text{carbon tetrachloride} \end{array}$
19	What are Freons? Discuss their uses and environmental effects The chloro fluoro derivatives of methane and ethane are called freons. Uses: (i) Freons are a used as refrigerants in refrigerators and air conditioners. (ii) It is used as a propellant for aerosols and foams (iii) It is used as propellant for foams to spray out deodorants, shaving creams, and insecticides. (iv) chlorine free radicals were formed from chloro fluoro derivatives. It forms hole in ozone layer.
20	Predict the products when bromoethane is treated with the following i) KNO₂ $\text{C}_2\text{H}_5\text{Br} + \text{KNO}_2 \longrightarrow \text{C}_2\text{H}_5\text{ONO} + \text{KBr}$ ii) AgNO₂ $\text{C}_2\text{H}_5\text{Br} + \text{AgNO}_2 \longrightarrow \text{C}_2\text{H}_5\text{NO}_2 + \text{AgBr}$
21	Chloroform is kept with a little ethyl alcohol in a dark coloured bottle why? Chloroform undergoes oxidation in the presence of light and air to form phosgene (carbonyl chloride) which is very poisonous. To avoid chloroform to undergo oxidation reaction it is kept with a little ethyl alcohol in a dark coloured bottle.

22 Explain the mechanism of S_N1 reaction by highlighting the stereochemistry behind it?

S_N1 Mechanism:

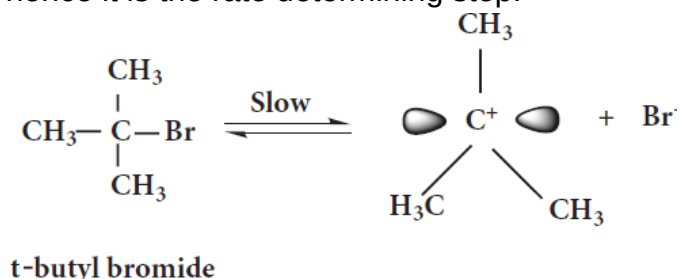
- S_N1 stands for unimolecular nucleophilic substitution
- 'S' stands for substitution
- 'N' stands for nucleophilic
- '1' stands for unimolecular (one molecule is involved in the rate determining step)
- The rate of the following S_N1 reaction depends upon the concentration of alkyl halide (RX) and is independent of the concentration of the nucleophile (OH^-).
- Hence, Rate of the reaction = k [alkyl halide]
- This S_N1 reaction follows first order kinetics and occurs in two steps.
- We understand S_N1 reaction mechanism by taking a reaction between tertiary butyl bromide with aqueous KOH.



Mechanism:

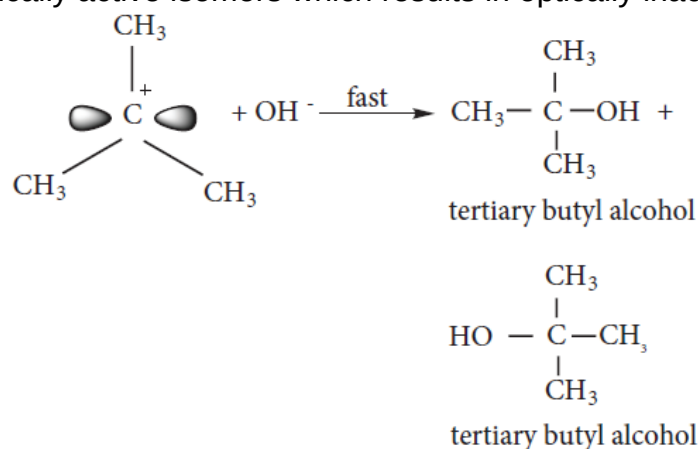
Step – 1:

- This step is slow and hence it is the rate determining step.



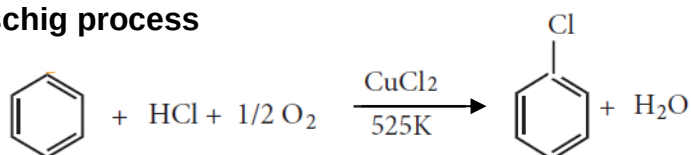
Step – 2:

- This step is fast and hence does not affect the rate of the reactions. The nucleophilic reagent OH^- can attack carbocation from both the sides, to form equal proportion of dextro and levorotatory optically active isomers which results in optically inactive racemic mixture.

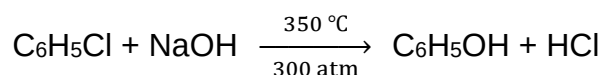


23 Write short notes on the the following

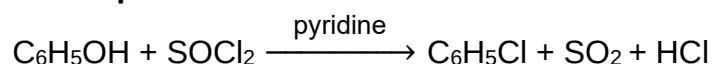
i) Raschig process



ii) Dows Process

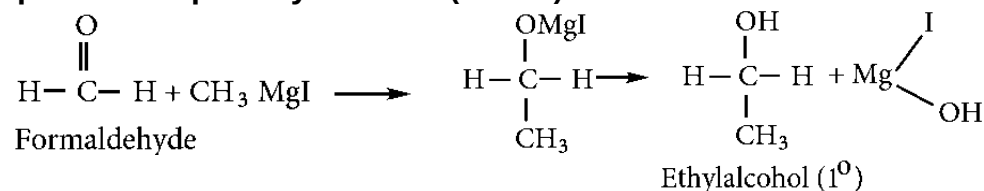


iii) Darzens process

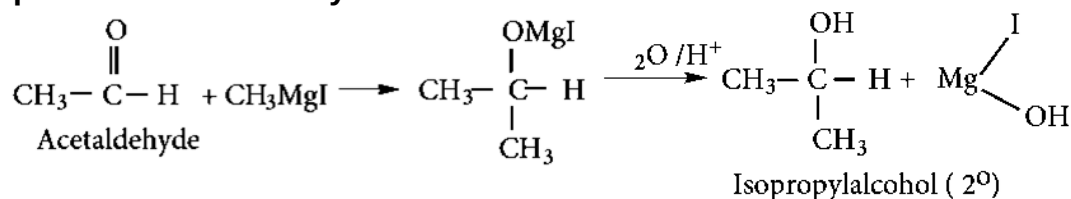


23 **Starting from CH_3MgI , how will you prepare the following?**

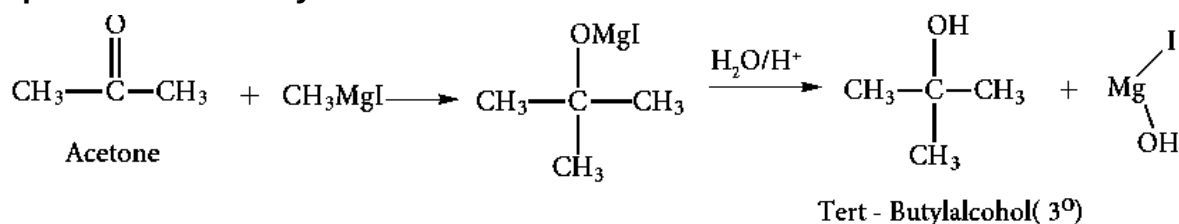
i) Preparation of primary alcohol: (Mar-23)



