

QUESTION BANK

XI STANDARD CHEMISTRY

UNDER THE GUIDANCE OF

Mr. S. MARS
CEO
CHENNAI DISTRICT

COORDINATORS

TMT.R.C. SARASWATHI
DEO SOUTH
CHENNAI DISTRICT

TMT.M. CHITRA
HEAD MISTRESS
RKM HR.SEC.SCHOOL MAIN
T NAGAR, CHENNAI-17

TEAM MEMBERS

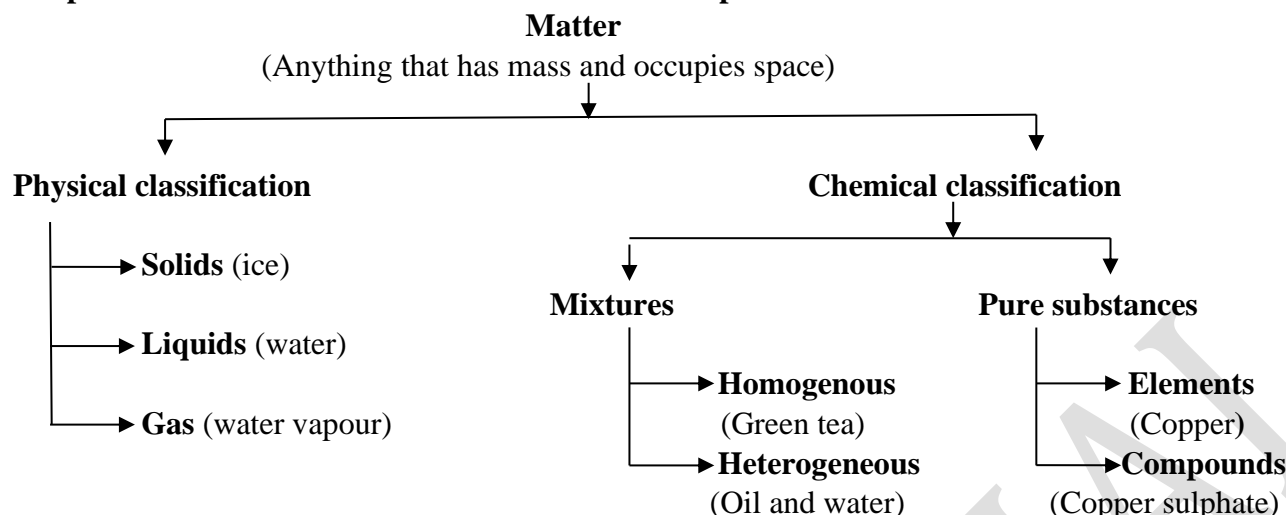
<p>TMT.M. VIMALA PG ASSISTANT GOVT GIRLS' HR.SEC.SCHOOL ASHOK NAGAR CHENNAI-83</p>	<p>THIRU.G. SOUNDARARAJAN PG ASSISTANT CHENNAI HR. SEC. SCHOOL, ALWARPET CHENNAI-18</p>
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REVIEWER AND COMPILER

A HELEN JAYANTHI
PG ASSISTANT
ST. RAPHAEL'S GIRLS' HR.SEC.SCHOOL
SANTHOME, CHENNAI-4

1. BASIC CONCEPTS OF CHEMISTRY AND CHEMICAL CALCULATIONS

1. Explain classification of matter with suitable examples



Mixtures:

It consist of more than one chemical entity present without any chemical interactions

Homogenous mixture:

A mixture in which the composition is uniform throughout the mixture.

Heterogeneous mixture:

A mixture consists of substances which remain physically separate

Pure substances:

Pure substances are composed of simple atoms or molecules.

Elements:

An element consists of only one type of atom. Element can exist as monatomic (Au, Ag) or polyatomic units (H₂, P₄, S₈).

Compounds:

Compounds are made up of molecules which contain two or more atoms of different elements.

2. By applying the knowledge of chemical classification, classify each of the following into elements, compounds or mixtures. (i) Sugar (ii) Sea water (iii) Distilled water (iv) CO₂ (v) Copper wire (vi) Table salt (vii) Silver plate (viii) Naphthalene balls

1	Element	Copper wire, Silver plate
2	Compound	Sugar, distilled water, carbon dioxide, Table salt, Naphthalene balls
3	Mixture	Sea water

3. Define relative atomic mass

The relative atomic mass is defined as the ratio of the average atomic mass factor to the unified atomic mass unit.

Relative atomic mass of hydrogen atom (H) = 1.008u

4. Calculate average relative atomic mass of chlorine consists of two naturally occurring isotopes ³⁵Cl and ³⁷Cl in the ratio 77:23.

$$\text{Average relative atomic mass of chlorine} = \frac{(35 \times 77) + (37 \times 23)}{100} = \frac{2695 + 851}{100} = \frac{2695 + 851}{100} = \frac{3546}{100} = 35.46 \text{ u}$$

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

Isotope	Isotopic atomic mass	Abundance (%)
Mg-24	23.99	78.99
Mg-26	24.99	10.00
Mg-25	25.98	11.01

$$\text{Average atomic mass} = \frac{(23.99 \times 78.99) + (24.99 \times 10) + (25.98 \times 11.01)}{100} = \frac{1895 + 249.9 + 286}{100} = \frac{2430.9}{100} = 24.31 \text{u}$$

6. Define molecular mass

Molecular mass is defined as the ratio of the mass of a molecule to the unified atomic mass unit.
Relative molecular mass of hydrogen molecule (H_2) = 2.016 u

7. Calculate the relative molecular mass of the following compounds

<p>i) Glucose [$\text{C}_6\text{H}_{12}\text{O}_6$] Molecular mass = $(12 \times 6) + (1 \times 12) + (16 \times 6)$ $= 72 + 12 + 96 = 180 \text{ gmol}^{-1}$</p>	<p>ii) Ethanol [$\text{C}_2\text{H}_5\text{OH}$] Molecular mass = $(12 \times 2) + (1 \times 6) + (16 \times 1)$ $= 24 + 6 + 16 = 46 \text{ gmol}^{-1}$</p>
<p>iii) Potassium permanganate [KMnO_4] Molecular mass = $(39 \times 1) + (55 \times 1) + (16 \times 4)$ $= 39 + 55 + 64 = 158 \text{ gmol}^{-1}$</p>	<p>iv) Potassium dichromate [$\text{K}_2\text{Cr}_2\text{O}_7$] Molecular mass = $(39 \times 2) + (52 \times 2) + (16 \times 7)$ $= 78 + 104 + 112 = 294 \text{ gmol}^{-1}$</p>
<p>v) Sucrose [$\text{C}_{12}\text{H}_{22}\text{O}_{11}$] Molecular mass = $(12 \times 12) + (1 \times 22) + (16 \times 11)$ $= 144 + 22 + 176 = 342 \text{ gmol}^{-1}$</p>	<p>vi) Carbon monoxide [CO] Molecular mass = $(12 \times 1) + (16 \times 1)$ $= 12 + 16 = 28 \text{ gmol}^{-1}$</p>

8. What do you understand by the term mole?

The total number of atoms present in 12 g of carbon -12 isotope.

$$1 \text{ Mole} = 6.022 \times 10^{23} \text{ entities}$$

9. Define Mole. (Jun19 & Jun23)

One mole is the amount of substances of a system, which contains as many elementary particles as there are atoms in 12g of carbon-12 isotope

10. Define Avogadro Number:

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

This number is called Avogadro number

11. Define molar mass

Molar mass is defined as the mass of one mole of a substance. Its unit is gmol^{-1}

12. Calculate the molar mass of the following compounds.

<p>i) Urea [$\text{CO}(\text{NH}_2)_2$] Molar mass = $(12 \times 1) + (16 \times 1) + (14 \times 2) + (1 \times 4)$ $= 12 + 16 + 28 + 4 = 60 \text{ gmol}^{-1}$</p>	<p>ii) Acetone [CH_3COCH_3] Molar mass = $(12 \times 3) + (16 \times 1) + (1 \times 6)$ $= 36 + 16 + 6 = 58 \text{ gmol}^{-1}$</p>
<p>iii) Boric acid [H_3BO_3] Molar mass = $(1 \times 3) + (11 \times 1) + (16 \times 3)$ $= 3 + 11 + 48 = 62 \text{ gmol}^{-1}$</p>	<p>iv) Sulphuric acid [H_2SO_4] Molar mass = $(1 \times 2) + (32 \times 1) + (16 \times 4)$ $= 2 + 32 + 64 = 98 \text{ gmol}^{-1}$</p>

13. 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.

At 273 K and 1 bar pressure (STP) molar volume = 22.7 L

At 273 K and 1 atm pressure molar volume = 22.4 L

14. The density of carbon dioxide is equal to 1.965 kgm^{-3} at 273 K and 1 atm pressure.

Calculate the molar mass of CO_2 .

Molecular mass = Density x Molar volume

$$\begin{aligned} \text{Molar Volume of CO}_2 \text{ at 273K and 1 atm pressure} &= 22.4 \text{ L} = 22.4 \times 10^{-3} \text{ m}^3 \\ \text{Density of CO}_2 &= 1.965 \text{ kgm}^{-3} \\ \text{Molecular mass} &= 22.4 \times 10^{-3} \text{ m}^3 \times 1.965 \times 10^3 \text{ gm}^{-3} \\ &= 1.965 \times 22.4 = 44 \text{ gmol}^{-1} \end{aligned}$$

15. Calculate the number of moles present in 9 g of ethane.

Molar mass of ethane, $\text{C}_2\text{H}_6 = (2 \times 12) + (6 \times 1) = 30 \text{ g mol}^{-1}$

$$\begin{aligned} \text{Number of moles} &= \frac{\text{mass}}{\text{molar mass}} = \frac{9}{30} \\ &= 0.3 \text{ mole} \end{aligned}$$

16. Calculate the number of molecules of oxygen gas that occupies a volume of 224 ml at 273K and 3 atm pressure.

1 mole of an oxygen occupies a volume of 22.4 L at 273 K and 1 atm pressure

Therefore, number of moles of oxygen that occupies a volume of 224 ml (0.224 L) at 273 K and 3 atm pressure = $\frac{0.224 \times 273 \times 3 \times 1}{22.4 \times 273 \times 1} = 0.03 \text{ moles}$

1 mole of oxygen contains 6.022×10^{23} molecules

$$\begin{aligned} 0.03 \text{ moles of oxygen contains} &= 6.022 \times 10^{23} \times 0.03 \\ &= 1.807 \times 10^{22} \text{ molecules of oxygen} \end{aligned}$$

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

i) 1 mole of ethanol

ii) 1 mole of formic acid

iii) 1 mole of H_2O

Compounds	No. of moles	No. of Oxygen atoms
Ethanol $\text{C}_2\text{H}_5\text{OH}$	1	$1 \times 6.022 \times 10^{23}$
Formic acid HCOOH	1	$2 \times 6.022 \times 10^{23}$
Water H_2O	1	$1 \times 6.022 \times 10^{23}$

1 mole of Formic acid contains the greatest number of Oxygen atoms

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

Molecular mass	Molar mass
The ratio of the mass of the molecule to the unified atomic mass unit	The mass of the one mole of a substance
It can be calculated by adding the relative atomic masses of its constituent atoms	It is equal to the sum of the relative atomic masses of the substance
Unit : u	Unit : g.mol^{-1}
Molecular mass carbon mono oxide is 28u	Molar mass of carbon mono oxide is 28 g.mol^{-1}

19. Mass of one atom of an element is $6.645 \times 10^{-23} \text{ g}$. How many moles of element are there in 0.320 kg?

Given: Mass of one atom = $6.645 \times 10^{-23} \text{ g}$

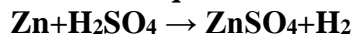
$$\text{Mass of 1 mole of atom} = 6.645 \times 10^{-23} \times 6.022 \times 10^{23} = 40 \text{ g}$$

$$\therefore \text{Number of moles of element in 0.320 kg (320 g)} = \frac{320}{40} = 8 \text{ moles}$$

20. Define gram equivalent mass. (May-22)

Gram equivalent mass of an element, compound or ion is the mass that combines or displaces 1.008 hydrogen or 8 g oxygen or 35.5 g chlorine.

21. Calculate equivalent mass of Zinc using below equation (Atomic mass of Zinc = 65.38 g)



1 mole (2.016 g) of hydrogen molecule displaces 1 mole (65.38 g) of Zinc

1.008 g of hydrogen displaces $\frac{65.38 \times 1.008}{2.016}$ g of Zinc

$$\text{Equivalent mass of Zinc} = \frac{65.38}{2} = 32.69 \text{ g eq}^{-1}$$

22. 0.456 g of a metal gives 0.606 g of its chloride. Calculate the equivalent mass of the metal.

Mass of the metal = 0.456 g

Mass of the metal chloride = 0.606 g

Mass of the chlorine = 0.15 g

0.456 g of the metal combines with 0.15 g of chlorine.

$$\text{Mass of the metal that combines with 35.5 g of chlorine} = \frac{35.5 \times 0.15}{0.456} = 107.92 \text{ g eq}^{-1}.$$

23. Define: Basicity. Find the basicity of ortho-phosphoric acid. (Sep-20)

The number of moles of ionisable H^+ ions present in 1 mole of the acid

Basicity of $\text{H}_3\text{PO}_4 = 3$

24. Define: Acidity

The number of moles of ionisable OH^- ion present in 1 mole of the base

Acidity of $\text{KOH} = 1$

25. How will you find out the equivalent mass of an acid? Give example (or) Calculate the equivalent mass of H_2SO_4 (Mar 19).

$$\text{Equivalent mass of an acid} = \frac{\text{Molar mass of an acid}}{\text{basicity}}$$

$$\text{Example: Gram equivalent mass of } \text{H}_2\text{SO}_4 = \frac{98}{2} = 49 \text{ g eq}^{-1}$$

26. How will you find out the equivalent mass of a base? Give example

$$\text{Equivalent mass of a base} = \frac{\text{Molar mass of a base}}{\text{acidity}}$$

$$\text{Example: Gram equivalent mass of } \text{KOH} = \frac{56}{2} = 56 \text{ g eq}^{-1}$$

27. How will you find out the equivalent mass of an oxidizing agent?

$$\text{Equivalent Mass of an oxid. agent} = \frac{\text{Molar mass of the Oxidizing agent}}{\text{no of moles of electron gained by one mole of the oxidising agent}}$$

28. How will you find out the equivalent mass of a reducing agent?

$$\text{Equivalent Mass of a redu. agent} = \frac{\text{Molar mass of the Reducing agent}}{\text{no of moles of electron lost by one mole of the reducing agent}}$$

29. Calculate the equivalent mass of potassium dichromate

The reduction half-reaction in acid medium is, $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$

$$\text{Equivalent mass of potassium dichromate} = \frac{294}{6} = 49 \text{ g eq}^{-1}.$$

30. Calculate the equivalent mass of potassium permanganate

The reduction half-reaction in acid medium is $\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$

$$\text{Equivalent mass of potassium permanganate} = \frac{158}{5} = 31.6 \text{ g eq}^{-1}.$$

31. Difference between Empirical formula and Molecular formula

S. No	Empirical formula	Molecular formula
1	Empirical formula of a compound is the formula written with the simplest ratio of the number of different atoms present in one molecule of the compound as subscript to the atomic symbol.	Molecular formula of a compound is the formula written with the actual number of different atoms present in one molecule as a subscript to the atomic symbol.
2	Empirical formula of acetic acid is CH_2O	Molecular formula of acetic acid is $\text{C}_2\text{H}_4\text{O}_2$

32. What is the empirical formula of the following? (Sept 2021)

- Fructose $\text{C}_6\text{H}_{12}\text{O}_6$ found in honey
- Caffeine ($\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2$) a substance found in tea and coffee.

Compound	Molecular formula	Empirical formula
Fructose	$\text{C}_6\text{H}_{12}\text{O}_6$	CH_2O
Caffeine	$\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2$	$\text{C}_4\text{H}_5\text{N}_2\text{O}$

33. An acid found in tamarinds on analysis shows following percentage composition: 32% Carbon; 4% Hydrogen; 64% Oxygen. Find the empirical formula of the compound.

Element	Percentage	Atomic mass	Relative number of atoms	Simple ratio	Whole number
C	32	12	$\frac{32}{12} = 2.66$	$\frac{2.66}{2.66} = 1$	2
H	4	1	$\frac{4}{1} = 4$	$\frac{4}{2.66} = 1.5$	3
O	64	16	$\frac{64}{16} = 4$	$\frac{4}{2.66} = 1.5$	3
Empirical formula = $\text{C}_2\text{H}_3\text{O}_3$					

34. A Compound on analysis gave the following percentage composition C=54.55%, H=9.09%, O=36.36%. Determine the empirical formula of the compound.

Element	Percentage	Atomic mass	Relative number of atoms	Simple ratio	Whole number
C	54.54	12	$\frac{54.54}{12} = 4.55$	$\frac{4.55}{2.27} = 2$	2
H	9.09	1	$\frac{9.09}{1} = 9.09$	$\frac{9.09}{2.27} = 4$	4
O	36.36	16	$\frac{36.36}{16} = 2.27$	$\frac{2.27}{2.27} = 1$	1
Empirical formula = $\text{C}_2\text{H}_4\text{O}$					

35. An organic compound present in vinegar has 40% carbon, 6.6% hydrogen and 53.4% oxygen. Find the empirical formula. If its molar mass is 60 find its molecular formula.

Element	Percentage	Atomic mass	Relative number of atoms	Simple ratio	Whole number
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
Empirical formula = CH₂O					

Empirical formula mass = (12 x 1) + (1 x 2) + (16 x 1) = 12 + 2 + 16 = 30

Molecular mass = 60

$$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}} = \frac{60}{30} = 2$$



36. Experimental analysis of a compound containing the elements x, y, z on analysis gave the following data. x = 32 %, y = 24 %, z = 44 %. The relative number of atoms of x, y and z are 2, 1 and 0.5, respectively. (Molecular mass of the compound is 400 g) Find out.

- i) The atomic masses of the element x, y, z. ii) Empirical formula of the compound
iii) Molecular formula of the compound.