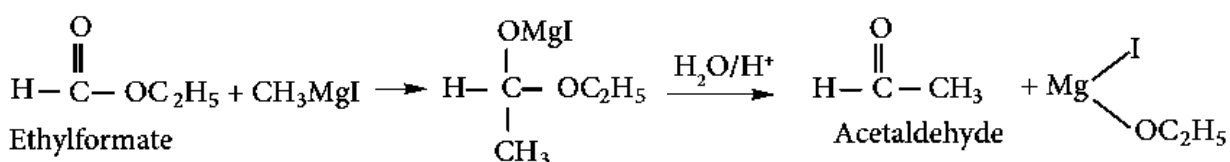
ii) Preparation of secondary alcohol:



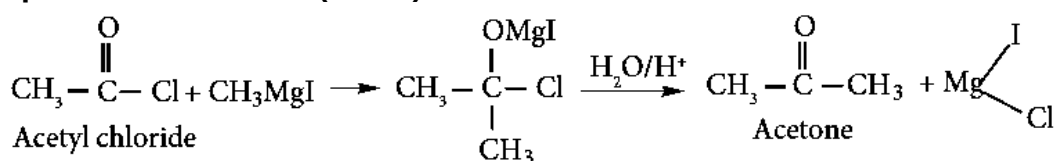
iii) Preparation of Tertiary alcohol:



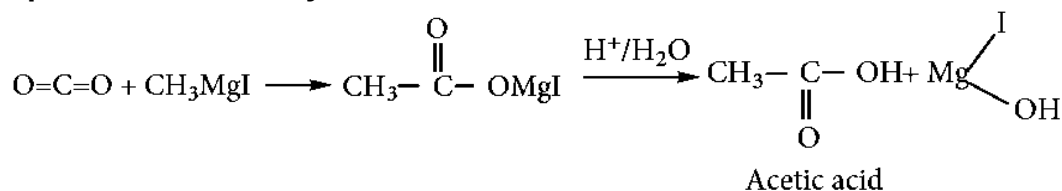
iv) Preparation of aldehyde: (Jul-22, Mar-23)



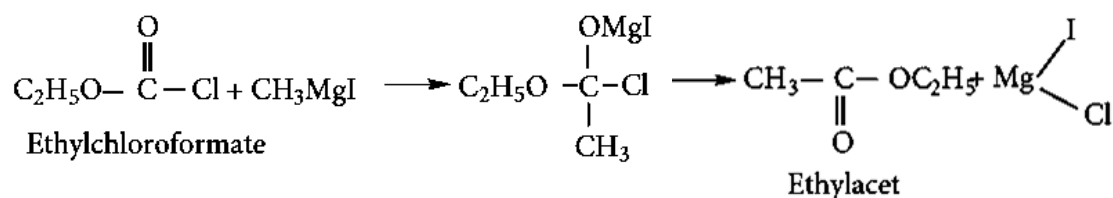
v) Preparation of ketone: (Jul-22)



vi) Preparation of carboxylic acids:

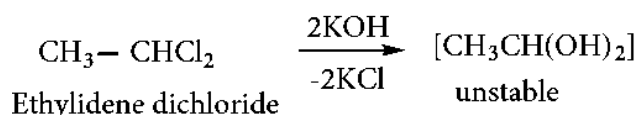


vii) Preparation of esters: (Mar-23)



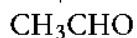
	viii) Preparation of higher ethers: $\text{CH}_3 - \text{O} - \text{CH}_2\text{Cl} + \text{CH}_3\text{MgI} \longrightarrow \text{CH}_3 - \text{O} - \text{CH}_2\text{CH}_3 + \text{Mg} \begin{array}{l} \text{I} \\ \text{Cl} \end{array}$ Chloro dimethyl ether Ethyl methyl ether ix) Preparation of alkyl cyanide: $\text{CH}_3\text{MgI} + \text{CNCl} \longrightarrow \text{CH}_3\text{CN} + \text{Mg} \begin{array}{l} \text{Cl} \\ \text{I} \end{array}$ Cyanogen chloride Methyl cyanide x) Preparation of Alkanes: (Mar-19, Jul-22) $\text{CH}_3\text{MgI} + \text{HO} - \text{H} \longrightarrow \text{CH}_4 + \text{MgI}(\text{OH})$ $\text{CH}_3\text{MgI} + \text{C}_2\text{H}_5\text{OH} \xrightarrow{\Delta} \text{CH}_4 + \text{MgI}(\text{OC}_2\text{H}_5)$ Ethyl alcohol methane
24	Complete the following reactions i) $\text{CH}_3 - \text{CH} = \text{CH}_2 + \text{HBr} \xrightarrow{\text{peroxide}} \text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$ (n – propyl bromide) ii) $\text{CH}_3 - \text{CH}_2 - \text{Br} + \text{NaSH} \xrightarrow[\text{H}_2\text{O}]{\text{alcohol}} \text{CH}_3\text{CH}_2\text{SH} + \text{NaBr}$ (Ethanethiol) iii) $\text{C}_6\text{H}_5\text{Cl} + \text{Mg} \xrightarrow{\text{THF}} \text{C}_6\text{H}_5\text{MgCl}$ (phenyl magnesium chloride) iv) $\text{CHCl}_3 + \text{HNO}_3 \xrightarrow{\Delta} \text{CCl}_3\text{NO}_2 + \text{H}_2\text{O}$ (Chloropicrin) v) $\text{CCl}_4 + \text{H}_2\text{O} \xrightarrow{\Delta} \text{COCl}_2 + 2\text{H}_2\text{O}$ (phosgene)
25	Explain the preparation of the following compounds i) DDT: (Sep-20, Jun-23) $\begin{array}{c} \text{H} \\ \\ \text{CCl}_3 - \text{C} = \text{O} \end{array}$ Chloral + $\begin{array}{c} \text{H} - \text{C}_6\text{H}_4 - \text{Cl} \\ \text{H} - \text{C}_6\text{H}_4 - \text{Cl} \end{array}$ Chloro benzene $\xrightarrow{\text{con. H}_2\text{SO}_4}$ $\begin{array}{c} \text{H} \\ \\ \text{CCl}_3 - \text{C} \begin{array}{l} \nearrow \text{C}_6\text{H}_4 - \text{Cl} \\ \searrow \text{C}_6\text{H}_4 - \text{Cl} \end{array} \end{array}$ DDT + H₂O ii) Chloroform: It is prepared in the laboratory by the reaction between ethyl alcohol with bleaching powder followed by the distillation of the product chloroform. Step – 1: Oxidation: $\text{CH}_3\text{CH}_2\text{OH} + \text{Cl}_2 \rightarrow \text{CH}_3\text{CHO} + 2\text{HCl}$ Step – 2: Chlorination: $\text{CH}_3\text{CHO} + 3\text{Cl}_2 \rightarrow \text{CCl}_3\text{CHO} + 3\text{HCl}$ Step – 3: Hydrolysis: $2\text{CCl}_3\text{CHO} + \text{Ca}(\text{OH})_2 \rightarrow 2\text{CHCl}_3 + (\text{HCOO})_2\text{Ca}$ iii) Biphenyl: $\text{C}_6\text{H}_5\text{Cl} + 2\text{Na} + \text{Cl} - \text{C}_6\text{H}_5 \xrightarrow[\Delta]{\text{Ether}} \text{C}_6\text{H}_5 - \text{C}_6\text{H}_5 + 2\text{NaCl}$ Chlorobenzene Biphenyl