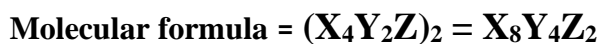
Elements	Percentage	Relative no.of atoms	Atomic mass	Simple ratio	Whole number
X	32 %	2	$\frac{32}{2} = 16$	$\frac{2}{0.5} = 4$	4
Y	24 %	1	$\frac{24}{1} = 24$	$\frac{1}{0.5} = 2$	2
Z	44 %	0.5	$\frac{44}{0.5} = 88$	$\frac{0.5}{0.5} = 1$	1
Empirical formula (X₄Y₂Z)					

Empirical formula mass = (16 x 4) + (24 x 2) + (88 x 1)

$$= 64 + 48 + 88 = 200$$

Molecular mass = 400

$$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}} = \frac{400}{200} = 2$$



37. Calculate the empirical and molecular formula of a compound containing 76.6% carbon, 6.38 %

hydrogen and rest oxygen its vapour density is 47. (Mar-19, Sep-20, (Jul-22))

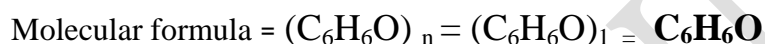
Element	Percentage	Atomic mass	Relative number of atoms	Simple ratio	Whole number
C	76.6	12	$\frac{76.6}{12} = 6.38$	$\frac{6.38}{1.06} = 6$	6
H	6.38	1	$\frac{6.38}{1} = 6.38$	$\frac{6.38}{1.06} = 6$	6
O	17.02	16	$\frac{17.02}{16} = 1.06$	$\frac{1.06}{1.06} = 1$	1
Empirical formula = C₆H₆O					

Empirical formula mass = (12 x 6) + (1 x 6) + (16 x 1) = 72 + 6 + 16 = 94

Molecular mass = 2 x vapour density

$$= 2 \times 47 = 94$$

$$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}} = \frac{94}{94} = 1$$



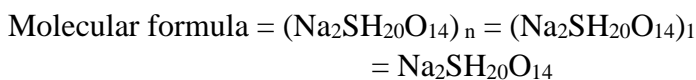
38. A compound on analysis gave Na = 14.31% S = 9.97% H= 6.22% and O= 69.5% calculate the molecular formula of the compound if all the hydrogen in the compound is present in combination with oxygen as water of crystallization. (molecular mass of the compound is 322 (March-2023))

Element	Percentage	Atomic mass	Relative number of atoms	Simple ratio	Whole number
Na	14.31	23	$\frac{14.31}{23} = 0.622$	$\frac{0.622}{0.311} = 2$	2
S	9.97	32	$\frac{9.97}{32} = 0.311$	$\frac{0.311}{0.311} = 1$	1
H	6.22	1	$\frac{6.22}{1} = 6.22$	$\frac{6.22}{0.311} = 20$	20
O	69.5	16	$\frac{69.5}{16} = 4.34$	$\frac{4.34}{0.311} = 14$	14
Empirical formula = Na₂SH₂₀O₁₄					

Empirical formula mass = (2 x 23) + (1 x 32) + (20 x 1) + (14 x 16)
= 322

Molecular mass = 322

$$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}} = \frac{322}{322} = 1$$



Since all the hydrogen in the compound present as water

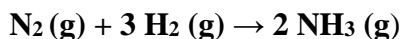


39. What is stoichiometry?

Stoichiometry is the quantitative relationship between reactants and products in a balanced chemical equation in moles. The quantity of reactants and products can be expressed in moles or in terms of mass unit or as volume.

40. How many moles of H₂ is required to produce 10 moles of NH₃?

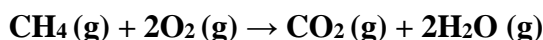
The balanced stoichiometric equation for the formation of ammonia is



2 moles of NH₃ is produced from = 3 moles of H₂

$$\begin{aligned}\therefore 10 \text{ moles of NH}_3 \text{ is produced from} &= \frac{10 \times 3}{2} \text{ moles of H}_2 \\ &= 15 \text{ moles of H}_2\end{aligned}$$

41. Calculate the amount of H₂O produced by combustion of 32 g CH₄.

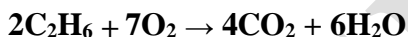


Combustion of 1 mole (16 g) CH₄ produces 2 moles (2 × 18 = 36 g) of water.

$$\therefore \text{Combustion of 32 g of CH}_4 \text{ produces } \frac{32 \times 36}{16} = 72 \text{ g of water}$$

42. How many moles of ethane is required to produce 44 g of CO₂ (g) after combustion.

Balanced equation for the combustion of ethane



Molar mass of CO₂ = (12 × 1) + (16 × 2) = 12 + 32 = 44 gmol⁻¹ = 1 mol

4 moles of CO₂ is produced by 2 moles of ethane

∴ 1 mole of CO₂ is produced by 2/4 = 0.5 moles of ethane

43. How much volume of carbon dioxide is produced when 50 g of solid calcium carbonate is heated under standard conditions?



Molar mass of CaCO₃ = 40 + 12 + (3 × 16) = 100 g mol⁻¹

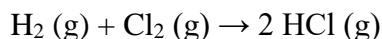
1 mole (100g) CaCO₃ on heating produces 1 mole CO₂

At STP, 1 mole of CO₂ occupies a volume of 22.7 litres

At STP, 100 g of CaCO₃ on heating produces 22.7 litres of CO₂

$$\therefore \text{At STP, 50 g of CaCO}_3 \text{ on heating produces } \frac{22.7 \times 50}{100} = 11.35 \text{ litres of CO}_2$$

44. How much volume of chlorine is required to form 11.2 L of HCl at 273 K and 1 atm. pressure?



To produce 2 moles of HCl, 1 mole of chlorine gas is required

To produce 44.8 litres of HCl, 22.4 litres of chlorine gas are required.

∴ To produce 11.2 litres of HCl =

$$\frac{11.2 \times 22.4}{44.8} = 5.6 \text{ litres of chlorine are required.}$$

45. Calculate the percentage composition of the elements present in magnesium carbonate. How many kilogram of CO₂ can be obtained by heating 1 kg of 90 % pure magnesium carbonate?

The balanced chemical equation is $\text{MgCO}_3 \rightarrow \text{MgO} + \text{CO}_2$

84 g MgCO₃ contain 24 g of Magnesium.

∴ 100 g of MgCO₃ contain

$$= \frac{100 \times 24}{84} \text{ g of Magnesium.}$$

∴ Percentage of magnesium = 28.57 %

84 g MgCO₃ contain 12 g of carbon

∴ 100 g MgCO₃ contain

$$= \frac{100 \times 12}{84} \text{ g of carbon}$$

∴ Percentage of carbon = 14.29 %.

84 g MgCO₃ contain 48 g of oxygen

∴ 100 g MgCO₃ contains $\frac{100 \times 48}{84}$ g of oxygen

∴ Percentage of oxygen = 57.14 %.

84 g of 100 % pure MgCO₃ contain 44 g of CO₂

$$1000 \text{ g of } 90 \% \text{ MgCO}_3 \text{ contain} = \frac{44 \times 90 \times 1000}{84 \times 100} = 471.43 \text{ g of CO}_2$$

$$= 0.471 \text{ kg of CO}_2$$

46. What is Limiting Reagents and Excess reagents? ((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

47. The balanced equation for a reaction is $2x+3y \rightarrow 4l + m$:

When 8 moles of x react with 15 moles of y, then (i) which is the limiting reagent? (ii) Calculate the amount of products formed.(iii) Calculate the amount of excess reactant left at the end of the reaction.

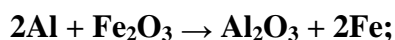
Content	Reactant		products	
	x	y	l	m
Stoichiometric coefficient	2	3	4	1
No. of moles allowed to react	8	15	-	-
No. of moles of reactant reacted and product formed	8	12	16	4
No. of moles of un-reacted reactants and the product formed	-	3	16	4

Limiting reagent : x

Product formed : 16 moles of l & 4 moles of m

Amount of excess reactant : 3 moles of y

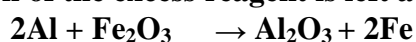
48. The reaction between aluminium and ferric oxide can generate temperatures up to 3273 K and is used in welding metals. (Atomic mass of Al = 27 u, Atomic mass of oxygen = 16 u)



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?



	Reactants		Products	
	Al	Fe ₂ O ₃	Al ₂ O ₃	Fe
Amount of reactant allowed to react	324g	1.12kg = 1120g		
Stoichiometric Co-efficient	2	1	1	2
Number of moles allowed to react	$\frac{324}{27} = 12$	$\frac{1120}{160} = 7$		
Number of moles consumed during reaction	12	6		
Number of moles of reactant unreacted and number of moles of product formed	-	1	6	12

Molar mass of Al_2O_3

$$\text{Molar mass of } \text{Al}_2\text{O}_3 = (2 \times 27) + (3 \times 16) = 102$$

$$\text{Mass of } \text{Al}_2\text{O}_3 \text{ formed} = \text{mole} \times \text{Molar mass} = 6 \times 102 = \mathbf{612g}$$

Excess reagent = Fe_2O_3

$$\text{Molar mass of } \text{Fe}_2\text{O}_3 = (2 \times 56) + (3 \times 16) = 160$$

$$\text{Mass of } \text{Fe}_2\text{O}_3 = \text{mole} \times \text{Molar mass} = 1 \times 160 = \mathbf{160g}$$

49. Urea, a commonly used nitrogen based fertilizer, is prepared by the reaction between ammonia and carbon dioxide as follows.



In a process, 646 g of ammonia is allowed to react with 1.144 kg of CO_2 to form urea

i) If the entire quantity of all the reactants is not consumed in the reaction which is the limiting reagent?

ii) Calculate the quantity of urea formed and unreacted quantity of the excess reagent.

	Reactants		Products	
	2NH_3	CO_2	urea	H_2O
Amount of reactant allowed to react	646g	1.144kg = 1144g		
Stoichiometric Co-efficient	2	1	1	1
Number of moles allowed to react	$\frac{646}{17} = 38$	$\frac{1144}{44} = 26$		
Number of moles consumed during reaction	38	19		
Number of moles of reactant unreacted and number of moles of product formed	-	7	19	19

i) NH_3 is the limiting reagent and CO_2 is the excess reagent.

ii) Molar mass of urea (H₂N-CO-NH₂)

Molar mass of urea = (2 x 14) + (1 x 16) + (12 x 1) + (4 x 1) = 28 + 16 + 12 + 4 = 60 gmol⁻¹

Mass of urea formed = mole x Molar mass = 19 x 60 = 1140g = **1.14kg**

Excess reagent = CO₂

Molar mass of CO₂ = (1 x 12) + (2 x 16) = 44

Mass of CO₂ = mole x Molar mass = 7 x 44 = **308g**

50. 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 z₂
- (b) 1mole of x + 1 mole of y + 3 moles of z₂
- (c) 50 atoms of x + 25 atoms of y + 50 molecules of z₂
- (d) 2.5 moles of x + 5 moles of y + 5 moles of z₂

Question	Number of moles of reactants allowed to react			Number of moles of reactants consumed during reaction			Limiting Reagent
	x	y	z ₂	x	y	z ₂	
a	200 atoms	200 atoms	50 molecules	50 atoms	50 atoms	50 molecules	z ₂
b	1mole	1mole	3moles	1mole	1mole	1mole	x & y
c	50 atoms	25 atoms	50 molecules	25 atoms	25 atoms	25 molecules	y
d	2.5 moles	5 moles	5 moles	2.5 moles	2.5 moles	2.5 moles	x

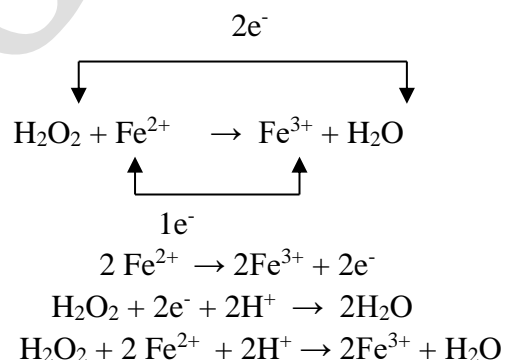
51. What do you understand by the term oxidation number?

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 that are assigned according to set of rules

52. Distinguish between oxidation and reduction. (Sept 2021, March-2023)

Oxidation	Reduction
1. Addition of oxygen	1. Addition of hydrogen
2. Removal of Hydrogen	2. Removal of Oxygen
3. Removal of electron	3. Addition of electron
4. Positive charge increases	4. Negative charge increases
5. Increase in oxidation number	5. Decrease in oxidation number

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



54. Explain the general rules for assigning oxidation number of an atom.

1. The oxidation number of the element in the free (or) elementary state is always Zero.
2. The oxidation number of the element in monoatomic ion is equal to the net charge on the ion.
3. The algebraic sum of oxidation states of all atoms in a molecule is equal to zero, while in ions, it is equal to the net charge on the ion.
4. Hydrogen has an oxidation number of +1 in all its compounds except in metal hydrides where it has -1 value.
5. The oxidation number of fluorine is always -1 in all its compounds.
6. The oxidation state of oxygen in most compounds is -2. Exceptions are peroxides, super oxides and compounds with fluorine.
7. Alkali metals have an oxidation state of +1 and alkaline earth metals have an oxidation state of +2 in all their compounds.

55. Calculate oxidation number of oxygen in H₂O₂. (Mar-19)

S.No	Oxidation number of the element	Compound	Calculation
1	O	H ₂ O ₂	$2(+1) + 2x = 0$ $2x = -2$ $x = -1$

56. Calculate the oxidation number of underlined elements. a) CO₂ b) H₂SO₄ (May-22)

S.No	Oxidation number of the element	Compound	Calculation
1	C	CO ₂	$x + 2(-2) = 0$ $x = +4$
2	S	H ₂ SO ₄	$2(+1) + x + 4(-2) = 0$ $2 + x - 8 = 0$ $x = +6$

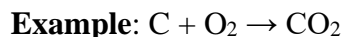
57. Find the oxidation state of underlined element:

- a) Cr₂O₇²⁻ b) CH₂F₂ c) SO₂ d) MnO₄⁻ e) OF₂
f) KO₂ g) Na₂S₂O₃ h) KClO₃ i) HNO₃ j) Cr₂O₃

S.No	Oxidation number of the element	Compound	Calculation
1	Cr	$\text{Cr}_2\text{O}_7^{2-}$	$2x + 7(-2) = -2$ $2x - 14 = -2$ $x = +6$
2	C	CH_2F_2	$x + 2(+1) + 2(-1) = 0$ $x = 0$
3	S	SO_2	$x + 2(-2) = 0$ $x = +4$
4	Mn	MnO_4^-	$x + 4(-2) = -1$ $x = -1 + 8$ $x = +7$
5	O	OF_2	$x + 2(-1) = 0$ $x = +2$
6	O	KO_2	$+1 + 2x = 0$ $2x = -1$ $x = -\frac{1}{2}$
7	S	$\text{Na}_2\text{S}_2\text{O}_3$	$2(+1) + 2x + 3(-2) = 0$ $2x + 2 - 6 = 0$ $2x = +4$ $x = +2$
8	Cl	KClO_3	$(+1) + x + 3(-2) = 0$ $x + 1 - 6 = 0$ $x = +5$
9	N	HNO_3	$+1 + x + 3(-2) = 0$ $0x + 1 - 6 = 0$ $x = +5$
10	Cr	Cr_2O_3	$2x + 3(-2) = 0$ $2x - 6 = 0$ $2x = 6$ $x = 3$

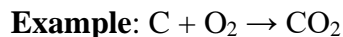
58. Define redox reaction. Give an example

The reaction involving loss of electron is oxidation and gain of electron is reduction. Both these reaction take place simultaneously and are called as redox reaction.



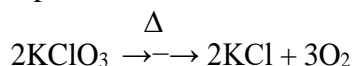
59. Write note on Combination reaction

Redox reactions in which two substances combine to form a single compound are called combination reaction.



60. Write note on decomposition reaction

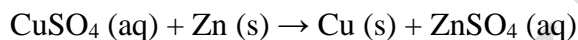
Redox reactions in which a compound breaks down into two or more components are called decomposition reactions. These reactions are opposite to combination reactions.



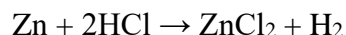
61. Write note on displacement reaction

Redox reactions in which an ion (or an atom) in a compound is replaced by an ion (or atom) of another element are called displacement reactions. They are further classified into (i) metal displacement reactions (ii) non-metal displacement reactions.

Metal displacement reactions:

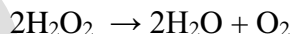


Non-metal displacement



62. What are disproportionation reactions (or) what are Auto redox reaction? Give an example (Jun19)

In some redox reactions, the same compound can undergo both oxidation and reduction. In such reactions, the oxidation state of one and the same element is both increased and decreased. These reactions are called disproportionation reactions.

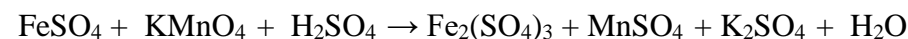


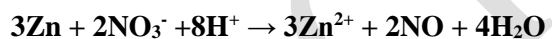
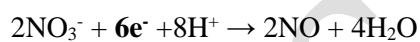
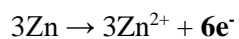
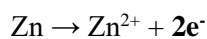
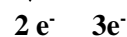
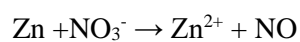
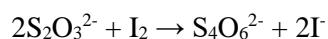
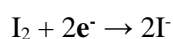
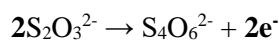
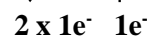
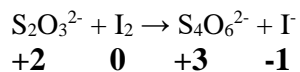
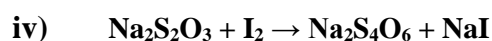
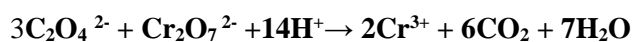
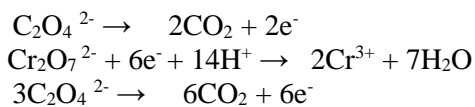
63. Predict the spontaneity of the reaction when a copper strip placed in zinc sulphate solution. Justify your answer.

Place a metallic copper strip in zinc sulphate solution. If copper replaces zinc from zinc sulphate solution, Cu^{2+} ions would be released into the solution and the colour of the solution would change to blue. But no such change is observed.

Therefore, we conclude that among zinc and copper, zinc has more tendency to release electrons and copper to accept the electrons.

64. Balance the following equations by oxidation number method





2. QUANTUM MECHANICAL MODEL OF ATOM

1. Explain Rutherford's α scattering experiment?

Rutherford bombarded a thin gold foil with a stream of fast moving α -particles. It was observed that

- Most of the α -particles passed through the foil
- Some of them were deflected through a small angle
- Very few α -particles were reflected back by 180°

2. Explain the postulates of Bohr's theory.

- The energies of electrons in an atom are quantised.
- The electron is revolving around the nucleus in a certain circular path of fixed energy called stationary orbit.
- Electron can revolve only in those orbits in which the angular momentum (mvr) of the electron must be equal to an integral multiple of $h/2\pi$.
i.e. $mvr = \frac{nh}{2\pi}$ where $n = 1, 2, 3, \dots$ etc.
- As long as an electron revolves in the fixed stationary orbit, it doesn't lose its energy. However, when an electron jumps from higher energy state (E_2) to a lower energy state (E_1), the excess energy is emitted as radiation.

The frequency of the emitted radiation is $E_2 - E_1 = h\nu$

$$\nu = \frac{E_2 - E_1}{h}$$

3. What are the limitations of Bohr's atom model?

- It is applicable only to species having one electron.
- It was unable to explain the splitting of spectral lines in the presence of magnetic field (Zeeman's effect) or an electrical field (Stark effect).
- Bohr's theory was unable to explain why the electron is restricted to revolve around the nucleus in a fixed orbit in which $mvr = \frac{nh}{2\pi}$

4. Derive de Broglie equation (March 19)

Planck's quantum hypothesis:

$$E = h\nu \quad \text{----- (1)}$$

Einstein's mass-energy relationship

$$E = mc^2 \quad \text{----- (2)}$$

$$(1) = (2) \quad h\nu = mc^2 \quad \text{----- (3)}$$

$$\nu = \frac{c}{\lambda} \quad \text{----- (4)}$$

Substitute (4) in (3)

$$\frac{hc}{\lambda} = mc^2$$

$$\lambda = \frac{h}{mc} \quad \text{----- (5)}$$

The above equation represents the wavelength of photons whose momentum is given by mc .

For a particle of matter with mass m and moving with a velocity v , then the equation can be written as

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

5. Protons can be accelerated in particle accelerators. Calculate the wavelength (in \AA) of such accelerated proton moving at $2.85 \times 10^8 \text{ ms}^{-1}$ (mass of proton is $1.673 \times 10^{-27} \text{ kg}$).

Given:- $v = 2.85 \times 10^8 \text{ ms}^{-1}$; $m = 1.673 \times 10^{-27} \text{ kg}$; $h = 6.626 \times 10^{-34}$

$$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34} \text{ kgm}^2\text{s}^{-1}}{1.673 \times 10^{-27} \text{ kg} \times 2.85 \times 10^8 \text{ ms}^{-1}} = 1.389 \times 10^{-15} \text{ m} = 1.389 \times 10^{-5} \text{ \AA}$$

6. What is the de Broglie wavelength (in cm) of a 160 g cricket ball travelling at 140 km hr^{-1}

Given: - $m = 160 \text{ g} = 160 \times 10^{-3} \text{ kg}$

$$v = 140 \text{ km hr}^{-1} = \frac{140 \times 1000}{60 \times 60} \text{ ms}^{-1} = 38.88 \text{ ms}^{-1}$$

$$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34} \text{ kgm}^2\text{s}^{-1}}{160 \times 10^{-3} \text{ kg} \times 38.88 \text{ ms}^{-1}} = 1.065 \times 10^{-34} \text{ m}$$

7. 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 \AA ?

Wave length of photon of green light = 5400 \AA : Mass (m) = 54 g

Planck's constant (h) = $6.626 \times 10^{-34} \text{ Js}$

$$\lambda = \frac{h}{mv} : v = \frac{h}{m\lambda}$$

$$v = \frac{6.626 \times 10^{-34} \text{ Js}}{54 \times 10^{-3} \text{ kg} \times 5400 \times 10^{-10} \text{ m}} = 2.27 \times 10^{-26} \text{ ms}^{-1}$$

8. How 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.

$$\text{Circumference of the orbit } 2\pi r = n\lambda$$

$$2\pi r = \frac{nh}{mv}$$

$$\text{Rearranging, } mvr = \frac{nh}{2\pi}$$

$$\text{Angular momentum} = \frac{nh}{2\pi}$$

9. Explain Davison and Germer experiment.

- i) The wave nature of electron was experimentally confirmed by Davisson and Germer.
- ii) An accelerated beam of electrons is allowed to fall on a nickel crystal and recorded the diffraction pattern.
- iii) The resultant diffraction pattern is similar to the x-ray diffraction pattern.
- iv) The finding of wave nature of electron leads to the development of various experimental techniques such as electron microscope, low energy electron diffraction

10. State Heisenberg's uncertainty principle (sept-20, july-22, mar-23)

'It is impossible to accurately determine both the position and the momentum of a microscopic particle simultaneously'.

$$\Delta x \cdot \Delta p \geq h/4\pi$$

where, Δx and Δp are uncertainties in determining the position and momentum

11. Calculate the uncertainty in velocity of the electron in Hydrogen atom, if $\Delta x = 0.5\%$ and $r = 0.529 \text{ \AA}$

$$\Delta x \cdot \Delta p \geq \frac{h}{4\pi} = \frac{6.626 \times 10^{-34} \text{ kgm}^2\text{s}^{-1}}{4 \times 3.14} = 5.28 \times 10^{-35} \text{ kgm}^2\text{s}^{-1}$$

$$\Delta x \cdot \Delta p \geq 5.28 \times 10^{-35} \text{ kgm}^2\text{s}^{-1}$$

$$\Delta x \cdot (m \Delta v) \geq 5.28 \times 10^{-35} \text{ kgm}^2\text{s}^{-1}$$

Given: $\Delta x = 0.5\%$, $r = 0.529 \times 10^{-10} \text{ m}$, $m = 9.11 \times 10^{-31} \text{ kg}$

$$\Delta x = \frac{0.5}{100} \times 0.529 \times 10^{-10} \text{ m} = 2.645 \times 10^{-13} \text{ ms}^{-1}$$

$$\Delta v \geq \frac{5.28 \times 10^{-35} \text{ kgm}^2\text{s}^{-1}}{9.11 \times 10^{-31} \times 2.645 \times 10^{-13} \text{ ms}^{-1}}$$

$$\Delta v \geq 2.191 \times 10^8 \text{ m}$$

12. Calculate the uncertainty in position of an electron, if $\Delta v = 0.1\%$ and $v = 2.2 \times 10^6 \text{ ms}^{-1}$

$$\Delta x \cdot (m \Delta v) \geq 5.28 \times 10^{-35} \text{ kgm}^2\text{s}^{-1}$$

Given: $\Delta v = 0.1\%$, $v = 2.2 \times 10^6 \text{ ms}^{-1}$, $m = 9.11 \times 10^{-31} \text{ kg}$

$$\Delta v = \frac{0.1}{100} \times 2.2 \times 10^6 \text{ ms}^{-1} = 2.2 \times 10^3 \text{ ms}^{-1}$$

$$\Delta x \geq \frac{5.28 \times 10^{-35} \text{ kgm}^2\text{s}^{-1}}{9.11 \times 10^{-31} \times 2.2 \times 10^3 \text{ ms}^{-1}}$$

$$\Delta x \geq 2.64 \times 10^{-8} \text{ m}$$

13. Calculate the uncertainty in the position of an electron, if the uncertainty in its velocity is $5.7 \times 10^5 \text{ ms}^{-1}$. (june 19)

$$\Delta x \cdot (m \Delta v) \geq 5.28 \times 10^{-35} \text{ kgm}^2\text{s}^{-1}$$

Given: $\Delta v = 5.7 \times 10^5 \text{ ms}^{-1}$, $m = 9.11 \times 10^{-31} \text{ kg}$

$$\Delta x \geq \frac{5.28 \times 10^{-35} \text{ kgm}^2\text{s}^{-1}}{9.11 \times 10^{-31} \times 5.7 \times 10^5 \text{ ms}^{-1}}$$

$$\Delta x \geq 1.017 \times 10^{-10} \text{ m}$$

14. Explain briefly the time independent Schrodinger wave equation?

The time independent Schrodinger equation can be expressed as,

$$\hat{H} \psi = E \psi \text{ ----- (1)}$$

\hat{H} is called Hamiltonian operator

ψ is the wave function

E is the energy of the system

$$\hat{H} = \left[\frac{-\hbar^2}{8\pi^2 m} \left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2} \right) + V \right]$$

Equation (1) can be written as

$$\left[\frac{-\hbar^2}{8\pi^2 m} \left(\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} + \frac{\partial^2 \psi}{\partial z^2} \right) + V\psi \right] = E\psi$$

Multiply by $-\frac{8\pi^2 m}{\hbar^2}$ and rearranging

$$\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} + \frac{\partial^2 \psi}{\partial z^2} + \frac{8\pi^2 m}{\hbar^2} (E - V)\psi = 0$$

The above *Schrodinger wave equation* does not contain time as a variable and is referred to as time independent Schrodinger wave equation.

15. What are the main features of the quantum mechanical model of atom

1. The energy of electrons in atoms is quantised.
2. The existence of quantized electronic energy levels is a direct result of the wave like properties of electrons. The solutions of Schrödinger wave equation gives the allowed energy levels (orbits).
3. According to Heisenberg uncertainty principle, the exact position and momentum of an electron cannot be determined with absolute accuracy. As a consequence, quantum mechanics introduced the concept of orbital. Orbital is a three dimensional space in which the probability of finding the electron is maximum.
4. The solution of Schrodinger 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 $dxdydz$ around a point (x,y,z) is proportional to $|\psi(x,y,z)|^2 dxdydz$ $|\psi(x,y,z)|^2$ is known as probability density and is always positive.

16. Define Quantum number and what are its types?

The electron in an atom can explained by Quantum numbers

Types of quantum numbers

1. Principal quantum number
2. Azimuthal quantum number
3. Magnetic quantum number
4. Spin quantum number

17. Which quantum number reveal information about the shape, energy, orientation and size of orbitals?

Principle quantum number	Energy and Size of the orbit
Azimuthal quantum number	Shape of the orbital
Magnetic quantum number	Orientation of the orbital

17. Write a notes on Principal quantum number (sept-21, march-23)

- i) It represents energy level (orbit) of an electron.
- ii) It is denoted by the symbol 'n' with values 1, 2, 3, 4 and designated as K, L, M, N....
- iii) The maximum number of electrons in a shell can be calculated by the formula $2n^2$.
- iv) The energy of the electron is given by $E_n = \frac{-1312.8 Z^2}{n^2} \text{ kJ mol}^{-1}$
- v) Radius is given by $r_n = \frac{(0.59)n^2}{Z} \text{ \AA}$

18. Write a notes on Azimuthal quantum number

- i) It represents shape of the orbital.
- ii) It is denoted by the symbol 'l' and have values from 0 to (n-1)
- iii) It can have the values 0, 1, 2, 3.... designated as s, p, d, f....
- iv) The maximum number of electrons in an orbital = $2(2l+1)$.
- v) It is used to calculate the orbitals angular momentum by using the expression

$$\text{Angular momentum} = \sqrt{l(l+1)} \frac{h}{2\pi}$$

19. Write a notes on Magnetic quantum number (july-22)

- i) It represents different orientation of orbitals in space
- ii) It is denoted by the symbol 'm' and have values from -l to +l through 0.
- iii) If $l=1$, then $m = -1, 0$ and $+1$
- iv) The Zeeman effect provides experimental justification of this quantum number.

20. Write a notes on Spin quantum number

- i) It represents spin of the electron
- ii) It is denoted by the symbol 's' and have values $+\frac{1}{2}$ and $-\frac{1}{2}$
- iii) The electron in an atom revolves around the nucleus and also spins in a clockwise or in anti-clockwise direction

21. Calculate orbital angular momentum for d and f orbital. (June-19 compulsory)

For d- orbital: Angular momentum = $\sqrt{2(2+1)} \frac{h}{2\pi} = \sqrt{6} \frac{h}{2\pi}$

For f- orbital: Angular momentum = $\sqrt{3(3+1)} \frac{h}{2\pi} = \sqrt{12} \frac{h}{2\pi} = \sqrt{3} \frac{h}{\pi}$

22. Calculate maximum number of electrons in L-shell. (may-22)

Maximum number of electrons in L-shell = $2n^2 = 2(2)^2 = 2 \times 4 = 8$

23. The quantum mechanical treatment of the hydrogen atom gives the energy

value: $E_n = \frac{-13.6}{n^2} \text{ eV atom}^{-1}$

- Use this expression to find ΔE between $n = 3$ and $m = 4$
- Calculate the wavelength corresponding to the above transition.

n	$E_n = \frac{-13.6}{n^2} \text{ eV atom}^{-1}$
3	$E_3 = \frac{-13.6}{3^2} = \frac{-13.6}{9} = -1.51 \text{ eV atom}^{-1}$
4	$E_4 = \frac{-13.6}{4^2} = \frac{-13.6}{16} = -0.85 \text{ eV atom}^{-1}$

$$\Delta E = (E_4 - E_3) = (-0.85) - (-1.51) \text{ eV atom}^{-1}$$

$$= (-0.85 + 1.51) \text{ eV atom}^{-1}$$

$$\Delta E = 0.66 \text{ eV atom}^{-1}$$

$$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$$

$$\Delta E = 0.66 \times 1.6 \times 10^{-19} \text{ J}$$

$$\Delta E = 1.06 \times 10^{-19} \text{ J}$$

$$h\nu = 1.06 \times 10^{-19} \text{ J}$$

$$\frac{-hc}{\lambda} = 1.06 \times 10^{-19} \text{ J}$$

$$\lambda = \frac{hc}{1.06 \times 10^{-19} \text{ J}} = \frac{6.626 \times 10^{-34} \text{ Js} \times 3 \times 10^8 \text{ ms}^{-1}}{1.06 \times 10^{-19} \text{ J}} = 1.875 \times 10^{-6} \text{ m}$$

24. Calculate the energy required for the process.



The ionisation energy for the H atom in its ground state is $-13.6 \text{ eV atom}^{-1}$.

$$E_n = \frac{-13.6 Z^2}{n^2} \text{ eV atom}^{-1}$$

$$E_1 = \frac{-13.6 (2)^2}{(1)^2} = -56.4 \text{ eV atom}^{-1}$$

$$E_\infty = \frac{-13.6 (2)^2}{(\infty)^2} = 0$$

$$\text{Required Energy} = E_\infty - E_1 = 0 - (-56.4) = 56.4 \text{ eV atom}^{-1}$$

25. 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. $r_n = \frac{(0.59)n^2}{Z} \text{ \AA}$

$$E_n = \frac{-13.6 Z^2}{n^2} \text{ eV atom}^{-1}$$

(Li^{2+} ion, $Z = 3$)

Bohr radius of the third orbit $r_3 = \frac{(0.59)(3)^2}{3} \text{ \AA} = 0.59 \times 3 = 1.587 \text{ \AA}$

Energy of an electron in 4th orbit $E_4 = \frac{-13.6 (3)^2}{(4)^2} \text{ eV atom}^{-1}$
 $= -7.65 \text{ eV atom}^{-1}$

26. Energy of an electron in hydrogen atom in ground state is -13.6 eV. What is the energy of the electron in the second excited state?

$$E_n = \frac{-13.6}{n^2} \text{ eV atom}^{-1}$$

Second excited state

$$E_3 = \frac{-13.6}{3^2} = \frac{-13.6}{9} = -1.51 \text{ eV atom}^{-1}$$

27. Explain the meaning of the symbol $4f^2$. Write all the four quantum numbers for these electrons.

$$n = 4 \text{ (f-orbital)}$$

$$l = 3$$

$$m_l = -3, -2$$

Electron	n	l	m_l	m_s
$1e^-$	4	3	-3	+1/2
$2e^-$	4	3	-2	+1/2

28. Define orbital? What are the n and l values for $3p_x$ and $4dx^2-y^2$ electron?

(June 19)

Orbital is a three dimensional space in which the probability of finding the electron is maximum.

Orbital	n	l
$3p_x$	3	-1
$4dx^2-y^2$	4	-2

29. 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) $n = 7, l = 0$

n	Sub level designation	Allowable m values	Number of orbitals
4	4d	+2, +1, 0, -1, -2	Five 4d orbitals
5	5f	+3, +2, +1, 0, -1, -2, -3	Seven 5f Orbitals
7	7s	0	One 7s orbital

30. How many orbitals are possible for 4th energy level? (n =4) (May-22)

n	l	m	Name of the orbitals	No: of orbitals
4	0	0	4s	1
	1	-1, 0, +1	4p	3
	2	-2, -1, 0, +1, +2	4d	5
	3	-3, -2, -1, 0, +1, +2, +3	4f	7
Total number of orbitals are possible				16

31. How many radial nodes for 2s, 4p, 5d and 4f orbitals exhibit?

How many angular nodes? (Sept -20)

Orbital	n	l	Radial nodes (n - l - 1)	Angular nodes (l)
2s	2	0	1	0
4p	4	1	2	1
5d	5	2	2	2
4f	4	3	0	3

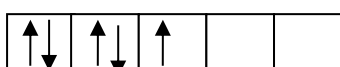
32. The stabilisation of a half-filled d - orbital is more pronounced than that of the p-orbital why?

In d- orbital **10 exchanges** are possible but in p-orbital **3 exchanges** are possible
Greater the number exchanges, greater the stability.

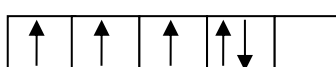
33. Consider the following electronic arrangements for the d⁵ configuration.

(i) Which of these represents the ground state?