	iv) Chloropicrin: $\text{CHCl}_3 + \text{HNO}_3 \xrightarrow{\Delta} \text{CCl}_3\text{NO}_2 + \text{H}_2\text{O}$ Chloroform Chloropicrin v) Freon-12 $\text{CCl}_4 + 2\text{HF} \xrightarrow{\text{SbCl}_5} 2\text{HCl} + \text{CCl}_2\text{F}_2$ Carbon tetrachloride Freon - 12												
27	An organic compound (A) with molecular formula $\text{C}_2\text{H}_5\text{Cl}$ reacts with KOH gives compounds (B) and with alcoholic KOH gives compound (C). Identify (A), (B) and (C). $\text{CH}_3\text{CH}_2\text{Cl} \xrightarrow{\text{aqueous KOH}} \text{CH}_3\text{CH}_2\text{OH} + \text{KCl}$ (A) (B) $\text{CH}_3\text{CH}_2\text{Cl} \xrightarrow{\text{alcoholic KOH}} \text{CH}_2 = \text{CH}_2 + \text{KCl} + \text{H}_2\text{O}$ (A) (C) <table><tr><th>Compound</th><th>Formula</th><th>Name</th></tr><tr><td>A</td><td>$\text{CH}_3\text{CH}_2\text{Cl}$</td><td>Ethyl chloride</td></tr><tr><td>B</td><td>$\text{CH}_3\text{CH}_2\text{OH}$</td><td>Ethyl alcohol</td></tr><tr><td>C</td><td>$\text{CH}_2 = \text{CH}_2$</td><td>Ethylene</td></tr></table>	Compound	Formula	Name	A	$\text{CH}_3\text{CH}_2\text{Cl}$	Ethyl chloride	B	$\text{CH}_3\text{CH}_2\text{OH}$	Ethyl alcohol	C	$\text{CH}_2 = \text{CH}_2$	Ethylene
Compound	Formula	Name											
A	$\text{CH}_3\text{CH}_2\text{Cl}$	Ethyl chloride											
B	$\text{CH}_3\text{CH}_2\text{OH}$	Ethyl alcohol											
C	$\text{CH}_2 = \text{CH}_2$	Ethylene											
28	Simplest alkene (A) reacts with HCl to form compound (B). Compound (B) reacts with ammonia to form compound (C) of molecular formula $\text{C}_2\text{H}_7\text{N}$. Compound (C) undergoes carbylamine test. Identify (A), (B) and (C). $\text{CH}_2 = \text{CH}_2 \xrightarrow{\text{HCl}} \text{CH}_3\text{CH}_2\text{Cl}$ (A) (B) $\text{CH}_3\text{CH}_2\text{Cl} + \text{NH}_3 \longrightarrow \text{CH}_3\text{CH}_2\text{NH}_2 + \text{HCl}$ (B) (C) <table><tr><th>Compound</th><th>Formula</th><th>Name</th></tr><tr><td>A</td><td>$\text{CH}_2 = \text{CH}_2$</td><td>Ethylene</td></tr><tr><td>B</td><td>$\text{CH}_3\text{CH}_2\text{Cl}$</td><td>Ethyl chloride</td></tr><tr><td>C</td><td>$\text{CH}_3\text{CH}_2\text{NH}_2$</td><td>Ethyl amine</td></tr></table>	Compound	Formula	Name	A	$\text{CH}_2 = \text{CH}_2$	Ethylene	B	$\text{CH}_3\text{CH}_2\text{Cl}$	Ethyl chloride	C	$\text{CH}_3\text{CH}_2\text{NH}_2$	Ethyl amine
Compound	Formula	Name											
A	$\text{CH}_2 = \text{CH}_2$	Ethylene											
B	$\text{CH}_3\text{CH}_2\text{Cl}$	Ethyl chloride											
C	$\text{CH}_3\text{CH}_2\text{NH}_2$	Ethyl amine											
29	A hydrocarbon C_3H_6 (A) reacts with HBr to form compound (B). Compound (B) reacts with aqueous potassium hydroxide to give (C) of molecular formula $\text{C}_3\text{H}_8\text{O}$. What are (A), (B) and (C). Explain the reactions. $\text{CH}_3 - \text{CH} = \text{CH}_2 \xrightarrow{\text{HBr}} \text{CH}_3 - \underset{\text{Br}}{\text{CH}} - \text{CH}_3$ (A) (B) $\text{CH}_3 - \underset{\text{Br}}{\text{CH}} - \text{CH}_3 \xrightarrow{\text{aqueous KOH}} \text{CH}_3 - \underset{\text{OH}}{\text{CH}} - \text{CH}_3 + \text{KBr}$ <table><tr><th>Compound</th><th>Formula</th><th>Name</th></tr><tr><td>A</td><td>$\text{CH}_3 - \text{CH} = \text{CH}_2$</td><td>Propene</td></tr><tr><td>B</td><td>$\text{CH}_3 - \underset{\text{Br}}{\text{CH}} - \text{CH}_3$</td><td>Isopropyl bromide</td></tr><tr><td>C</td><td>$\text{CH}_3 - \underset{\text{OH}}{\text{CH}} - \text{CH}_3$</td><td>Isopropyl alcohol</td></tr></table>	Compound	Formula	Name	A	$\text{CH}_3 - \text{CH} = \text{CH}_2$	Propene	B	$\text{CH}_3 - \underset{\text{Br}}{\text{CH}} - \text{CH}_3$	Isopropyl bromide	C	$\text{CH}_3 - \underset{\text{OH}}{\text{CH}} - \text{CH}_3$	Isopropyl alcohol
Compound	Formula	Name											
A	$\text{CH}_3 - \text{CH} = \text{CH}_2$	Propene											
B	$\text{CH}_3 - \underset{\text{Br}}{\text{CH}} - \text{CH}_3$	Isopropyl bromide											
C	$\text{CH}_3 - \underset{\text{OH}}{\text{CH}} - \text{CH}_3$	Isopropyl alcohol											
30	What is the IUPAC name of the insecticide DDT? Why is their use banned in most of the countries? • IUPAC name of the DDT is 2, 2 – bis (4 – chloro phenyl) – 1, 1, 1 – trichloro ethane • DDT is more stable and non-biodegradable. • DDT is banned because of its long-term toxic effect through food chain.												
31	Two isomers (A) and (B) have the same molecular formula $\text{C}_2\text{H}_4\text{Cl}_2$. Compound (A) reacts with aqueous KOH gives compound (C) of molecular formula $\text{C}_2\text{H}_4\text{O}$. Compound (B) reacts with aqueous KOH gives compound (D) of molecular formula $\text{C}_2\text{H}_6\text{O}_2$. Identify (A), (B), (C) and (D). $\begin{array}{c} \text{Cl} \\ \\ \text{CH}_3\text{CH} \\ \\ \text{Cl} \end{array}$ (A) மற்றும் $\begin{array}{cc} \text{CH}_2 & - & \text{CH}_2 \\ & & \\ \text{Cl} & & \text{Cl} \end{array}$ (B)												

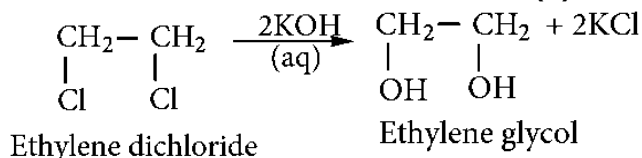


(A)

unstable
↓
-H₂O



Acetaldehyde
(C)

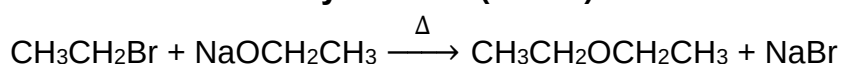


(B)

(D)

Compound	Formula	Name
A	CH ₃ CHCl ₂	Ethylene chloride
B	$\begin{array}{cc} \text{CH}_2 & - & \text{CH}_2 \\ & & \\ \text{Cl} & & \text{Cl} \end{array}$	Ethylene dichloride
C	CH ₃ CHO	Acetaldehyde
D	$\begin{array}{cc} \text{CH}_2 & - & \text{CH}_2 \\ & & \\ \text{OH} & & \text{OH} \end{array}$	Ethylene glycol

32 Write a note on Williamson's synthesis? (Mar-19)



33 Give any two uses of the following Poly halogen compounds.

1) Chloroform:

- it is used as an anaesthetic.
- it is used as solvent

2) Carbon tetrachloride:

- it is used in dry cleaning process
- Carbon tetrachloride is used in fire extinguishers.

3) DDT (Sep-19, Mar-24)

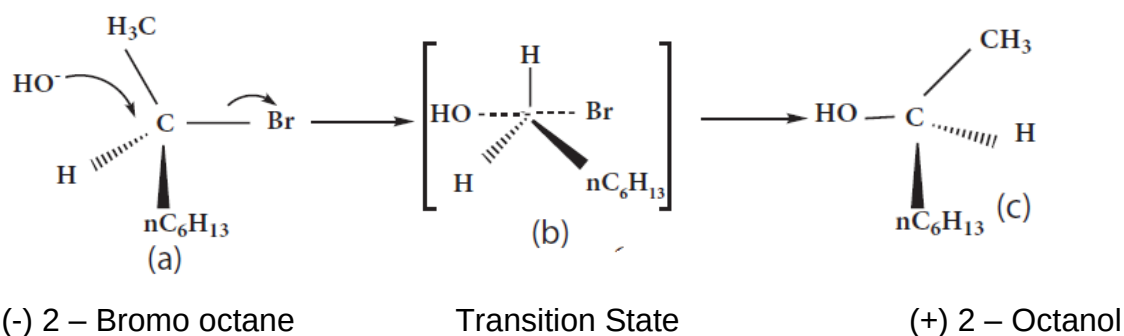
- It is used to control certain insects which carries diseases like malaria and yellow fever
- It is used in farms to control some agricultural pests
- It is used in building construction as pest control.

4) Iodoform:

- It is used as an antiseptic
- It is used in pharmaceutical industry.

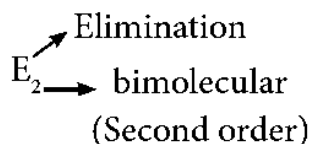
34 Explain the mechanism of S_N² reaction? (Mar-24)

- S_N² stands for bimolecular nucleophilic substitution
- 'S' stands for substitution
- 'N' stands for nucleophilic
- '2' stands for bimolecular
- The rate of S_N² reaction depends upon the concentration of both alkyl halide and the nucleophile.
- Rate of reaction = k₂ [alkylhalide][nucleophile]
- It follows second order kinetics and occurs in one step.
- This reaction involves the formation of a transition state in which both the reactant molecules are partially bonded to each other. The attack of nucleophile occurs from the back side.
- The carbon at which substitution occurs has inverted configuration during the course of reaction just as an umbrella has tendency to invert in a wind storm. This inversion of configuration is called Walden inversion.

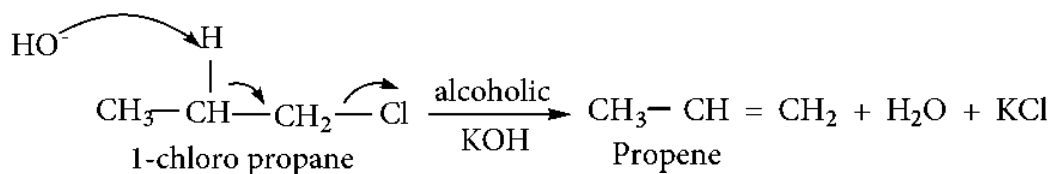


35 **Explain the mechanism of Elimination reaction?**

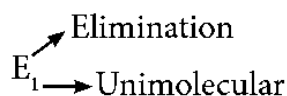
E₂ reaction mechanism:



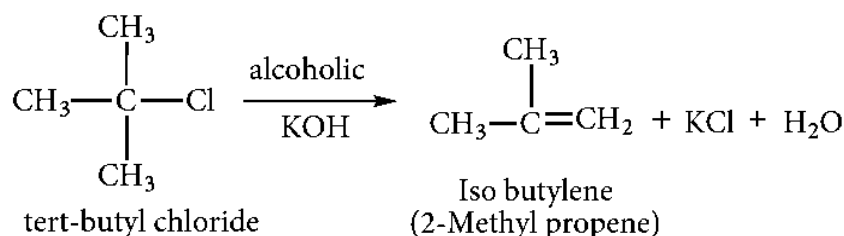
- The rate of E₂ reaction depends on the concentration of alkyl halide and base
- Rate = k [alkyl halide] [base]
- It is therefore, a second order reaction. Generally primary alkyl halide undergoes this reaction in the presence of alcoholic KOH.
- It is a one step process in which the abstraction of the proton from the β carbon and expulsion of halide from the α carbon occur simultaneously.