(ii) Which configuration has the maximum exchange energy?



(a)



(b)



(c)

(i) (c) (ii) (c)

34.State and explain Pauli's exclusion principle.(march 19, march-23)

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

Eg. For the electron in Helium [He]²

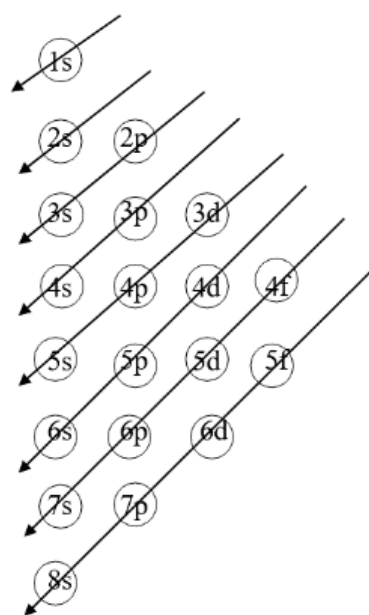
Quantum number	I st electron	II nd electron
n	1	1
l	0	0
m	0	0
s	+1/2	-1/2

35.State Hund's rule of maximum multiplicity

It states that electron pairing in the degenerate orbitals does not take place until all the available orbitals contain one electron each.

36.Describe the Aufbau principle (sept-21)

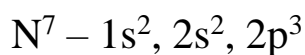
In the ground state of the atoms, the orbitals are filled in the order of their increasing energies which is in accordance with (n+l) rule.



37.Give the electronic configuration of Mn²⁺ and Cr³⁺. (july-22)

Mn ²⁵	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ⁵ 4s ²
Mn ²⁺	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ⁵
Cr ²⁴	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ⁴ 4s ²
Cr ³⁺	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ³

38. Write the electronic configuration and orbital diagram of Nitrogen. (May-22)

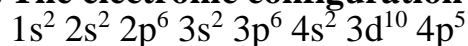


39. An atom of an element contains 35 electrons and 45 neutrons. Deduce

i) The number of protons

The number of protons = Number of electrons = 35

ii) The electronic configuration for the element



iii) All the four quantum numbers for the last electron

Last electron present in 4p_y orbital

n	l	m _l	m _s
4	1	0	1/2

40. 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.

Numbers	Atom	Uni-negative ion
Number of electron	x - 1	x
Number of protons	x - 1	x - 1
Number of neutrons	y	y

Given that $y = x + 11.1\%$ of x

$$y = x + \frac{11.1}{100}x = \frac{111.1}{100}x$$

$$y = 1.11x$$

$$\text{Mass number} = 37$$

Mass number = number of protons + number of neutrons

$$= (x - 1) + 1.11x = 37$$

$$= x + 1.11x = 38$$

$$= 2.11x = 38$$

$$x = \frac{38}{2.11} = 18$$

Number of electron (or) number of protons = $(x - 1) = 18 - 1 = 17$

Symbol of the ion is ${}_{17}^{37}\text{Cl}^-$

41. Which has stable electronic configuration? Ni^{2+} or Fe^{3+}

Ni^{28}	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$
Ni^{2+}	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^8$

Fe ²⁶	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ⁶ 4s ²
Fe ³⁺	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ⁵

If d – orbital is *half filled*, then the ion is more stable. Fe³⁺ is more stable.
So is more stable Fe³⁺ than Ni²⁺

42. What is meant by nodal surface?

The region where the probability density function reduces to zero is called nodal surface or a radial node

For ns orbital, (n-1) nodes are found in it.

43. What are degenerate orbitals?

Three different orientations in space that are possible for a p-orbital. All the three p - orbitals namely p_x, p_y and p_z have same energies and are called degenerate orbitals. In the presence of magnetic or electric field the degeneracy is lost.

44. How many unpaired electrons are present in the ground state of Cr³⁺ (Z = 24) and Ne (Z=10)

Cr ³⁺	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ³	3
Ne ¹⁰	1s ² 2s ² 2p ⁶	nil

45. Which is the actual electronic configuration of Cr (Z=24) why?

Expected electronic configuration	Cr ²⁴	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ⁴ 4s ²
Actual electronic configuration	Cr ²⁴	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ⁵ 4s ¹

Cr with 3d⁵ is *half filled* and it will be *more stable*

46. Which is the actual electronic configuration of Cu (Z=29) why?

Expected electronic configuration	Cu ²⁹	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ⁹ 4s ²
Actual electronic configuration	Cu ²⁹	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ¹⁰ 4s ¹

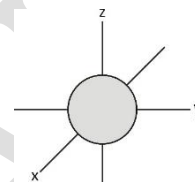
Cu with 3d¹⁰ is *completely filled* and it will be *more stable*

47. How many unpaired electrons are present in the ground state of Fe³⁺ (Z = 26), Mn²⁺ (Z = 25) and Ar (Z = 18)

Fe ³⁺	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ⁵	5
Mn ²⁺	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ⁵	5
Ar	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶	nil

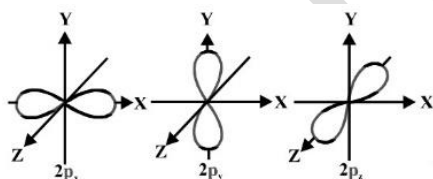
48. Sketch and explain the shapes of s-orbital.

- For s-orbital $l = 0$ and hence, m can have only one value, i.e., $m = 0$.
- The shape of the s orbital is *spherically symmetrical*.
- This means that the probability of finding the electron in s-orbital is the same in all directions at a particular distance.



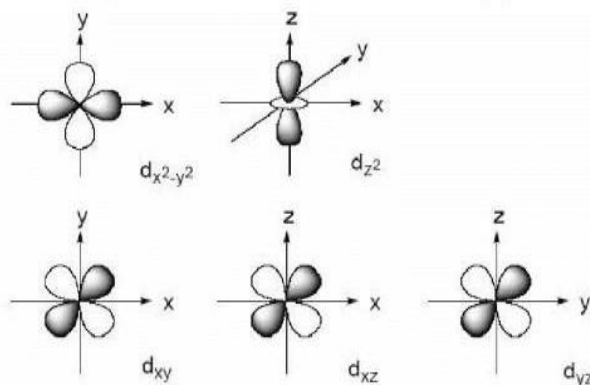
49. Sketch and explain the shapes of p-orbitals.

- For p-orbitals, $l = 1$ and the corresponding m values are $-1, 0$ & $+1$.
- The shape of the p orbital is dumb-bell
- The three different ' m ' values indicates that there are three different possible orientations as p_x, p_y and p_z and the angular distribution along the x, y and z axis respectively.



50. Sketch and explain the shapes of d-orbitals.

- For d-orbitals, $l = 2$ and the corresponding m values are $-2, -1, 0, +1, +2$.
- The shape of the d orbital looks like a 'clover leaf'.
- The five m values give rise to five d orbitals namely $d_{xy}, d_{yz}, d_{zx}, d_{x^2-y^2}$ and d_{z^2} .



51. In degenerate orbitals, why do half-filled and completely filled configuration are more stable than partially filled configuration? (Sept 20-compulsory)

i) Symmetrical distribution of electrons in the orbital

The shielding of one electron by the other is relatively small and hence the electrons are attracted more strongly by the nucleus and it increases the stability

ii) Exchange energy

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.

52. Explain exchange energy with an example (sept-21)

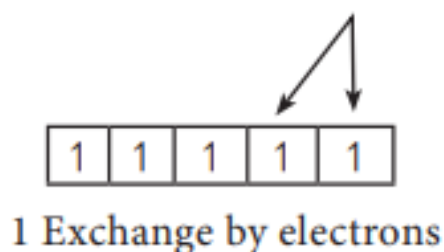
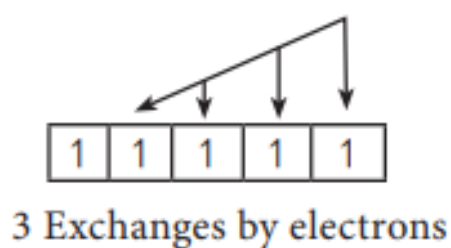
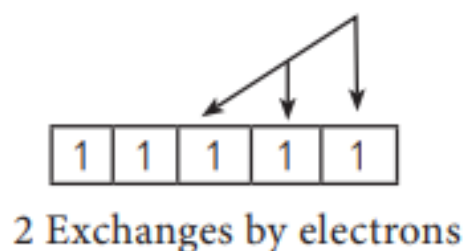
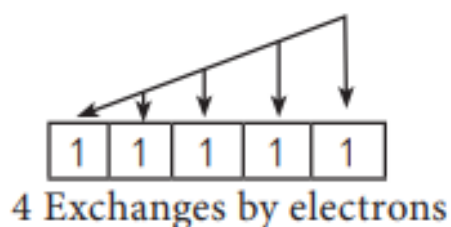
If two or more electrons with the same spin are present in degenerate orbitals, there is a possibility for exchanging their positions.

During exchange process the energy is released and the released energy is called exchange energy.

If more number of exchanges are possible, more exchange energy is released.

More number of exchanges are possible only in case of half-filled and fully filled configurations.

For example, in chromium the electronic configuration is $[\text{Ar}] 3d^5 4s^1$. The 3d orbital is half filled and there are ten possible exchange.



Overall electron exchanges
(4+3+2+1 = 10)

53. What is the de Broglie wave length of an electron, which is accelerated from the rest, through a potential difference of 1ke V?

Given:

Potential difference = 1keV = 1000 x 1.6 x 10⁻¹⁹ J (1eV = 1.6 x 10⁻¹⁹ J)

$$\frac{1}{2}mv^2 = eV$$

$$m(mv^2) = 2meV$$

$$(mv)^2 = 2meV$$

$$mv = \sqrt{2meV}$$

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

$$\lambda = \frac{h}{\sqrt{2meV}}$$

$$\lambda = \frac{6.626 \times 10^{-34} \text{ kgm}^2 \text{ s}^{-1}}{\sqrt{2 \times 9.11 \times 10^{-31} \text{ kg} \times 1000 \times 1.6 \times 10^{-19} \text{ J}}}$$

$$\lambda = 3.8 \times 10^{-11} \text{ m}$$

54. What is the de Broglie wave length of an electron, which is accelerated from the rest, through a potential difference of 100 V?

Given:

Potential difference = 100 V = 100 x 1.6 x 10⁻¹⁹ J

$$\lambda = \frac{h}{\sqrt{2meV}}$$

$$\lambda = \frac{6.626 \times 10^{-34} \text{ kgm}^2 \text{ s}^{-1}}{\sqrt{2 \times 9.11 \times 10^{-31} \text{ kg} \times 100 \times 1.6 \times 10^{-19} \text{ J}}}$$

$$\lambda = 1.2 \times 10^{-10} \text{ m}$$

55. Identify the missing quantum numbers and the sub energy level

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	5	-1 or 0 or +1	5p
3	2	-2	3d

56. Show that if the measurement of the uncertainty in the location of the particle is equal to its de Broglie wavelength, the minimum uncertainty in its velocity is equal to its velocity / 4π .

Given:

$$\Delta x = \lambda$$

$$\Delta V = ?$$

Solution:

$$\Delta x \cdot \Delta p = \frac{h}{4\pi}$$

$$\Delta x \cdot m \Delta v = \frac{h}{4\pi}$$

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

$$= \frac{h}{4\pi m \lambda} \quad (\text{since } \Delta x = \lambda)$$

$$= \frac{h}{4\pi m \frac{h}{mv}}$$

$$= \frac{v}{4\pi}$$

$$\Delta v = \frac{v}{4\pi}$$

Hence proved.

3 .PERIODIC CLASSIFICATION OF ELEMENTS

1. Define Dobereiner Triads (March-19)

The atomic weight of the middle element nearly equal to the mean of the atomic weight of the remaining two elements.

Elements in the triad	Atomic weight of the middle element	Average atomic weight of middle element
Li, Na, K	23	$\frac{7 + 39}{2} = 23$

2. Define Law of Octaves

On arranging the elements in the increasing order of atomic weights, the property of every *eighth elements is similar to the property of the first element.*

3. Define Mendeleev's Periodic law

The physical and chemical properties of the elements are the periodic functions of the *atomic weights.*

4. Define Modern Periodic law (March-23)

The physical and chemical properties of the elements are the periodic functions of the *atomic numbers.*

5. What are the basic difference between Mendeleev's and Modern periodic table

Sl.No	Mendeleev's periodic table	Modern periodic table
1	The properties of the elements are the periodic functions of the atomic weights.	The Physical and chemical properties of the elements are the periodic functions of the atomic numbers.
2	There 8 groups and 12 periods	There 18 groups and 7 periods
3	Contains vacant place for new Elements.	No vacant place
4	Elements of same group contains different properties	Elements of same group contains identical properties
5	Isotopes are not explained	Isotopes are explained.

6. Give the Anomalies of Mendeleev's Periodic table

- Elements with same properties are placed in different groups
- Elements with different properties are placed in same groups
- Elements with higher atomic weights are placed before the lower atomic weights.

7. Explain the Henry Moseley X-ray spectra experiment

- Hendry Moseley studied the X-ray spectra of many elements by bombarding them with high energy electrons.
- He observed a linear correlation between the atomic number and the frequency of the X-ray emitted.

8. Explain the different types of elements in the Periodic table.

There are 4 types of elements

a) s-block elements

- The elements of **group 1 and group 2** are called as s-block elements
- Their general electron configuration is ns^{1-2}
- Group 1 elements are called as Alkali metals & group 2 are called as Alkaline earth metals
- They are soft metals with low boiling and melting point
- They are highly electropositive in nature and form ionic compounds.
- They are highly reactive and most of the elements imparts colour to the flame

b) p-block elements

- The elements of **group 13 to 18** are called p-block elements or representative elements.
- Their general electron configuration is ns^2np^{1-6}
- Group 16 elements are called as Chalcogens, Group 17 elements are as Halogens and Group 18 elements are called as Noble gases or inert gases.
- They have high negative electron gain enthalpies and form covalent compounds
- They have high ionization energy values and show variable oxidation states

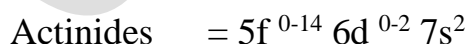
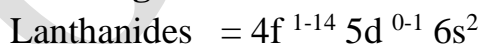
c) d-block elements

- The elements of **group 3 to 12** are called d-block elements or transition elements.
- Their general electron configuration is $ns^2 (n-1)d^{1-10}$
- They have high boiling and melting points
- They form ionic, covalent and co-ordination compounds.
- They can form interstitial compounds and alloys which can also act as catalysts.
- They are good conductor of heat and electricity
- They show variable oxidation states

d) f-Block elements (July-22)

- There are **2 series** of f-block elements, Lanthanides = $4f^{1-14} 5d^{0-1} 6s^2$ and Actinides = $5f^{0-14} 6d^{0-2} 7s^2$
- They are metallic in nature and have high melting points
- Most of the compounds are coloured
- They show variable oxidation states

9. Write the general electronic configuration of Lanthanides and actinides (June-19)



10. Predict the position of the element in periodic table satisfying the electronic configuration $(n-1)d^2, ns^2$ where $n=5$

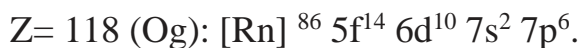
For $n=5$, the electronic configuration is $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 4d^2 5s^2$

Atomic number = 40 (group-4 and period – 5 transition element)

The element is Zirconium (Zr)

11. In what period and group will an element with Z = 118 will be present?

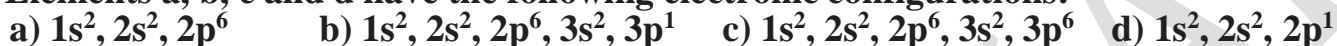
Element with Z= 118 will occupy in period number 7 and Group number 18 (Noble gas).



12. Justify that the fifth period of the periodic table should have 18 elements on the basis of quantum numbers.

According to Aufbau principle, 5th period elements filled in the orbitals like s, d, p ($5s^2, 4d^{10}, 6p^6$), totally 18 electron accommodate in these orbitals. Hence 5th period contains 18 elements.

13. Elements a, b, c and d have the following electronic configurations:



Which elements among these will belong to the same group of periodic table?

Elements with equal electron in outermost shell belongs to same group.

Hence a & c belongs to same group. And b & d belongs to same group.

14. How elements with atomic number greater than 100 are named?

i) The name was derived directly from the atomic number of the new element using the following numerical roots

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

ii) The numerical roots corresponding to the atomic number are put together and 'ium' is added as suffix

iii) 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 written before 'ium' (bi + ium = bium; tri + ium = trium)

iv) The symbol of the new element is derived from the first letter of the numerical roots.

15. The element with atomic number 120 has not been discovered so far. What would be the IUPAC name and the symbol for this element? Predict the possible electronic configuration of this element

IUPAC name	Unbinilium
Symbol	Ubn
Electronic configuration	[Og] $8s^2$

16. Define atomic radius and explain the variation in the periodic table (Sept-21)

The distance between the center of the nucleus and the valence shell called as atomic radius.

Along the Group: It increases down the group.

Reason

- As we move down the group the valence electrons are added into new shells.
- As a result the distance between the nucleus and the valence electrons increases. So, radius increases.

Along the Period: It decrease along the period.

Reason

- As we move along the period the valence electrons are added to the same shell and the nuclear charge increases.
- The attractive force between the valence electron and the nucleus increases. So, radius decreases.

17. Define covalent radius

The half of the *inter nuclear distance between two identical atoms* linked by a single covalent bond is called as covalent radius

18. Why the covalent radius is less than atomic radius.

During the formation of the covalent bond there is a overlapping of atomic orbitals so the inter nuclear distance decreases. So covalent radius also decreases

19. Calculate covalent radius of chlorine. The internuclear distance in chlorine molecule is 1.98\AA

$$r_{\text{Cl}} = \frac{d_{\text{Cl-Cl}}}{2} = \frac{1.98}{2} = 0.99 \text{\AA}$$

20. How covalent radius of an atom is calculated in heteronuclear diatomic molecule by Schomaker and Stevenson?

The covalent radius of individual atom can also be calculated as follow.

$$d_{\text{A-B}} = r_{\text{A}} + r_{\text{B}} - 0.09 (\chi_{\text{A}} - \chi_{\text{B}})$$

χ_{A} and χ_{B} - electronegativities of A and B respectively in Pauling units ($\chi_{\text{A}} > \chi_{\text{B}}$)

r_{A} and r_{B} - radius in \AA .