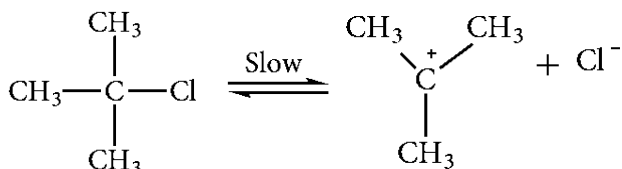
E₁ reaction mechanism:

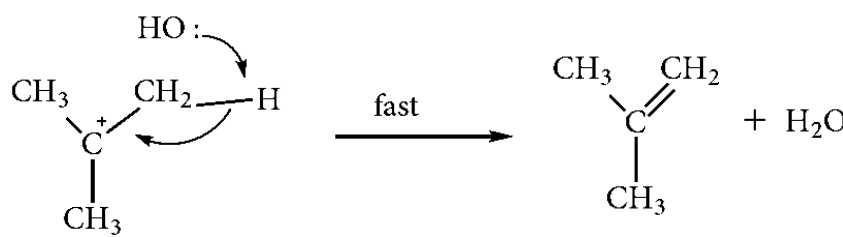
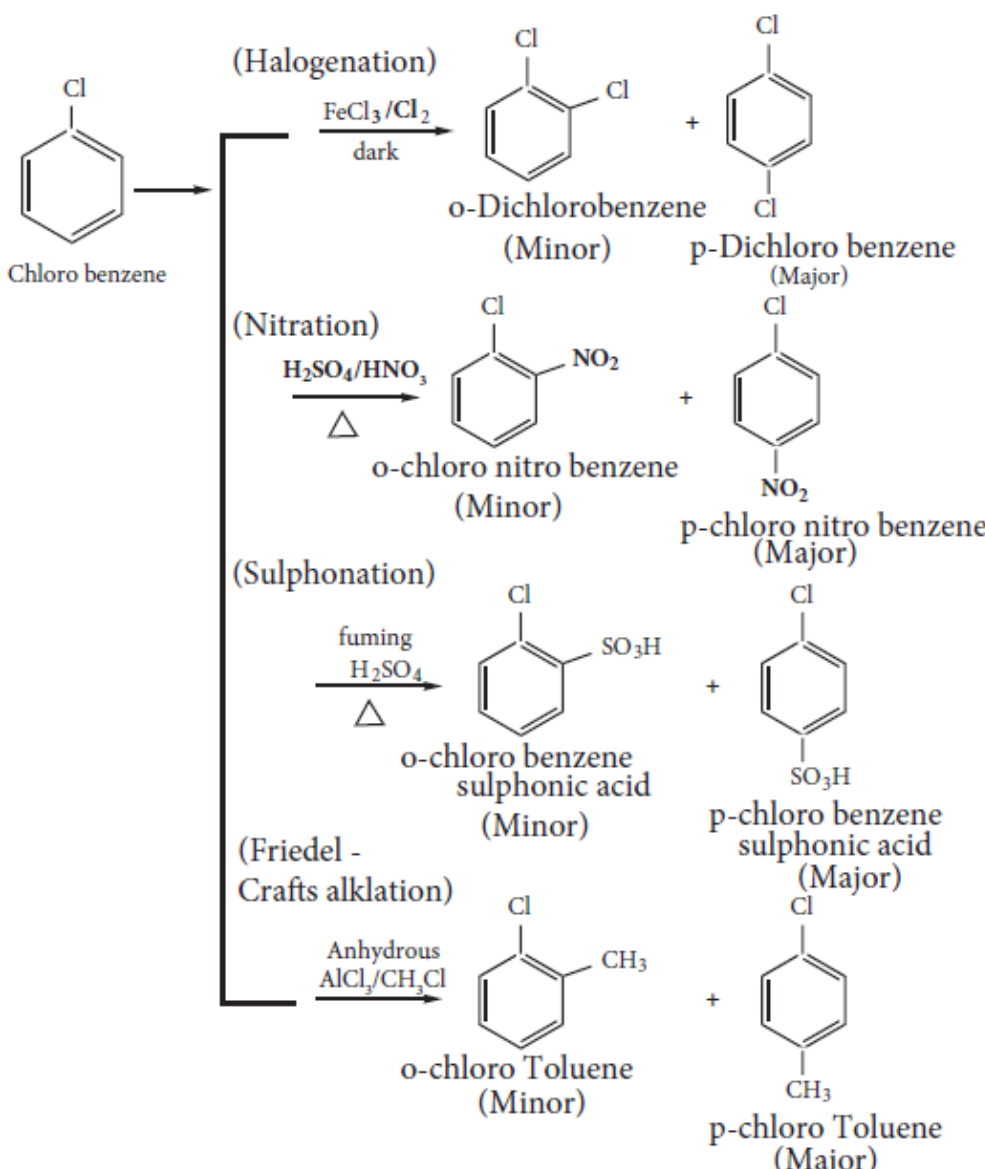


- Generally, tertiary alkyl halide which undergoes elimination reaction by this mechanism in the presence of alcoholic KOH.
- Rate = k [alkyl halide]
- It follows first order kinetics.

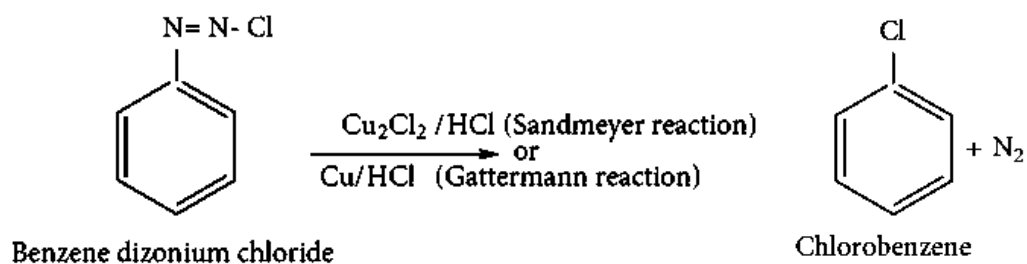


Step – 1:

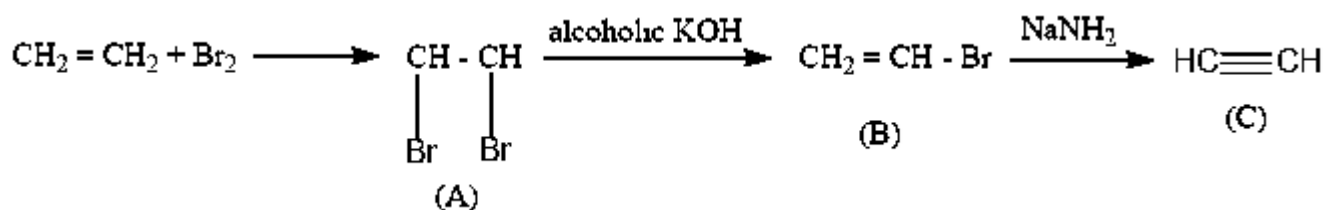


	Step – 2:  Carbocation 2 - methyl propene
36	Write short notes on Swarts reaction? (Sep-21) $\text{CH}_3\text{CH}_2\text{Br} + \text{AgF} \xrightarrow{\Delta} \text{CH}_3\text{CH}_2\text{F} + \text{AgBr}$ Bromo ethane Fluoro ethane
37	Write Hunsdiccker reaction? $\text{CH}_3\text{CH}_2\text{COOAg} + \text{Br}_2 \xrightarrow{\text{CCl}_4} \text{CH}_3\text{CH}_2\text{Br} + \text{CO}_2 + \text{AgBr}$ Silver propionate Bromo ethane
38	Explain Electrophilic substitution reaction of chloro benzene? (or) Write the following reactions of chlorobenzene. Halogenation, Nitration, Sulphonation and Friedel - Crafts alklation. 