21. Calculate the covalent radius of hydrogen using the experimental $d_{\text{H-Cl}}$ value is 1.28\AA and the covalent radius of chlorine is 0.99\AA . In Pauling scale, the electronegativity of chlorine and hydrogen are 3 and 2.1 respectively.

$$d_{\text{H-Cl}} = r_{\text{H}} + r_{\text{Cl}} - 0.09 (\chi_{\text{H}} - \chi_{\text{Cl}})$$

$$1.28 = r_{\text{H}} + 0.99 - 0.09 (3 - 2.1)$$

$$1.28 = r_{\text{H}} + 0.99 - 0.09 (0.9)$$

$$1.28 = r_{\text{H}} + 0.99 - 0.081$$

$$1.28 = r_{\text{H}} + 0.909$$

$$\therefore r_{\text{H}} = 1.28 - 0.909 = 0.371 \text{\AA}$$

22. Define metallic radius

The half of the distance between two adjacent metal atoms in a closely packed metallic crystal is called as metallic radius

23. Calculate the metallic radius of copper. The distance between the adjacent copper atoms in solid copper is 2.56\AA .

$$\text{Metallic radius of copper} = \frac{2.56}{2} = 1.28 \text{\AA}$$

24. Define Shielding effect

The *inner shell electrons act as a shield between the nucleus* and the valence electrons, this effect is called as Shielding effect.

25. What is effective nuclear charge?

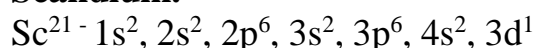
The net nuclear charge experienced by valence electrons in the outermost shell is called the effective nuclear charge.

$$Z_{\text{eff}} = Z - S$$

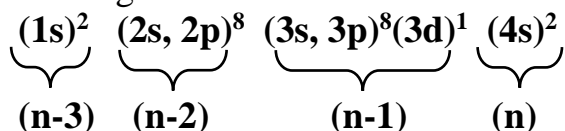
Z - Atomic number

'S' - Screening constant which can be calculated using Slater's rules.

26. Calculate the effective nuclear charge on 4s electron and 3d electron in Scandium.



We can rearrange as below.

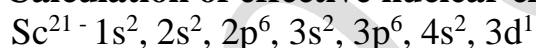


Group	No: of electron in the group	Contribution of each electron to 'S' value	Contribution of particular group to electrons to 'S' value
n	1	0.35	0.35
n-1	9	0.85	7.65
n-2 & others	10	1	10.00
S value			18.00

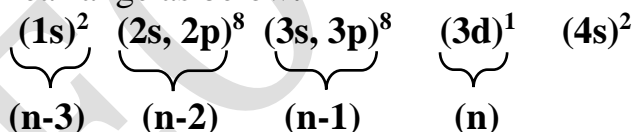
$$(Z_{\text{eff}})_{\text{Sc}} = Z - S = 21 - 18$$

$$\therefore (Z_{\text{eff}})_{\text{Sc}} = 3$$

27. Calculation of effective nuclear charge on 3d electron in Scandium



We can rearrange as below.

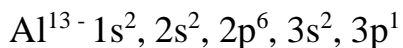


Group	No: of electron in the group	Contribution of each electron to 'S' value	Contribution of particular group to electrons to 'S' value
n	0	0.35	0
n-1 & others	18	1	18
S value			18.00

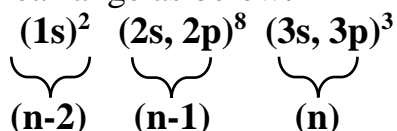
$$(Z_{\text{eff}})_{\text{Sc}} = Z - S = 21 - 18$$

$$\therefore (Z_{\text{eff}})_{\text{Sc}} = 3$$

28. 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.



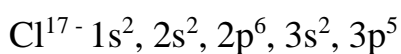
We can rearrange as below.



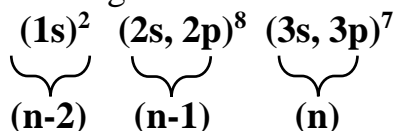
Group	No: of electron in the group	Contribution of each electron to 'S' value	Contribution of particular group to electrons to 'S' value
n	2	0.35	0.7
n-1	8	0.85	6.8
n-2 & others	2	1	2.0
S value			9.5

$$(Z_{\text{eff}})_{\text{Al}} = Z - S = 13 - 9.5$$

$$\therefore (Z_{\text{eff}})_{\text{Al}} = 3.5$$



We can rearrange as below.



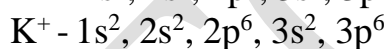
Group	No: of electron in the group	Contribution of each electron to 'S' value	Contribution of particular group to electrons to 'S' value
n	6	0.35	2.1
n-1	8	0.85	6.8
n-2 & others	2	1	2.0
S value			10.9

$$(Z_{\text{eff}})_{\text{Cl}} = Z - S = 17 - 10.9$$

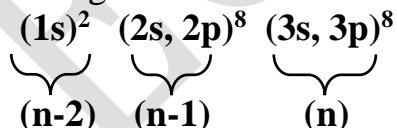
$$\therefore (Z_{\text{eff}})_{\text{Cl}} = 6.1$$

$$(Z_{\text{eff}})_{\text{Cl}} > (Z_{\text{eff}})_{\text{Al}}. \text{ Hence } r_{\text{Cl}} < r_{\text{Al}}$$

29. Calculate the effective nuclear charge for K^+ and Cl^-



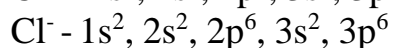
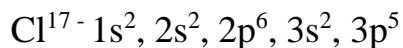
We can rearrange as below.



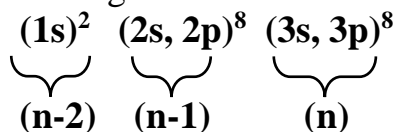
Group	No: of electron in the group	Contribution of each electron to 'S' value	Contribution of particular group to electrons to 'S' value
n	7	0.35	2.45
n-1	8	0.85	6.8
n-2 & others	2	1	2.0
S value			11.25

$$(Z_{\text{eff}})_{\text{K}^+} = Z - S = 19 - 11.25$$

$$\therefore (Z_{\text{eff}})_{\text{K}^+} = 7.75$$



We can rearrange as below.

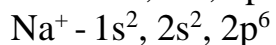
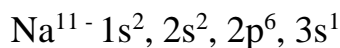


Group	No: of electron in the group	Contribution of each electron to 'S' value	Contribution of particular group to electrons to 'S' value
n	7	0.35	2.45
n-1	8	0.85	6.8
n-2 & others	2	1	2.0
S value			11.25

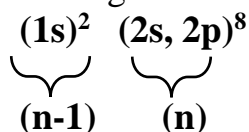
$$(Z_{\text{eff}})_{\text{Cl}^-} = Z - S = 17 - 11.25$$

$$\therefore (Z_{\text{eff}})_{\text{Cl}^-} = 5.75$$

30. Calculate the effective nuclear charge for Na^+ and F^-



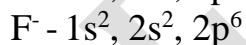
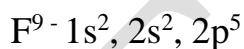
We can rearrange as below.



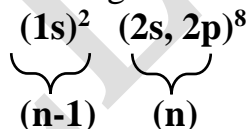
Group	No: of electron in the group	Contribution of each electron to 'S' value	Contribution of particular group to electrons to 'S' value
n	7	0.35	2.45
n-1	2	0.85	1.7
S value			4.15

$$(Z_{\text{eff}})_{\text{Na}^+} = Z - S = 11 - 4.15$$

$$\therefore (Z_{\text{eff}})_{\text{Na}^+} = 6.85$$



We can rearrange as below.



Group	No: of electron in the group	Contribution of each electron to 'S' value	Contribution of particular group to electrons to 'S' value
n	7	0.35	2.45
n-1	2	0.85	1.7
S value			4.15

$$(Z_{\text{eff}})_{\text{F}^-} = Z - S = 9 - 4.15$$

$$\therefore (Z_{\text{eff}})_{\text{F}^-} = 4.85$$

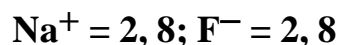
31. Define ionic radius

The distance between the center of the nucleus of an ion and the valence shell called as ionic radius.

32. What are isoelectronic ions? Give examples.

Ions having same number of electrons and same electronic configuration are called as isoelectronic ions

Example for Isoelectronic:



33. Define ionic radius and explain the variation in the periodic table

The distance between the center of the nucleus of an ion and the valence shell called as ionic radius.

Down the Group: It increases down the group.

Reason

- As we move down the group the valence electrons are added into new shells.
- As a result the distance between the nucleus and the valence electrons increases. So, radius increases.

Along the Period: It decrease along the period.

Reason

- As we move along the period the valence electrons are added to the same shell and the nuclear charge increases.
- The attractive force between the valence electron and the nucleus increases. So, radius decreases.

34. Explain the Pauling method of calculating ionic radius (Sept-20, May-22)

- Ionic radius is calculated from the inter ionic distance between the nuclei of the cation and anion.

$$d = r_{C^+} + r_{A^-} \text{-----(1)}$$

d - distance between the centre of the nucleus of cation C^+ and anion A^-

r_{C^+}, r_{A^-} - the radius of the cation and anion

- The radius of the ion having noble gas electronic configuration is inversely proportional to the effective nuclear charge.

$$r_{C^+} \propto \frac{1}{(Z_{eff})_{C^+}} \text{-----(2)}$$

$$r_{A^-} \propto \frac{1}{(Z_{eff})_{A^-}} \text{-----(3)}$$

Z_{eff} - effective nuclear charge.

$$Z_{eff} = Z - S$$

Dividing equation (2) and (3)

$$\frac{r_{C^+}}{r_{A^-}} = \frac{(Z_{eff})_{A^-}}{(Z_{eff})_{C^+}} \text{-----(4)}$$

Using Equation (1) and (4) ionic radius can be calculated.

35. Calculate the ionic radii of Na^+ and F^- in NaF crystal whose interionic distance is equal to 231 pm

$$d = r_{\text{Na}^+} + r_{\text{F}^-} = 231 \text{ pm} \text{ -----(1)}$$

$$\frac{r_{\text{Na}^+}}{r_{\text{F}^-}} = \frac{(Z_{\text{eff}})_{\text{F}^-}}{(Z_{\text{eff}})_{\text{Na}^+}} = \frac{4.85}{6.85} = 0.71$$

$$r_{\text{Na}^+} = 0.71 r_{\text{F}^-} \text{ -----(2)}$$

Substitute (2) in (1)

$$0.71 r_{\text{F}^-} + r_{\text{F}^-} = 1.71 r_{\text{F}^-} = 231$$

$$r_{\text{F}^-} = \frac{231}{1.71} = 135.1 \text{ pm} \text{ -----(3)}$$

Substitute (3) in (2)

$$r_{\text{Na}^+} = 0.71 \times 135.1 = 95.9 \text{ pm}$$

36. Calculate the ionic radii of K^+ and Cl^- in KCl crystal whose interionic distance is equal to 3.14 \AA

$$d = r_{\text{K}^+} + r_{\text{Cl}^-} = 3.14 \text{ \AA} \text{ -----(1)}$$

$$\frac{r_{\text{K}^+}}{r_{\text{Cl}^-}} = \frac{(Z_{\text{eff}})_{\text{Cl}^-}}{(Z_{\text{eff}})_{\text{K}^+}} = \frac{5.75}{7.75} = 0.74$$

$$r_{\text{K}^+} = 0.74 r_{\text{Cl}^-} \text{ -----(2)}$$

Substitute (2) in (1)

$$0.74 r_{\text{Cl}^-} + r_{\text{Cl}^-} = 1.74 r_{\text{Cl}^-} = 3.14$$

$$r_{\text{Cl}^-} = \frac{3.14}{1.74} = 1.81 \text{ \AA} \text{ -----(3)}$$

Substitute (3) in (2)

$$r_{\text{K}^+} = 0.74 \times 1.81 = 1.33 \text{ \AA}$$

37. A student reported the ionic radii of isoelectronic species X^{3+} , Y^{2+} and Z^- as 136 pm, 64 pm and 49 pm respectively. Is that order correct? Comment.

- Anion is larger than cation
- When the charge of the cation increases, ionic radii decreases.
- When the charge of the anion increases, ionic radii increases

So, the anionic radii Z^- will be greater than the cationic radii X^{3+} and Y^{2+} . Y^{2+} will have more ionic radii than X^{3+} .

Hence the correct order of ionic radii is $\text{Z}^- > \text{Y}^{2+} > \text{X}^{3+}$

38. Define ionization energy and explain the variation in the periodic table.

Ionization energy is the amount of energy required to remove a loosely bounded electron from the outermost shell of an atom. Its unit is eV

Down the Group: It decreases down the group.

Reason

- As we move down the group the valence electrons are added into new shells.
- As a result the distance between the nucleus and the valence electrons increases.
- Hence the nuclear charge decreases, easy to remove electron and the ionization energy also decreases.

Along the period: It increases along the period

Reason

- As we move along the period the valence electrons are added to the same shell.
- So the nuclear charge increases and the attraction between the valence electron and the nucleus increases
- Hence more energy is required to remove the valence electron, so ionization energy increases.

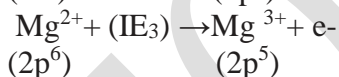
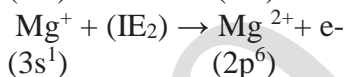
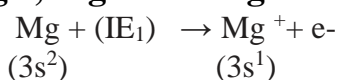
39. Define second ionization energy

Second ionization energy is the amount of energy required to remove an electron from a uni positive cation.

40. Why the second ionization energy is always greater than the first ionization energy

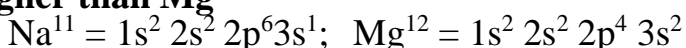
- The total number of electrons is less in a cation than a neutral atom
- So the effective nuclear charge of the cation is greater than the atom
- The order is $IE_1 < IE_2 < IE_3 < \dots$

41. Mg^{+1} , Mg^{+2} and Mg^{+3} which step required more energy?



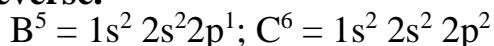
- The formation of the Mg^{+3} ion from Mg^{+2} ion requires more ionization energy because Mg^{+2} has stable noble gas configurations of 2, 8 electrons
- Since the valence orbital is completely filled it requires more energy to remove an electron.
- Mg^{+2} ion has more effective nuclear charge.

42. Why the first IE value of sodium is lower than Mg. but the second IE value is higher than Mg



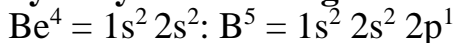
- First IE value of Mg is larger because Mg is smaller in size and has high nuclear charge. So more energy is required to remove an electron from Magnesium than sodium
- But in second IE value is larger for Sodium because Sodium has full filled stable $ns^2 np^6$ electronic configuration with high nuclear charge.

43. Why the first IE value of Carbon greater than Boron. But the second IE value is reverse.



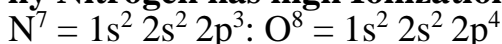
- First IE value of Carbon is larger because Carbon is smaller in size and has high nuclear charge. So more energy is required to remove an electron from Carbon than Boron
- But in second IE value is larger for Boron because Boron has full filled stable ns^2 electronic configuration with high nuclear charge.

44. Why Beryllium has high Ionisation energy than Boron? (July-22)



- Beryllium has high Nuclear Charge
- Beryllium has stable **Fully filled** ns^2 electronic configuration
- The force of attraction between the nucleus and the outermost electron is very high in Beryllium
- So it is difficult to remove 2s electrons of Beryllium

45. Why Nitrogen has high Ionization energy than oxygen? (June-19)



- Nitrogen has high Nuclear Charge
- Nitrogen has Stable **Half filled** np^3 electronic configuration
- The force of attraction between the nucleus and the outer most electron is very high in Nitrogen
- So it is difficult to remove the 2p electrons of Nitrogen

46. Energy of an electron in the ground state of the hydrogen atom is $-2.18 \times 10^{-18} \text{ J}$. Calculate the ionisation enthalpy of atomic hydrogen in terms of kJ mol^{-1} .

Energy of electron in the ground state = $-2.18 \times 10^{-18} \text{ J}$

Energy of electron at infinity = 0

Energy required to remove an electron = $0 - (-2.18 \times 10^{-18} \text{ J}) = 2.18 \times 10^{-18} \text{ J}$

Energy required to remove one mole of electron = $2.18 \times 10^{-18} \text{ J} \times 6.023 \times 10^{23}$
 $= 13.13 \times 10^5 \text{ J mol}^{-1} = 1313 \text{ kJ mol}^{-1}$

Ionisation enthalpy of atomic hydrogen = $13.13 \times 10^5 \text{ J mol}^{-1}$

47. The first ionisation energy (IE_1) and second ionisation energy (IE_2) of elements X, Y and Z are given below.

Element	IE_1 (kJ mol^{-1})	IE_2 (kJ mol^{-1})
X	2370	5250
Y	522	7298
Z	1680	3381

Which one of the above elements is the most reactive metal, the least reactive metal and a noble gas?

For element X, the IE_1 , value is in the range of noble gas, more over for this element both IE_1 and IE_2 are higher and hence X is the noble gas.

For Y, the first ionisation energy is low and second ionisation energy is very high and hence Y is most reactive metal.

For Z, both IE_1 and IE_2 are higher and hence it is least reactive.

48. Define electron affinity and explain the variation in the periodic table. (May-22)

Electron affinity is defined as the amount of energy released when an electron is added to the valence shell of an atom.

Down the Group: It decreases down the group.

Reason

- As we move down the group the nuclear charge decreases
- The atomic size increases.
- The shielding effect of the inner electrons increase and difficult to add an electron

Along the period: It increases along the period

Reason

- As we move along the period the nuclear charge increases
- The atomic size decreases.
- The attraction between the valence electron and the nucleus increases and easy to add an electron

49. Why Beryllium has Zero electron affinity? (Sept-20)

- $Be^4 = 1s^2 2s^2$
- Beryllium has stable fully filled ns^2 electronic configuration
- If an electron is added it will disturb the stable electronic configuration. So it will not accept electrons

50. Why Nitrogen has Zero electron affinity? (Sept-20)

- $N^7 = 1s^2 2s^2 2p^3$
- Nitrogen has Stable Half-filled np^3 electronic configuration
- If an electron is added it will disturb the stable electronic configuration. So it will not accept electrons

51. Why Noble gases (Neon) has Zero electron affinity?

- $Ne^{10} = 1s^2 2s^2 2p^6$
- Neon has stable Fully filled $ns^2 np^6$ electronic configuration
- If an electron is added it will disturb the stable electronic configuration. And it requires more energy. So it will not accept electrons

52. Why the 17th group (Halogens) have high electron affinity?

- Halogens have an unstable $ns^2 np^5$ electronic configuration.
- By gaining one electron it becomes a stable Fully filled $ns^2 np^6$ electronic configuration
- Hence it accepts one electron and become a stable Noble gas configuration

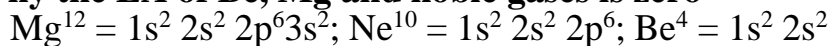
53. Why the electron affinity of Oxygen and Fluorine is lower than sulphur and chlorine

- Oxygen and Fluorine is smaller in size.
- Oxygen and Fluorine have high electron density.
- In oxygen and Fluorine the valence electrons enter into the 2p orbital.
- But in Sulphur and Chlorine the valence electrons enter into the 3p orbital.

54. Why halogens act as oxidizing agents?

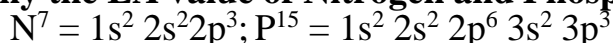
- Halogens have high electron negativity and electron affinity values.
- Halogens have an unstable $ns^2 np^5$ electronic configuration.
- By gaining one electron it becomes a Stable fully filled $ns^2 np^6$ electronic configuration
- Hence it accepts one electron and become a stable Noble gas configuration

55. Why the EA of Be, Mg and noble gases is zero



Be, Mg and Noble gases are having fully filled stable electronic configuration. These elements will not accept electrons

56. Why the EA value of Nitrogen and Phosphorous is very low?



Nitrogen and Phosphorous has *Stable Half filled* np^3 electronic configuration

If an electron is added it will disturb the stable electronic configuration. So it will not accept electrons

57. Define electron negativity & explain the variation in the periodic table. (Sep-21, Ju-22)

Electro negativity is a tendency of an element present in covalent molecule to attract the shared pair of electrons towards itself.

Group: It decreases down the group.

- As we move down the group the nuclear charge decreases
- The atomic size increases.
- The shielding effect of the inner electrons increase and difficult to attract electron pair

Period: It increases along the period

Reason:

- As we move along the period the nuclear charge increases
- The atomic size decreases.
- The attraction between the valence electron and the nucleus increases and difficult to attract electron pair

58. Explain the Pauling's method of calculating the Electro negativity.

According to Pauling, the EN value of Hydrogen is 2.1 and for Fluorine is 4.0.

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 energy of AB, A_2 and B_2 molecules.

59. How will you determine the ionic character in covalent bond using electronegativity values? (May22)

Pauling estimated the percentage of ionic character in various $A^{\delta-} - B^{\delta+}$ polar covalent bonds from known $(X_A - X_B)$ values and has derived the following conclusions:

(i) When $(X_A - X_B) = 1.7$, the amount of ionic character in $A^{\delta-} - B^{\delta+}$ bond is 50% and that of covalent character is also 50%.

Thus the bond is 50% ionic and 50% covalent.

(ii) When $(X_A - X_B) < 1.7$, the amount of ionic character in $A^{\delta-} - B^{\delta+}$ bond is less than 50%

and that of covalent character is more than 50%.

Thus the bond is predominantly covalent and hence is represented as A–B.

(iii) When $(X_A - X_B) > 1.7$, the amount of ionic character in $A^{\delta-} - B^{\delta+}$ bond is more than 50% and that of covalent character is less than 50%.

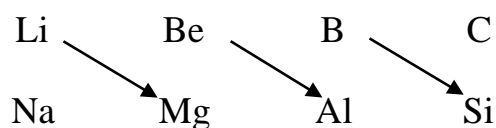
Hence the bond is predominantly ionic and hence is represented as $A^- B^+$

60. Define Diagonal relationship (March-19, Sept-21, March-23)

The similarities in the properties between the diagonally present elements are called as Diagonal relationship.

Eg: Li and Mg have same properties.

Example lithium and magnesium have similar properties



61. Give any 2 Anomalous properties of 2nd group elements

Lithium and Beryllium form covalent compounds but other forms ionic compounds

The second period has only 2 orbitals (2s and 2p) in the valence shell. So the maximum valency is 4. But others have more orbital in the valence shell and higher valencies. Example Boron forms BF_4^- but Aluminum forms AlF_6^{3-}

62. Define Valence State or Oxidation state (March-19)

Valence state is the number of electrons present in the valence shell

- Along the group the Valence state remains a constant
Because along the group the valence electrons does not changes.
- Along the period the Valence State increases.
Because along the period the of valence electrons increases

63. The formation of $F^-(g)$ from $F(g)$ is exothermic while that of O^{2-} from $O(g)$ is endothermic.

- Fluorine is highly electron negative in nature therefore as it gains the electron its octet become stable and releases the energy so exothermic.
- In oxygen the addition of first electron is exothermic in nature but addition of second electron experiences high repulsive force. So needs extra external energy to enter outer shell, hence endothermic in nature.

4. HYDROGEN

1. Explain why hydrogen is not placed with the halogen in the periodic table.

- The electron affinity of hydrogen is much less than that of halogen.
- The tendency of hydrogen to form hydride ion is low compared to that of halogens to form the halide ions

2. Discuss the three types of covalent hydrides. (May 2022)

They are compounds in which hydrogen is attached to another element by sharing of electrons. Covalent hydrides are further divided into three categories.

- i) Electron precise (CH_4)
- ii) Electron deficient (B_2H_6)
- iii) 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.

NaH is a solid as the ions Na^+ and H^- are held together by strong electrostatic forces but it's not so in HCl. therefore HCl is a gas

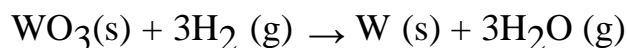
4. Write the expected formulas for the hydrides of 4th period elements. What is the trend in the formulas? In what way the first two numbers of the series different from the others?

4th period elements hydrides

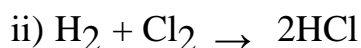
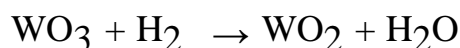
1. MH - KH (Ionic hydrides)
2. MH_2 - CaH_2 (Ionic hydrides)
3. Metallic (Interstitial hydrides)
Most of the hydrides are non-stoichiometric with variable composition ($\text{TiH}_{1.5-1.8}$)
3d series elements stoichiometry MH (Ti H , VH, NiH) or sometimes MH_2 - ZnH_2
4. XH_3 , - GaH_3 Ga_2H_6 - Covalent hydride (electron deficient)
5. XH_4 - GeH_4 EH_4 - GeH_4 - Covalent hydrides (electron precise)
6. EH_3 - AsH_3 Covalent hydrides (electron-rich hydrides)
7. H_2E - H_2Se . selenium hydride, or selenane
8. HX - HBr
9. HNgY , where Ng = noble-gas atom and Y = electronegative fragment HKrCl

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) Powdered tungsten (VI) oxide is heated to temperatures in the range 550 - 850°C in a stream of hydrogen.

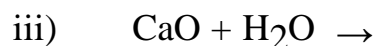
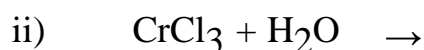
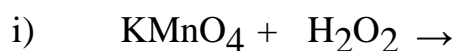


Tungsten (VI) oxide react with hydrogen to produce tungsten (IV) oxide and water. This reaction takes place at a temperature of 570-600°C.

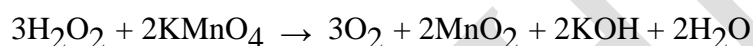


6. Complete the following chemical reactions and classify them in to

(a) Hydrolysis (b) redox (c) hydration reactions.



i) Redox reaction



ii) Hydrolysis

Chromium(III) chloride react with water to produce hydrogen chloride and chromium(III) oxide. This reaction takes place at a temperature of 350 - 450°C.



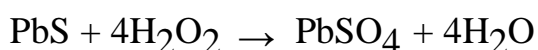
iii) Hydration reactions



7. Hydrogen peroxide can function as an oxidising agent as well as reducing agent. Substantiate this statement with suitable examples.

Oxidising Nature:

1. It oxidised black lead sulphide to white lead sulphate.



Reducing Nature-

1. Reduces moist silver oxide to silver. $\text{H}_2\text{O}_2 + \text{Ag}_2\text{O} \rightarrow \text{Ag} + \text{H}_2\text{O} + \text{O}_2$

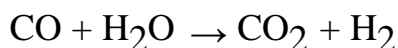
2. Reduces chlorine to hydrogen chloride $\text{Cl}_2 + \text{H}_2\text{O}_2 \rightarrow 2\text{HCl} + \text{O}_2$

8. Do you think that heavy water can be used for drinking purposes?

It cannot be used for drinking purposes because it will slow down metabolic reactions taking place in the body and lead to death.

9. What is water-gas shift reaction?(June 2023)

Carbon mono oxide can be converted into carbon di oxide by mixing the gas mixture with more steam 400°C and passed over a shift converter containing iron/copper catalyst. This reaction is called as *water-gas shift reaction*.



10. Justify the position of hydrogen in the periodic table?

Resemblance with alkali metals:

- i) Like alkali metals, hydrogen contains one valence electron in its valence shell.
- ii) It forms unipositive ion (H^+) like alkali metals (Na^+ , K^+ , Cs^+)
- iii) It forms halides (HX), oxides (H_2O), peroxides (H_2O_2) and sulphides (H_2S) like alkali metals (NaX , Na_2O , Na_2O_2 , Na_2S)
- iv) In their compounds both hydrogen & alkali metals show +1 oxidation states. Eg HCl & NaCl

Resemblance with halogens:

- i) Both hydrogen and halogens require one electron to complete their octets. Hence, Hydrogen can gain one electron to form a uni negative ion
 - ii) Like halogens, it forms a diatomic molecule and several covalent compounds.
 - iii) Unlike alkali metals, hydrogen does not possess metallic characteristics. On the other hand, it possesses a high ionization enthalpy. Also, it is less reactive than halogens
- It is difficult to find the right position in the periodic table. However, in most of its compounds hydrogen exists in +1 oxidation state. Therefore, it is reasonable to place the hydrogen in group 1 along with alkali metals as shown in the latest periodic table published by IUPAC

11. What are isotopes? Write the names of isotopes of hydrogen. (April 2022)

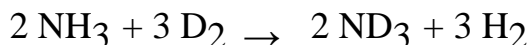
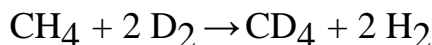
Elements having same atomic number but different mass number is called as isotopes
Hydrogen has 3 isotopes.

1. Protium (${}_1\text{H}^1$ or H),
2. Deuterium (${}_1\text{H}^2$ or D)
3. Tritium (${}_1\text{H}^3$ or T)

12. Give the uses of heavy water. (June 2023)

- i) Heavy water is widely used as moderator in nuclear reactors as it can lower the energies of fast neutrons
- ii) It is commonly used as a tracer to study organic reaction mechanisms and mechanism of metabolic reactions
- iii) It is also used as a coolant in nuclear reactors as it absorbs the heat generated.

13. Explain the exchange reactions of deuterium.



14. How do you convert para hydrogen into ortho hydrogen?

(Sept 2020, Sept 2021 & Apr 2022)

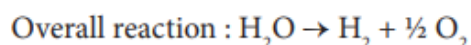
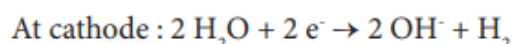
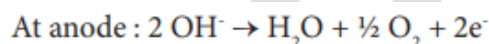
- By passing electric discharge
- By heating at 800°C
- By mixing with atomic hydrogen
- By using catalyst like Fe, Pt
- By mixing with paramagnetic molecules like oxygen

15. Mention the uses of deuterium.

- Moderators in Nuclear reactor.
- Coolant in nuclear reactors.
- Tracer element to study the mechanisms of organic reactions

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



17. 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 (B), a strong base. Identify A, B, C, D and E. Explain the reactions.

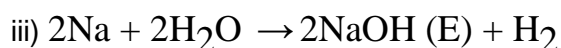
Metal (A) is sodium (present in common salt)



(A) (B) (C)



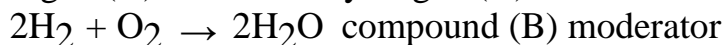
(B) (D)



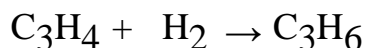
A- Sodium B- Hydrogen C- NaH D- H₂O E – NaOH

18. 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) - Normal hydrogen (H)



Compound - C is C_3H_4 after hydrogenation with H it forms into C_3H_6



A - Hydrogen (H) B - H_2O C - C_3H_4 (propyne) D - C_3H_6 (propene)

19. 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.

- i) Has exceptionally high melting and boiling point as compared to those of the hydrides of the remaining elements of group 15 due to presence of hydrogen bonding.
- ii) Hydrogen bonding (H-bonding) is an intermolecular force having partial ionic-covalent character.

20. Why interstitial hydrides have a lower density than the parent metal.

Most of the hydrides are non-stoichiometric with variable composition ($TiH_{1.5-1.8}$ and $PdH_{0.6-0.8}$)

So it have lower density than parent metal

21. How do you expect the metallic hydrides to be useful for hydrogen storage?

In metallic hydrides, hydrogen is adsorbed as H-atoms. This property of adsorption of hydrogen on transition metals is widely used as its storage media. Some of the metals such as Pd, Pt can accommodate a very large volume of hydrogen. This property has high potential for hydrogen storage and as a source of energy. Metallic

hydrides on heating decompose to form hydrogen and very finely divided metal.

22. Arrange NH_3 , H_2O and HF in the order of increasing magnitude of hydrogen banding and explain the basis for your arrangement

The extent of hydrogen bonding depends upon electronegativity and the number of hydrogen atoms available for bonding. Among nitrogen, fluorine, and oxygen, the increasing order of their electro negativities are $N < O < F$.

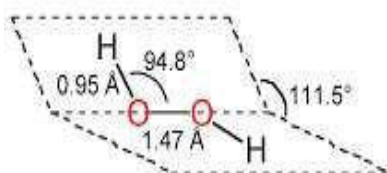
Hence, the expected order of the extent of hydrogen bonding is $HF > H_2O > NH_3$

But, the actual order is $H_2O > HF > NH_3$.

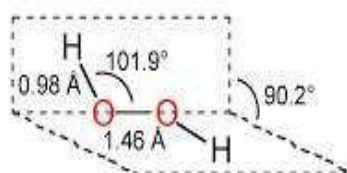
23. Compare the structures of H_2O and H_2O_2

In gaseous phase, water molecule has a bent form with a bond angle of

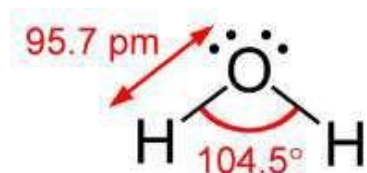
104.5° . The O-H bond length is 95.7 pm .



(a) Gas phase



(b) Solid phase



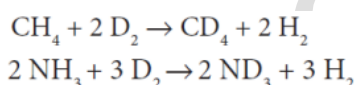
Hydrogen peroxide has a non-planar structure both in gas and solid phase. The dihedral angle in gas and solid phase is 111.5° and 90.2° respectively.

ADDITIONAL QUESTIONS

1. Give the difference between Ortho and para hydrogen

S No	Ortho hydrogen	Para hydrogen
1.	In hydrogen molecule, if the two nuclei rotate in the same direction In a hydrogen molecule	In hydrogen molecule, if the two nuclei rotate in the opposite direction In a hydrogen molecule
2.	It is more stable	It is less stable
3.	75% at room temperature	25% at room temperature
4.	It has a net magnetic moment	It has Zero magnetic moment
5.	Its melting point is 13.95K	Its melting point is 13.83K

2. Explain the exchange reactions of deuterium. (Sept 2020)



3. Give the preparation of Tritium (March 2019 & 2023)

Tritium is prepared by bombarding Lithium with slow neutrons



4. What is Hard water and Soft water?

Hard water are the soluble metal ions such as calcium and magnesium.

Soft water are the water free from soluble salts of calcium and magnesium.

5. What is Temporary hardness and how it is removed?

Temporary hardness is due to the presence of Bicarbonates of Calcium and Magnesium.

1. It can be removed by boiling and filtration.
2. Clark's method - lime is added to hard water

6. What is Permanent hardness and how it is removed?

Permanent hardness is due to the presence of Sulphates of Calcium and Magnesium.

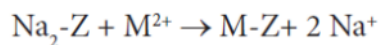
1. It is removed by adding washing soda.
2. Passed through an ion exchange Zeolites.

7. Explain the Ion Exchange method of Softening hard water.

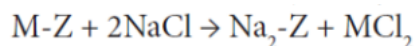
In this method the hard water is passed through an ion exchange Zeolites.

The Zeolites are hydrated Sodium Alumino Silicates ($\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot x\text{SiO}_2 \cdot y\text{H}_2\text{O}$)

The Zeolites contains porous structure of mono valent sodium ions, which is exchanged with Calcium and Magnesium ions in water.



The Zeolites can be reused by treating with sodium chloride



8. Why hydrogen peroxide is stored in plastic containers not in glass bottles? (June 2019)

Hydrogen peroxide undergoes a catalyzed disproportionation reaction of alkali metals present in glass bottles.

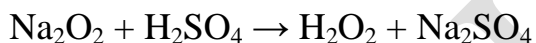
9. Derive hydrogen bonding and types of hydrogen bonding.

When a hydrogen atom is covalently bonded to a highly electronegative atom such as fluorine (F) or oxygen (O) or nitrogen (N), the bond is polarized.