39 Write Sandmeyer reaction (or) Gattermann reaction?



40 $\text{CH}_2 = \text{CH}_2 + \text{Br}_2 \longrightarrow \text{A} \xrightarrow{\text{alcoholic KOH}} \text{B} \xrightarrow{\text{NaNH}_2} \text{C}$. Identify A, B and C. (Mar-24)



Compound	Name
A	1,2 – dibromo ethane
B	Vinyl bromide (or) Bromo ethene
C	Acetylene (or) Ethyne

15. ENVIRONMENTAL CHEMISTRY

1	Dissolved oxygen in water is responsible for aquatic life. What processes are responsible for the reduction in dissolved oxygen in water? • Human activities • Organic matters • Eutrophication • Growth of algae Due to these above activities, microorganisms present in water decompose organic matter and consume dissolved oxygen in water causes reduction in dissolved oxygen in water.
2	What would happen, if the greenhouse gases were totally missing in the earth's atmosphere? If the greenhouse gases were totally missing in the earth's atmosphere, then earth's average surface temperature would be only about -18°C (0°F).
3	Define smog. • Smog = smoke + fog • It forms droplets that remain suspended in the air.
4	Which is considered to be earth's protective umbrella? Why? (Jun-23) • Ozone layer is considered to be the earth's protective umbrella • It acts as an umbrella or shield for harmful UV radiations. • It protects us from harmful effect such as skin cancer.
5	What are degradable and non-degradable pollutants? i. Bio-degradable pollutants: • The pollutants which can be easily decomposed by the natural biological processes • Eg: plant wastes, animal wastes etc. ii. Non bio-degradable pollutants: • The pollutants which cannot be decomposed by the natural biological processes • Eg: metal wastes, plastics, nuclear wastes etc.,
6	From where does ozone come in the photo chemical smog? Ozone in the photo chemical smog is formed through sequence of following reactions. $\text{N}_2 + \text{O}_2 \longrightarrow 2\text{NO}$ $2\text{NO} + \text{O}_2 \longrightarrow 2\text{NO}_2$ $\text{NO}_2 \xrightarrow{\text{Sunlight}} \text{NO} + (\text{O})$ $(\text{O}) + \text{O}_2 \longrightarrow \text{O}_3$ $\text{O}_3 + \text{NO} \longrightarrow \text{NO}_2 + \text{O}_2$ $\text{NO}_2 \xrightarrow{\text{Sunlight}} \text{NO} + (\text{O})$
7	A person was using water supplied by corporation. Due to shortage of water he started using underground water. He felt laxative effect. What could be the cause? Excessive concentration ($>500\text{ppm}$) of sulphates in drinking water causes laxative effect.
8	What is green chemistry? (Jun-19, Jun-23) Green chemistry is a chemical philosophy encouraging the design of products and processes that reduce or eliminate the use and generation of hazardous substances.

9	Explain how does greenhouse effect cause global warming? (Sep-20) • The trapping of heat in the atmosphere by certain gases is called as greenhouse effect. • The earth's atmosphere allows most of the visible light from the Sun to pass through and reach Earth's surface. As Earth's surface is heated by sunlight, it radiates part of this energy back toward space as longer wavelengths (IR). • Some of the heat is trapped by CH₄, CO₂, CFCs and water vapour present in the atmosphere. They absorb IR radiation and effectively block a large portion of earth's emitted radiation. The radiation thus absorbed is partly reemitted to earth's surface. Therefore, the earth's surface gets heated up by a phenomenon called greenhouse effect. • Thus, Greenhouse effect may be defined as the heating up of the earth surface due to trapping of infrared radiations reflected by earth's surface by CO₂ layer in the atmosphere". • The heating up of earth through the greenhouse effect is called global warming.																																				
10	Mention the standards prescribed by BIS for quality of drinking water <table><tr><th>S.No</th><th>Characteristics</th><th>Desirable limit</th></tr><tr><td>I</td><td colspan="2">Physico-chemical Characteristics</td></tr><tr><td>i)</td><td>pH</td><td>6.5 to 8.5</td></tr><tr><td>ii)</td><td>Total Dissolved Solids (TDS)</td><td>500 ppm</td></tr><tr><td>iii)</td><td>Total Hardness (as CaCO₃)</td><td>300 ppm</td></tr><tr><td>iv)</td><td>Nitrate</td><td>45 ppm</td></tr><tr><td>v)</td><td>Chloride</td><td>250 ppm</td></tr><tr><td>vi)</td><td>Sulphate</td><td>200 ppm</td></tr><tr><td>vii)</td><td>Fluoride</td><td>1 ppm</td></tr><tr><td>II</td><td colspan="2">Biological Characteristics</td></tr><tr><td>i)</td><td>Escherichia Coli (E.Coli)</td><td>Not at all</td></tr><tr><td>ii)</td><td>Coliforms</td><td>Not to exceed 10 (In 100 ml water sample)</td></tr></table>	S.No	Characteristics	Desirable limit	I	Physico-chemical Characteristics		i)	pH	6.5 to 8.5	ii)	Total Dissolved Solids (TDS)	500 ppm	iii)	Total Hardness (as CaCO ₃)	300 ppm	iv)	Nitrate	45 ppm	v)	Chloride	250 ppm	vi)	Sulphate	200 ppm	vii)	Fluoride	1 ppm	II	Biological Characteristics		i)	Escherichia Coli (E.Coli)	Not at all	ii)	Coliforms	Not to exceed 10 (In 100 ml water sample)
S.No	Characteristics	Desirable limit																																			
I	Physico-chemical Characteristics																																				
i)	pH	6.5 to 8.5																																			
ii)	Total Dissolved Solids (TDS)	500 ppm																																			
iii)	Total Hardness (as CaCO ₃)	300 ppm																																			
iv)	Nitrate	45 ppm																																			
v)	Chloride	250 ppm																																			
vi)	Sulphate	200 ppm																																			
vii)	Fluoride	1 ppm																																			
II	Biological Characteristics																																				
i)	Escherichia Coli (E.Coli)	Not at all																																			
ii)	Coliforms	Not to exceed 10 (In 100 ml water sample)																																			
11	How does classical smog differ from photochemical smog? Smog is a combination of smoke and fog which forms droplets that remain suspended in the air. <table><tr><th>Classical smog</th><th>Photochemical smog</th></tr><tr><td>It occurs in cool humid climate.</td><td>It occurs in warm, dry and sunny climate.</td></tr><tr><td>It generally occurs in the morning and becomes worse when the sun rises.</td><td>It forms when the sun shines and becomes worse in the afternoon.</td></tr><tr><td>This is mainly due to the induced oxidation of SO₂ to SO₃, which reacts with water yielding sulphuric acid aerosol.</td><td>It is is formed by the combination of smoke, dust and fog with air pollutants like oxides of nitrogen and hydrocarbons in the presence of sunlight.</td></tr></table>	Classical smog	Photochemical smog	It occurs in cool humid climate.	It occurs in warm, dry and sunny climate.	It generally occurs in the morning and becomes worse when the sun rises.	It forms when the sun shines and becomes worse in the afternoon.	This is mainly due to the induced oxidation of SO ₂ to SO ₃ , which reacts with water yielding sulphuric acid aerosol.	It is is formed by the combination of smoke, dust and fog with air pollutants like oxides of nitrogen and hydrocarbons in the presence of sunlight.																												
Classical smog	Photochemical smog																																				
It occurs in cool humid climate.	It occurs in warm, dry and sunny climate.																																				
It generally occurs in the morning and becomes worse when the sun rises.	It forms when the sun shines and becomes worse in the afternoon.																																				
This is mainly due to the induced oxidation of SO ₂ to SO ₃ , which reacts with water yielding sulphuric acid aerosol.	It is is formed by the combination of smoke, dust and fog with air pollutants like oxides of nitrogen and hydrocarbons in the presence of sunlight.																																				
12	What are particulate pollutants? Explain any three. (Mar-23) Particulate pollutants are small solid particles and liquid droplets suspended in air. (i) Smoke: Smoke particulate consists of solid particles (or) mixture of solid and liquid particles formed by combustion of organic matter. (ii) Dust: Dust composed of fine solid particles produced during crushing and grinding of solid materials. (iii) Mists: They are formed by particles of spray liquids and condensation of vapours in air.																																				

13	Even though the use of pesticides increases the crop production, they adversely affect the living organisms. Explain the function and the adverse effects of the pesticides. Pesticides are the chemicals that are used to kill or stop the growth of unwanted organisms. But these pesticides can affect the health of human beings. These are further classified as a. Insecticides: Insecticides like DDT, BHC, aldrin etc. can stay in soil for long period of time and are absorbed by soil. They contaminate root crops like carrot, raddish, etc. b. Fungicide: Organo mercury compounds are used as most common fungicide. They dissociate in soil to produce mercury which is highly toxic. c. Herbicides: Herbicides are the chemical compounds used to control unwanted plants. They are otherwise known as weed killers. Example sodium chlorate (NaClO_3) and sodium arsenite (Na_3AsO_3). Most of the herbicides are toxic to mammals.
14	Ethane burns completely in air to give CO_2, while in a limited supply of air gives CO. The same gases are found in automobile exhaust. Both CO and CO_2 are atmospheric pollutants i) What is the danger associated with these gases • CO is a poisonous gas • CO_2 is responsible for global warming. ii) How do the pollutants affect the human body? 1. CO: • It binds with haemoglobin and forms carboxy haemoglobin • It impairs normal oxygen transport by blood and hence the oxygen carrying capacity of blood is reduced. • This oxygen deficiency results in headache, dizziness, tension, Loss of consciousness, blurring of eye sight and cardiac arrest. 2. CO_2: • It s responsible for global warming. • It causes headache and nausea.
15	On the basis of chemical reactions involved, explain how do CFC's cause depletion of ozone layer in stratosphere? • The chloro fluoro derivatives of methane and ethane are referred by trade name Freons. • These Chloro Fluoro Carbon compounds are stable, non-toxic, noncorrosive and non-inflammable, easily liquefiable • They are used in refrigerators, air- conditioners and in the production of plastic foams. • CFC's are the exhaust of supersonic air craft's and jumbo jets flying in the upper atmosphere. • They slowly pass from troposphere to stratosphere. • They stay for very longer period of 50 - 100 years. • In the presence of uv radiation, CFC's break up into chlorine free radical $\text{CF}_2\text{Cl}_2 \xrightarrow{h\nu} \cdot\text{CF}_2\text{Cl} + \text{Cl}\cdot$ $\text{CFCl}_3 \xrightarrow{h\nu} \cdot\text{CFCl}_2 + \text{Cl}\cdot$ $\text{Cl}\cdot + \text{O}_3 \rightarrow \text{ClO}\cdot + \text{O}_2$ $\text{ClO}\cdot + (\text{O}\cdot) \rightarrow \text{Cl}\cdot + \text{O}_2$

	- Chlorine radical is regenerated in the course of reaction. Due to this continuous attack of $Cl^{\bullet}$ thinning of ozone layer takes place which leads to formation of ozone hole. - It is estimated that for every reactive chlorine atom generated in the stratosphere 1,00,000 molecules of ozone are depleted.																	
16	How is acid rain formed? Explain its effect. (Mar-19, Mar-24) - 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 result, pH of rain water drops below the level 5.6, hence it is called acid rain. Harmful effects of acid rain: - Acid rain causes extensive damage to buildings and structural materials of marbles. This attack on marble is termed as Stone leprosy. $CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + H_2O + CO_2 \uparrow$ - Acid rain affects plants and animal life in aquatic ecosystem. - It is harmful for agriculture, trees and plants as it dissolves and removes the nutrients needed for their growth. - It corrodes water pipes resulting in the leaching of heavy metals such as iron, lead and copper into drinking water which have toxic effects. - It causes respiratory ailment in humans and animals.																	
17	Differentiate the following (i) BOD and COD (Jun-23) <table><tr><th></th><th>BOD</th><th>COD</th></tr><tr><td>1</td><td>The total amount of oxygen in milligrams consumed by microorganisms in decomposing the waste in one litre of water at 20°C for a period of 5 days is called biochemical oxygen demand (BOD) and its value is expressed in ppm.</td><td rowspan="2">It is defined as the amount of oxygen required by the organic matter in a sample of water for its oxidation by a strong oxidising agent like $K_2Cr_2O_7$ in acid medium for a period of 2 hrs.</td></tr><tr><td>2</td><td>BOD is used as a measure of degree of water pollution. Clean water would have BOD value less than 5 ppm whereas highly polluted water has BOD value of 17 ppm or more.</td></tr></table> (ii) Viable and non-viable particulate pollutants <table><tr><th></th><th>Viable particulate</th><th>Non-viable particulate</th></tr><tr><td>1</td><td>The viable particulates are the small size living organisms such as bacteria, fungi, moulds, algae, etc. which are dispersed in air.</td><td>The non-viable particulates are small solid particles and liquid droplets suspended in air.</td></tr><tr><td>2</td><td>Some of the fungi cause allergy in human beings and diseases in plants.</td><td>There are four types of non-viable particulates in the atmosphere. Eg: Smoke, Dust, Mists and Fumes</td></tr></table>		BOD	COD	1	The total amount of oxygen in milligrams consumed by microorganisms in decomposing the waste in one litre of water at 20°C for a period of 5 days is called biochemical oxygen demand (BOD) and its value is expressed in ppm.	It is defined as the amount of oxygen required by the organic matter in a sample of water for its oxidation by a strong oxidising agent like $K_2Cr_2O_7$ in acid medium for a period of 2 hrs.	2	BOD is used as a measure of degree of water pollution. Clean water would have BOD value less than 5 ppm whereas highly polluted water has BOD value of 17 ppm or more.		Viable particulate	Non-viable particulate	1	The viable particulates are the small size living organisms such as bacteria, fungi, moulds, algae, etc. which are dispersed in air.	The non-viable particulates are small solid particles and liquid droplets suspended in air.	2	Some of the fungi cause allergy in human beings and diseases in plants.	There are four types of non-viable particulates in the atmosphere. Eg: Smoke, Dust, Mists and Fumes
	BOD	COD																
1	The total amount of oxygen in milligrams consumed by microorganisms in decomposing the waste in one litre of water at 20°C for a period of 5 days is called biochemical oxygen demand (BOD) and its value is expressed in ppm.	It is defined as the amount of oxygen required by the organic matter in a sample of water for its oxidation by a strong oxidising agent like $K_2Cr_2O_7$ in acid medium for a period of 2 hrs.																
2	BOD is used as a measure of degree of water pollution. Clean water would have BOD value less than 5 ppm whereas highly polluted water has BOD value of 17 ppm or more.																	
	Viable particulate	Non-viable particulate																
1	The viable particulates are the small size living organisms such as bacteria, fungi, moulds, algae, etc. which are dispersed in air.	The non-viable particulates are small solid particles and liquid droplets suspended in air.																
2	Some of the fungi cause allergy in human beings and diseases in plants.	There are four types of non-viable particulates in the atmosphere. Eg: Smoke, Dust, Mists and Fumes																
18	Explain how oxygen deficiency is caused by carbon monoxide in our blood? Give its effect. - Carbon monoxide is a poisonous gas produced as a result of incomplete combustion of coal or firewood. It is released into the air mainly by automobile exhaust. - It binds with haemoglobin and forms carboxy haemoglobin which impairs normal oxygen transport by blood. Hence the oxygen carrying capacity of blood is reduced.																	