Two types of hydrogen bonding.

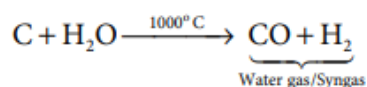
1. Intermolecular hydrogen bond - H_2O , NH_3
2. Intramolecular hydrogen bond – Salicylaldehyde

10. Complete the following reaction (March 2019)



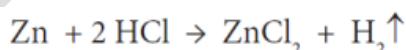
11. What is syn gas? How it is prepared? (June 2019)

Steam is passed over a red-hot coke to produce carbon monoxide and hydrogen. The mixture of gases produced in this way is known as water gas ($\text{CO} + \text{H}_2$). This is also called syngas (Synthetic gas)



12. Write the laboratory preparation of Hydrogen (Sept 2020)

Hydrogen is prepared by heating Zinc with dilute HCl



13. Give an example for ionic hydride and covalent hydride (Sept 2022)

Ionic hydride – NaH

Covalent hydride – CH_4

5. Alkali and Alkaline Earth Metals

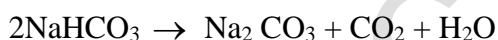
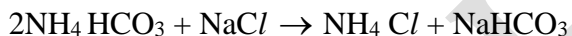
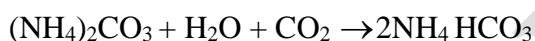
Textual questions with answers:

1. Why sodium hydroxide is much more water soluble than chloride?

Sodium hydroxide is much more soluble than chloride because when the Na^+ and OH^- ions break up, the OH^- ions are much smaller than Cl^- ions are able to form H-bond with water, thus dissolving easier than Cl^- ions would be able to.

2. Write the chemical equation for the reactions involved in Solvay process of preparation of sodium carbonate.

In this process, ammonia is converted into ammonium carbonate which then converted into ammonium bicarbonate by passing excess carbon dioxide in a sodium chloride solution saturated with ammonia. The ammonium bicarbonate thus formed reacts with NaCl to give sodium bicarbonate and ammonium chloride. As sodium bicarbonate has poor solubility, it gets precipitated. It is isolated and is heated to give sodium carbonate.



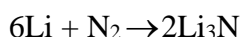
3. An alkali metal (X) forms a hydrated sulphate, $\text{X}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$. Is the metal more likely to be sodium (or) potassium.

The metal is more likely to be sodium, because the charge density of sodium is higher than potassium. ex: $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$

4. Write the balanced chemical equation for each of the following chemical reaction.

(i) Lithium metal with nitrogen gas:

Lithium combine with nitrogen on heating to give lithium nitride



(ii) Heating solid sodium bicarbonate:

The crystal of sodium bicarbonate are heated to obtain sodium carbonate.



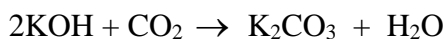
(iii) Rubidium with oxygen gas:

Rubidium react with oxygen to obtain Rubidium oxide (super oxide)



(iv) Solid potassium hydroxide with CO_2 :

Solid potassium hydroxide react with CO_2 to produce potassium carbonate.



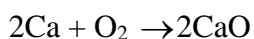
(v) Heating calcium carbonate:

Calcium carbonate is heated about 1070-1270 K to give calcium oxide.



(vi) Heating calcium with oxygen:

Calcium react with oxygen to produce calcium oxide.



5. Discuss briefly the similarities between Beryllium and Aluminium?

(i) Be and Al ions have strong tendency to form complexes. Ex BeF_4^{2-} , AlF_6^{3-}

(ii) Both Be and Al hydroxide are amphoteric in nature.

(iii) Both Be and Al are rendered passive by nitric acid.

6. Give the systematic names for the following:

(i) Milk of magnesia (ii) Lye (iii) Lime (iv) Caustic potash (v) Washing soda (vi) Soda ash (vii) Trona

Milk of magnesia – Magnesium hydroxide

Lye – sodium hydroxide

Lime - Calcium hydroxide

Caustic potash – potassium hydroxide

Washing soda – sodium carbonate

Soda ash - anhydrous sodium carbonate

Trona – sodium carbonate

7. Substantiate lithium fluoride has the lowest solubility among group one metal fluorides.

The high lattice enthalpy due to small size of Li^+ and F^- . Hydration is very high.

8. Write the uses of Plaster of Paris. (April 2020)

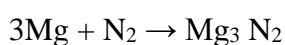
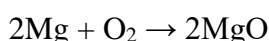
- (i) It is used in building industry as plasters
- (ii) It is used for immobilising agent in bone fracture or sprain.
- (iii) It is used for density, in ornamental work and for making casts of statues and busts.

9. Beryllium halides are covalent whereas magnesium halides are ionic why?

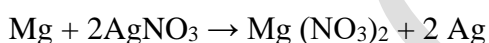
- (i) Beryllium halides are covalent due to smaller size, higher ionisation energy of Be.
- (ii) Magnesium halides are ionic due to the larger atomic size and lesser ionisation energy of Mg.

10. Alkaline earth metal (A), belongs to IIIrd period reacts with oxygen and nitrogen to form compound (B) and (C) respectively. It undergo metal displacement reaction with AgNO₃ solution to form compound (D).

- (i) Magnesium (A) is belongs to IIIrd period.
- (ii) Magnesium (A) reacts with oxygen and nitrogen to give magnesium. Oxide (B) and Magnesium nitride (C).



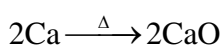
- (iii) Magnesium (A) undergo displacement reacts with AgNO₃ to give Magnesium nitrite(D).



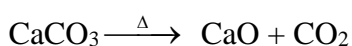
Compound	Name	Formula
A	Magnesium	Mg
B	Magnesium oxide	MgO
C	Magnesium nitride	Mg ₃ N ₂
D	Magnesium nitrate	Mg(NO ₃) ₂

11. Write the balanced chemical equation for the following process.

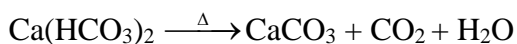
- a. Heating of calcium in oxygen.



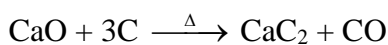
- b. Heating of calcium carbonate.



c. Evaporating solution of calcium hydrogen carbonate.



d. Heating calcium oxide with carbon.



12. Explain the important common features of Group 2 elements.

General electronic configuration is ns^2 .

The common oxidation state is +2.

They are good conductors of heat and electricity.

They have higher ionization energy.

They show characteristic colour in the flame.

They have higher hydration enthalpy.

13. Discuss the similarities between beryllium and aluminium. (June 2019, Sept 2021 & June 2023)

S.No	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 hydroxide are amphoteric in nature.
5.	Carbides of beryllium (Be_2C) like aluminium carbide (Al_4C_3) give methane.
6.	Both beryllium and aluminium are rendered passive by nitric acid.

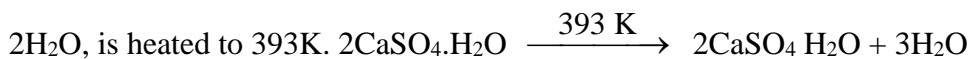
14. Why alkaline earth metals are harder than alkali metals?

The strength of metallic bond is higher than the alkali metals due to presence of two electrons in its outer most shell.

Due to higher nuclear charge of these atoms which tends to draw the electron inwards and the size of the atom become smaller. Hence this metals becomes much harder.

15. How is Plaster of Paris prepared?

Hemihydrate of calcium sulphate is called plaster of pairs. It is obtained when gypsum, $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$, is heated to 393K.



16. Give the uses of gypsum.

1. Gypsum is used in making drywalls or plaster boards. Plaster boards are used as the finish for walls and ceilings and for partitions.
2. Important use of gypsum is the production of plaster of Paris known as gypsum plaster.
3. Gypsum plays an important role in agriculture as a soil additive, conditioner, and fertilizer.
4. Gypsum is used in making surgical and orthopaedic casts, such as surgical splints and casting moulds.
5. 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. It can be also be used for removing sodium from soils having excess salinity.
6. It is used in toothpaste, shampoos, and hair products mainly due to its binding and thickening properties.
7. Gypsum component of Portland cement, where it act as a hardening retarder to control the speed at which concrete.

17. Write biological importance of Magnesium and Calcium.

Importance of Mg:

1. Magnesium plays an important role many biochemical reaction catalysed by enzymes.
2. It is the co-factor of all enzymes that utilize ATP in phosphate transfer and energy release.
3. It also essential for DNA synthesis and is responsible for the stability and proper functioning of DNA. It is also used for balancing electrolytes in our body.
4. Deficiency of magnesium results into convulsion and neuromuscular irritation.

Importance of Ca:

1. Calcium is a major component of bones and teeth.

2. It is also present in blood and its concentration is maintained by hormones.
3. Deficiency of calcium in blood causes it to take longer time to clot.
4. It is also important for muscle contraction.
5. Chlorophyll contains magnesium which plays an important role in photosynthesis

18. Which would you expect to have a higher melting point magnesium oxide (or) magnesium fluoride? Explain your reasoning.

(i) Magnesium oxide is higher melting point. Around 2800°C .

(ii) Magnesium oxide stays solid at such high temperatures, it remains non-conductive.

Reason: This is because Mg^{2+} and O^{2-} ions have greater number of charge, so they form stronger ionic bond than magnesium fluoride.

Additional questions and answers

1. Why do alkali metals are stored under oil?

They are very reactive with water even with moisture hence they are stored under oil

2. Why alkali metals show color in flame?

When the alkali metals and its compounds are heated in the flame the valence electron is excited to a higher energy level. When it drops back to its actual energy level, the excess energy is emitted as light, whose wavelength is in the visible region. Hence produces color flame. Example

Lithium - Crimson red Sodium - Yellow

Potassium - Lilac Cesium - Blue

3. Write the similarities between Li and Mg. (Sept 2022)

- Both Li and Mg are harder than other elements in the respective groups
- They do not give any super oxides and form only oxides, Li_2O and MgO .
- They do not form bicarbonates.

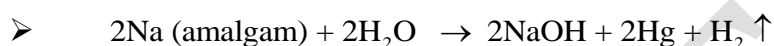
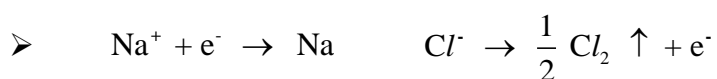
4. Write any three uses of sodium carbonate.

- It is known as washing soda which is used heavily for laundering.

- It used in the qualitative analysis and in volumetric analysis.
- It is also used in water treatment to convert the hard water to soft water.
- It is used in the manufacturing of glass paper and paint.

5. How to prepared sodium hydroxide by Castner -kellner cell method?

- Sodium hydroxide is prepared by the electrolysis of brine solution Castner kellner cell using a mercury cathode and a carbon anode.
- Sodium metal is discharged at the cathode and combines with mercury to form sodium amalgam. Chlorine gas is evolved at the anode.
- The sodium amalgam thus obtained is treated with water to give sodium hydroxide.



6. What is soda lime?

The mixture of quick lime (CaO) and sodium hydroxide in the ratio of 3: 1

7. What is Milk of lime?

A suspension of slaked lime in water is known as Milk of lime.

8. Why alkaline earth metals have higher ionisation energy than group 1 elements? Justify your answer.

- Because of more nuclear charge and smaller size, the electrons are more attracted towards the nucleus of the atoms.
- Hence, they are less electropositive than alkali metals.

9. BeSO₄ and MgSO₄ are readily soluble in water why?

The greater hydration enthalpies of Be²⁺ and Mg²⁺ ions overcome the lattice enthalpy factor and therefore their sulphates are readily soluble in water.

10. Why the second ionization enthalpies of alkali metals are very high than alkaline earth metals?

- The electron removed from the monovalent cation is called second ionization energy.

- Monovalent cation having very stable electronic configuration similar to the noble gas.
- Therefore it becomes very difficult to remove the second electron from the stable configuration already attained.

11. Mention the uses of Barium.

- Used in pyrotechnics, petroleum mining and radiology.
- Deoxidizer in copper refining.
- As a scavenger to remove last traces of oxygen and other gases in television and other electronic tubes.

12. Write the uses of Magnesium. (Sept 2020)

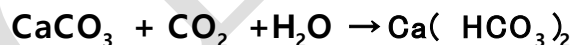
- It is used for removal of sulfur from iron and steel
- As a desiccant
- Mg alloys are used in aero plane and missile construction.

13. Write anomalous behaviour of Beryllium? (May 2022)

- It is small and high polarizing power.
- Relatively high electronegativity and ionisation enthalpy as compared other member.
- Absence of vacant d - orbital in its valence shell.

14. What is the reaction of CaCO₃ on passing excess of CO₂?

On passing excess of carbon dioxide, the precipitate dissolves to form calcium hydrogen carbonate.



15. How is bleaching powder prepared? (Sept 2020)

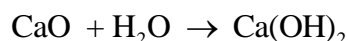
Milk of lime reacts with chlorine to form hypochlorite it is called bleaching powder.



16. What is slaking of lime?

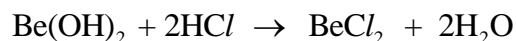
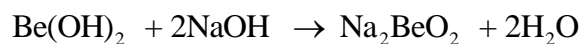
The process of the addition of limited amount of water breaks the lump of lime is called slaking of

lime and product is slaked lime.



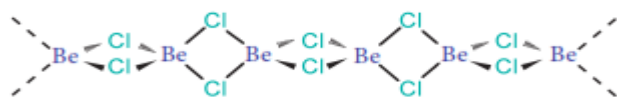
17. Prove that Be (OH)₂ is act as amphoteric in nature.

Be(OH)₂ reacts with both acid and base hence it is amphoteric nature.

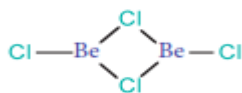


18. Draw the structure of BeCl₂ in different phase

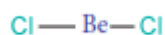
i. In solid state BeCl₂ exist as linear chain structure



ii. In the vapour state it exists as a dimer with bridge chlorine atom



iii. At 1200k Linear monomer



19. Write the uses of slaked lime.

- In the preparation of mortar a building material.
- In white wash due to its disinfectant nature.
- In glass making, in tanning industry, for the preparation of bleaching powder and for purification of sugar.

20. Explain the term " Retrograde solubility".

Unlike other salts, gypsum becomes less soluble in water as the temperature increase. This is known as retrograde solubility, which is a distinguishing characteristics of gypsum.

21. What is Dead burnt plaster?

- When plaster of Paris heated above 393K no water of crystallisation is left and anhydrous calcium

sulphate, CaSO_4 is formed. This is known as Dead burnt plaster.

- It has remarkable property of setting with water.

22. What is Desert Rose?

Gypsum crystals are sometimes occur in a form that resembles the petals of a flower. This type of formation is referred to as Desert rose.

23. Write note on Alabaster?

- It is variety of gypsum.
- It is highly valued as an ornamental stone.
- It is granular and opaque.
- Its specific gravity is 2.3 to 2.4.

24. List out the characteristics of Alkali metals.

- They are soft and highly reactive.
- They form oxides and hydroxides and these compounds are basic in nature.
- They are highly electropositive in nature.
- Alkali metals have only one oxidation state which +1.
- They have the lower ionisation energy.
- The second ionisation enthalpy are very high.
- They are very low electronegativity value.
- When alkali metal salts mixed with Con. HCl are heated on a 'Pt' wire in a flame they show characteristics colored flame.
- They show characteristics color in the flame.

25. Explain what to meant by Efflorescence?

- It is a white greyish or crystalline tint deposit of salts often seen on the surface of nature stone, concrete and brick surfaces. It occurs when water is present on (or) in the masonry surface.

26. Write the difference between alkali metals and alkaline earth metals.

S.No.	Alkali metals	Alkaline earth metals
1	Soft metals	Hard metals
2.	It has a single valence electron	It has two valence electron
3.	Low melting points	Relatively high melting points
4.	Hydroxides are strongly basic	Relatively less basic
6.	Carbonates does not decompose	All the carbonates decomposes on heating

27. Explain why $\text{Ca}(\text{OH})_2$ is used in white washing (March 2019)

Due to its disinfectant nature

28. Among alkaline earth metals BeO is insoluble in water but other oxides are soluble. Why? (March 2019)

BeO is amphoteric. It is covalent due to the small size of Be^{2+} ion and insoluble in water.

29. Among the alkali metal halides, which is covalent? Explain the reason (June 2019)

All alkali metal halides are ionic crystals. However lithium halides shows covalent character, as it is the smallest cation that exerts high polairising power on the halides.

30. Why blue colour appears during the dissolution of alkali metals in liquid ammonia? (June 2019)

The blue colour of the solution is due to the ammoniated electron which absorbs energy in the visible region of light and thus imparts blue colour to the solution.

31. Give any three properties of Beryllium that are different from other elements of the group (May 2022)

No	Beryllium	other elements
1.	Forms covalent compounds	form ionic compounds
2.	High melting and boiling point	Low melting and boiling point
3.	Does not react with water even at elevated temperature	React with water

32. Write he uses of sodium bicarbonate (June 2023)

- 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 inversely proportional to its pressure.

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

2. A balloon filled with air at room temperature and cooled to a much lower temperature can be used as a model for Charles's law.

Yes, it is a model for Charles's law. According to Charles's law $V \propto T$. When temperature decrease volume also decrease.

Hence, at lower temperature the volume of the balloon decreases.

3. Name two items that can serve as a model for Gay Lussac's law and explain.

According to Gay – Lussac's law $P \propto T$ (n)

1. Firing a bullet: Here the ignition of gun powder generates super-heated gases which turn increase the pressure so that the bullet travels longer with high speed.
2. In summer the car tyres are completely filled with air, the tyres cannot change its shape and volume. But in winter comes, the pressure inside the tyres is reduced and the shape is also reduced. This confirms that pressure and temperature are directly related to each other.

4. Give the mathematical expression that relates gas volume and moles. Describe in words what the mathematical expression means.

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

$$V \propto n, \quad \frac{V_1}{n_1} = \frac{V_2}{n_2} = \text{constant}$$

V_1 and n_1 = volume and number of molecules of a gas

V_2 and n_2 = different set of values of volume and number of moles of the same gas at same temperature and pressure.