	Effects: This oxygen deficiency results in headache, dizziness, tension, Loss of consciousness, blurring of eye sight and cardiac arrest.
19	What are the various methods you suggest to protect our environment from pollution? (Sep-20) Waste management: Environmental pollution can be controlled by proper disposal of wastes. Recycling: A large amount of disposed waste material can be reused by recycling the waste, thus it reduces the land fill and converts waste into useful forms. Green Chemistry: Substitution of less toxic solvents for highly toxic ones used in certain industrial processes. - Use of fuels with lower sulphur content. - Growing more trees. - Control measures in vehicle emissions are adequate.
20	What causes methemoglobinemia or blue baby syndrome? Use of drinking water having concentration of nitrate higher than 45 ppm may causes methemoglobinemia (blue baby syndrome) disease in children.
21	Explain Eutrophication? (Mar-23) - Eutrophication is a process by which water bodies receive excess nutrients that stimulates excessive plant growth (algae, other plant weeds). This enhanced plant growth in water bodies is called as algae bloom. - The growth of algae in extreme abundance covers the water surface and reduces the oxygen concentration in water. Thus, bloom-infested water inhibits the growth of other living organisms in the water body. - This process in which the nutrient rich water bodies support a dense plant population, kills animal life by depriving it of oxygen and results in loss of biodiversity is known as eutrophication.
22	What are the effects of classical smog? - Smog is primarily responsible for acid rain. - Smog results in poor visibility and it affects air and road transport. - It also causes bronchial irritation.
23	What is the Impact of ozone depletion on environment? The formation and destruction of ozone is a regular natural process, which never disturbs the equilibrium level of ozone in the stratosphere. Any change in the equilibrium level of the ozone in the atmosphere will adversely affect life in the biosphere in the following ways. - Depletion of ozone layer will allow more UV rays to reach the earth surface and layer would cause skin cancer and also decrease the immunity level in human beings. - UV radiation affects plant proteins which leads to harmful mutation of cells. - UV radiation affects the growth of phytoplankton, as a result ocean food chain is disturbed and even damages the fish productivity.
24	What includes in Total dissolved solids (TDS)? Give its effects. - It includes cations like calcium, magnesium, sodium, potassium, iron and anions like carbonate, bicarbonate, chloride, sulphate, phosphate and nitrate. - Use of drinking water having total dissolved solids concentration higher than 500 ppm causes possibilities of irritation in stomach and intestine.

25	How does oxides of sulphur forms? What are its effects on humans and other living things? Sulphur dioxide and sulphur trioxide are produced by burning sulphur containing fossil fuels and roasting sulphide ores. Effects: - Sulphur dioxide is a poisonous gas to both animals and plants. - Sulphur dioxide causes eye irritation, coughing and respiratory diseases like asthma, bronchitis, etc. - Sulphur dioxide is oxidised into more harmful sulphur trioxide in the presence of particulate matter present in polluted air. $2\text{SO}_2 + \text{O}_2 \xrightarrow{\text{Particulate matter}} 2\text{SO}_3$ - SO₃ combines with atmospheric water vapour to form H₂SO₄, which comes down in the form of acid rain. $\text{SO}_3 + \text{H}_2\text{O} \longrightarrow \text{H}_2\text{SO}_4$
26	Write a note on oxides of nitrogen? - Oxides of nitrogen are produced during high temperature combustion processes, oxidation of nitrogen in air and from the combustion of fuels. $\text{N}_2 + \text{O}_2 \xrightarrow{>1210^\circ\text{C}} 2\text{NO}$ $2\text{NO} + \text{O}_2 \xrightarrow{1100^\circ\text{C}} 2\text{NO}_2$ $\text{NO} + \text{O}_3 \longrightarrow \text{NO}_2 + \text{O}_2$ Effects: - The oxides of nitrogen are converted into HNO₃ which comes down in the form of acid rain. - They also form reddish brown haze in heavy traffic. - Nitrogen dioxide potentially damages plant leaves and retards photosynthesis. - NO₂ is a respiratory irritant and it can cause asthma and lung injury. - NO₂ is also harmful to various textile fibres and metals.
27	List out few contributions of green chemistry in our day to day life? (1) Dry cleaning of clothes: - Solvents like tetrachloroethylene used in dry cleaning of clothes, pollute the ground water and are carcinogenic. - In the place of tetrachloroethylene, liquefied CO₂ with suitable detergent, is an alternate solvent used. Liquefied CO₂ is not harmful to the ground water. - Now a days H₂O₂ used for bleaching clothes in laundry, gives better results and utilises less water. (2) Bleaching of paper - Conventional method of bleaching was done with chlorine. - Now a days H₂O₂ can be used for bleaching paper in presence of catalyst. (3) Synthesis of chemicals - Acetaldehyde is now commercially prepared by one step oxidation of ethene in the presence of ionic catalyst in aqueous medium with 90% yield. - Instead of petrol, methanol is used as a fuel in automobiles. - Neem based pesticides have been synthesised, which are safer than the chlorinated hydrocarbons.

Don't wait for the opportunity, create one – Dr. A.P.J. Abdul Kalam