5. What are ideal gases? In what way real gases differ from ideal gases.

(March 2019)

Ideal gases: Gases that obey the equation $PV = nRT$ (or) Gaseous laws under all conditions.

Real gases: Real gases have attractive forces between molecules and it occupy larger volume than ideal gas.

6. Can a Vander Waals gas with $a = 0$ be liquefied? Explain.

If the Vander Walls constant (a) = 0; for a gas, the, it behave ideally. ie there are no intermolecular forces of attraction. So, it cannot be liquefied. $P_c = \frac{a}{27b^2}$ If $a = 0$, then P_c and $27b = 0$, which means that either $P = 0$ or $b = 0$ which is not possible therefore the gas cannot be liquefied.

7. Suppose there is tiny sticky area on the wall of a container of gas. Molecules hitting this area stick there permanently. Is the pressure greater or than on the ordinary area of walls?

Molecule hitting the tiny sticky area on the wall of the container of gas moves faster as they get closer to adhesive surface, but this effect is not permanent. The pressure on the sticky wall is greater than on the ordinary area of walls.

8. Explain the following observation.

A) Aerated water bottles are kept under water during summer.

1. The aerated water bottles mean the excess amount of oxygen and minerals present in the water which dissolved under certain pressure.
2. In summer, the solubility of the gas in water is decrease because the rise in temperature decreases the solubility.
3. Hence, more of gas will be present above the liquid surface and pressure of the gas becomes too high. The bottle may explode. So, to avoid this bottles are kept under water.

B) Liquid ammonia bottle is cooled before opening the seal.

1. The vapour pressure of ammonia at room temperature is very high.
2. Cooling decrease the vapour pressure so that the liquid remains in the same state otherwise the bottle may explode. Hence the bottle is cooled before opening.

C) The tyre of automobiles is inflated to slightly lesser pressure in summer than in winter.

1. According to Gay Lussac's law pressure is proportional to temperature.
2. In summer, gas expands more than in winter. Hence the tyre of an automobile is inflated to slightly lesser pressure in summer than in winter. Otherwise the tyre may burst

D) The size of a weather balloon becomes larger and largest as it ascends up into larger altitude.

1. According to Boyle's law $V \propto \frac{1}{P}$
2. As we go to higher altitudes, the atmospheric pressure decreases.
3. Thus, the pressure outside the balloon decreases.
4. To regain equilibrium with the external pressure, the gas inside expands to decrease its pressure. Hence the size of the balloon increases.

9. Give suitable explanation for the following facts about gases.

A) Gases doesn't settle at the bottom of a container.

(i) Solid and liquids would stay at the bottom, as they are dense, but molecules in gases stay as far away from each other as possible. So gases don't settle at the bottom of a container.

B) Gases diffuse through all the space available to them.

(i) Gases fill the entire space available to them because of low intermolecular space and weak intermolecular forces of attraction between the gas molecules.

(ii) The weak forces allow them to flow freely in all the direction.

10. Suggest why there is no hydrogen (H₂) in our atmosphere.

(i) Hydrogen is the lightest element yet found thus when produced in free from its rises above all the other gases to the top of the atmosphere.

(ii) Hydrogen easily gains velocity required to escape earth's magnetic field.

11. Why does the moon have no atmosphere?

(i) The escape velocity on the surface of moon is very much less, less than the RMS velocity of the molecules of a gas at the surface temperature of moon.

(ii) Therefore the molecules will escape and moon cannot hold an atmosphere.

12. Explain whether a gas approaches ideal behaviour or deviates from ideal behaviour if

a) It is compressed to a smaller volume at constant temperature.

Generally we learn that the behaviour of a real gas approaches the behaviour of an ideal gas under the conditions of low pressures and high temperature.

At high pressure:

(i) The gas molecules are, close to each other.

(ii) The volume occupied by the gas molecules is significant compared to the volumes of its container. The interaction between gas molecules is significant. The gas deviate from ideal behaviour.

b) The temperature is raised at while keeping the volume constant.

At high temperature:

At high temperature keeping the volume the 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.

(i) The more gases is introduced in to the same volume the gas approaches deviates from ideal behaviour.

(ii) Because the attractive forces between the molecules increase. So, it become non ideal behaviour.

13. Would it be easier to drink water with a straw on the top Mount Everest?

It is difficult to drink water with a straw on the top of Mount Everest. This is because the reduced atmospheric pressure is less effective in pushing. Water into the straw at the top of the mountain because gravity falls off gradually with height. The air pressure falls off, there isn't enough atmospheric pressure to push the water up in the straw the way to the mouth.

14. Which of the following gases would you expect to deviate from ideal behaviour under condition of low temperature F₂, Cl₂, or Br₂? Explain

- (i) The larger the size of the molecular for the greater, he deviation from an ideal gas clearly bromine has the biggest size than others.
- (ii) The amount of attraction between molecules is directly proportional to the boiling point of the liquid made from those molecules, and bromine has the highest boiling point.
- (iii) So it has the greatest deviation from ideal gas behaviour than F₂ and Cl₂.

15. Distinguish between diffusion and effusion.

Diffusion: When two non- reactive allowed to mix, the gas molecules migrate from region of higher concentration to a region of lower concentration. (or)

The tendency of the molecules of a given substance to move from region of higher concentration to region of lower concentration. Eg Ascent spreading throughout a room.

Effusion: The process in which a gas escapes from a container through a very small hole.

Eg. Air slowly leaking out of a tire.

16. When the driver of an automobile applies brake, the passenger are pushed toward the front of the car but a helium balloon is pushed toward back of the car. Upon forward acceleration the passengers are pushed toward the front of the car. Why?

- (i) Because the Helium balloon has buoyancy in air, because Helium has a lower density than air. That means it moves in a direction opposite to the force on the surrounding air.
- (ii) Normally, air is pulled downwards due to gravity which pushes the balloon upwards.
- (iii) In this case, the air in the car is pulled forward by the acceleration of the car,

which pushes the air backwards.

17. When ammonia combines with HCl, NH₄Cl is formed as white dense fumes.

Why do more fumes appear near HCl?



It can be explained by Diffusion in property of gas. Ammonia and HCl solution are placed in a separate test tube. After sometime, the gases diffuses to meet and solid NH₄Cl is formed near the HCl.

18. Write the Vander Waals equation for a real gas. Explain the correction term for pressure and volume.

Vander Waals modified the ideal gas equation $PV = nRT$ by introducing two correction factors, namely, pressure correction and volume correction.

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.

The forces of attraction experienced by a molecule near the wall are directly proportional to the square of the density of the gas.

$$P' \propto \rho^2$$
$$\rho = \frac{n}{V}$$

where n is the number of moles of gas and V is the volume of the container

$$\Rightarrow P' \propto \frac{n^2}{V^2}$$
$$\Rightarrow P' = a \frac{n^2}{V^2}$$

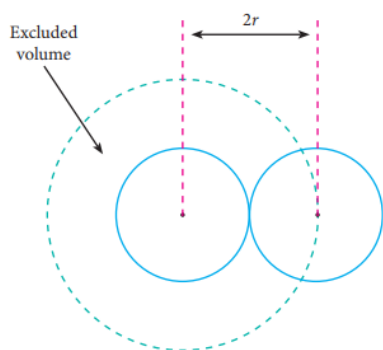
where a is proportionality constant and depends on the nature of gas

Therefore,

$$\text{Pressure correction } P_{\text{ideal}} = P + \frac{an^2}{V^2}$$

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

$$\begin{aligned} \text{Excluded volume for two molecules} &= \frac{4}{3} \pi (2r)^3 \\ &= 8 \left(\frac{4}{3} \pi r^3 \right) = 8 V_m \end{aligned}$$

where v is a volume of a single m molecule

$$\text{Excluded volume for single molecule} = \frac{8 V_m}{2} = 4 V_m$$

$$\text{Excluded volume for } n \text{ molecule} = n (4V_m) = nb$$

where b is van der waals constant which is equal to $4V_m$

$$V' = nb$$

$$\text{Volume correction } V_{\text{ideal}} = (V - nb)$$

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,

$$P + \frac{an^2}{V^2} (V - nb) = nRT$$

The constants a and b are van der Waals constants and their values vary with the nature of the gas

19. Why do Astronauts have to wear protective suits when they are on the surface of moon?

(i) Astronauts must wear space suits whenever they leave a space craft and are exposed to the environment of space. In a space there is no air to breath and no air pressure.

(ii) Space is extremely cold and filled with dangerous radiation without protection an astronaut would quickly die in space.

(iii) Space suits are specially designed to protect astronauts from the cold, radiation and low pressure they also provide air to breathe.

20. Aerosol can carry clear warning heating of the can. Why?

(i) There are volatile liquids inside often a LPG propellant. If these heated, they will produce more vapour inside the can and which will make the pressure rise very quickly.

(ii) At the room temperature the lot of pressure created inside the Can.

(iii) Even though the Cans are tested, they will burst if the pressure goes up too far.

21. Derive the relationship between critical constants and Vander Waal's constants (Apr 2022)

Let us the values of critical constants T_c (critical temperature), V_c (critical volume) and P_c (critical pressure) in terms of the Vander Waal's constants 'a' and 'b'. The Vander Waal's equation is given by $(P + \frac{a}{V^2})(V - b) = RT$ (1)

Expanding the equation

$$PV + \frac{a}{V} - Pb - \frac{ab}{V^2} - RT = 0 \quad \dots (2)$$

Multiplying by $\frac{V^2}{P}$

$$\frac{V^2}{P} \left(PV + \frac{a}{V} - Pb - \frac{ab}{V^2} - RT \right) = 0$$

$$V^3 - \frac{aV}{P} - bV^2 - \frac{ab}{P} - \frac{RTV^2}{P} = 0 \quad \dots (3)$$

Rearranging this equation of V,

$$V^3 - \left[\frac{RT}{P} + b \right] V^2 + \left[\frac{a}{P} \right] V - \frac{ab}{P} = 0 \quad \dots (4)$$

For this cubic equation three roots (values of V) are possible. At the critical point, three values of V becomes identical and is equal to the critical volume (V_c).

The pressure and temperature becomes P_c and T_c

Therefore $V = V_c$ (at T_c)

$$V - V_c = 0$$

$$(V - V_c)^3 = 0$$

$$V^3 - 3V^2V_c + 3VV_c^2 - V_c^3 = 0 \quad \dots (5)$$

Comparing the coefficients of equations (4) and (5)

$$3V_c = \frac{RT_c}{P_c} + b \quad \dots (6)$$

$$3V_c^2 = \frac{a}{P_c} \quad \dots (7)$$

$$V_c^3 = \frac{ab}{P_c} \quad \dots (8)$$

$$\frac{\text{equ 8}}{\text{equ 7}} \Rightarrow \frac{V_c^3}{3V_c^2} = \frac{ab}{P_c} \times \frac{P_c}{a}$$

$$V_c = 3b^2 \quad \dots (9)$$

(9) in (7)

$$3(3b)^2 = \frac{a}{P_c}$$

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

$$P_c = \frac{a}{27b^2} \dots\dots\dots(10)$$

Equation (9) and (10) in (6)

$$3(3b) = \frac{RT_c}{\frac{a}{27b^2}} + b$$

$$9b - b = \frac{RT_c 27b^2}{a}$$

$$8ab = RT_c 27b^2$$

$$T_c = \frac{8ab}{27Rb^2}$$

$$T_c = \frac{8a}{27Rb} \dots\dots (11)$$

ADDITIONAL QUESTIONS AND ANSWERS

1. What is Boyle temperature? What happens to real gases above and below the Boyle's temperature? (June 2019)

The temperature at which a real gas obeys ideal gas law over an appreciable range of pressure is called Boyle temperature or Boyle point.

Above the Boyle point, the real gases show positive deviation from ideal behaviour and the compressibility factor, $Z > 1$ and the gases are less compressible. Below Boyle point, gases show negative deviation from ideal behaviour and the compressibility factor, $Z < 1$ and gases are highly compressible.

2. Define: Critical temperature (T_c).

It is defined as the temperature above which it cannot be liquefied even at high pressure may be applied on the gas.

3. Define: Critical pressure (P_c).

It is defined the minimum pressure required to liquefy 1 mole of a gas as its critical temperature.

4. What Joule Thomson effect? (June 2023)

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.

5. Define: Critical volume (V_C).

It is defined as "the volume occupied by 1 mole of a gas at its critical temperature and critical pressure".

6. What is meant by Inversion temperature (T_I). (June 2019)

The temperature below which a gas obeys Joule Thomson effect is called inversion temperature

$$T_i = \frac{2a}{Rb} \quad R = \text{Gas constant; } a \text{ \& } b \text{ -vanderwaals constant}$$

7. Define: Avogadro's Hypothesis.

Avogadro hypothesis states that "Equal volumes of all gases under the same conditions of temperature and pressure contain equal number of molecules". $V \propto n$

8. Define: Dalton's law of partial pressure. (May 2022)

At constant Temperature "The total pressure of a mixture of non- reacting gases is the sum of partial pressure of the gases present in the mixture."

$$P_{\text{Total}} = P_1 + P_2 + P_3$$

9. Write one application of Dalton's law.

In a reaction involving the collection of gases by downward displacement of water, the pressure of dry vapor collected can be calculated using Dalton's law

$$P_{\text{dry gas collected}} = P_{\text{total}} - P_{\text{water vapour}}$$

Where, $P_{\text{water vapour}}$ is aqueous tension and its values are available for air at various temperature.

9. Define: Graham's law of Diffusion. (March 2019)

The rate of diffusion or effusion is inversely proportional to the square root of molar mass.

$$\text{Rate of diffusion (r)} \propto \frac{1}{\sqrt{M}}$$

$$\text{For two gases: } \frac{r_A}{r_B} = \sqrt{\frac{M_B}{M_A}}$$

r_A and r_B = Rate of diffusion of A and B. M_A and M_B = Molar mass of A and B

10. Write the significance of Vanderwaal's constant.

- The term a/v^2 is the measure of the attractive forces of the molecules. It is also called the cohesion (or) internal pressure.
- The inversion temperature of a gas can be expressed in term of 'a' and 'b'. $T_i = \frac{2a}{Rb}$
- The Vanderwaal's constant 'a' and 'b' are used to calculate the critical constant of gas.

11. What are the methods used for liquefaction of gases? (June 2023)

- In Linde's method Joule Thomson effect is used to get liquid air or any other gas.
- In Claude's process, the gas is allowed to perform mechanical work in addition to Joule Thomson effect so that more cooling is produced.
- 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. ie as low as 0 K can be achieved.

12. Why the gas at low pressure and high temperature it behaves ideally? Justify your answer.

- When the pressure is low the volume of the container is very large compared to the volume of the gas molecules so that individual volume of the gas molecules can be neglected. In addition, the molecules in a gas are far apart and attractive forces are negligible. The gas becomes ideal

- Effect of temperature: at high temperatures the average kinetic energy of the molecules is very high and hence inter molecular attractions will become insignificant. Hence the gas becomes ideal.

13. Can a Van der Waals gas with $a = 0$ be liquefied? Explain.

- The van der Waals constant 'a' is a measure of the attractive forces among the
- Molecules of the gas. Greater the value of 'a' larger the intermolecular force of attraction and the gas can be liquefied.
- Here $a = 0$ means there is intermolecular attraction and the gas cannot be liquefied.

14. Write the mathematical formula for Compressibility factor Z (Sept 2020)

- 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.

$$Z = \frac{PV}{nRT}$$

15. Why does gases don't settle at the bottom of the container.

- Gases have less density with high kinetic energy.
- All gases molecules have negligible inter molecular force of attraction and free to roam about

16. Why the gas behaves ideally in low pressure and high temperature or Give the effect of T and P on an ideal gas or Real gas.

- At high temperature the kinetic energy of the molecules increases hence the inter molecular force of attraction decreases. So the gas behaves ideally.
- At high pressure the density of the gas increases and the molecules come closer to one another. The inter molecular force of attraction increases. Hence the gas do not behaves ideally

17. Name two items that can serve as a model for Gay Lussac law and explain

$P \propto T$ at constant volume.

- Pressure in well inflated tyre is almost constant but when temperature increases in summer days it increases the pressure and sometimes tyres may burst.
- Guns and other firing equipment's are thrilling examples of Gay Lussac law. When gun pin strikes, it ignites the gun powder and this increases the temperature which in turn increases the pressure and bullet is fired from the gun.
- Heating a closed aerosol can. The increased pressure may cause the container to explode. Don't toss an "empty" can of hair spray into a fire.
- The egg in the bottle experiment.
- A glass bottle is taken, inside the bottle put some pieces of cotton with fire. Then place a boiled egg (shell removed) at the top of the bottle. The temperature inside the bottle increases from the fire, rising the pressure. By sealing the bottle with egg, the fire goes on, dropping the temperature and pressure. This causes the egg to be sucked into the bottle

18. What are the consequences of Boyle's law?

- The pressure-density relationship can be derived from the Boyle's law as shown below.
- $P_1 V_1 = P_2 V_2$ (Boyle's law) Type equation here. $V = \frac{m}{d}$ $V_1 = \frac{m}{d_1}$
 $V_2 = \frac{m}{d_2}$
- $P_1 \frac{m}{d_1} = P_2 \frac{m}{d_2}$

where "m" is the mass, d_1 and d_2 are the densities of gases at pressure P_1 and P_2 .

In other words, the density of a gas is directly proportional to pressure.

- $\frac{P_1}{d_1} = \frac{P_2}{d_2}$

19. What are ideal and real gases?

S.No	Ideal gas	Real gas
1.	Ideal gases obeys the gas law under all conditions of temperature and pressure	Real gases only obey at low pressure and high temperature
2.	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
3.	There is no force of attraction between the gas molecules	There is a force of attraction between the gas molecules
4.	They obey Ideal gas equation $PV = nRT$	They obey the Van der waals equation.

20. State Charles law

At constant pressure the volume of a gas is directly proportional to the temperature.

$$V \propto T$$

21 State Gay Lussac law

At constant volume the pressure of a gas is directly proportional to the temperature.

$$P \propto T$$

22. Derive the deal gas equation (June 2019 & April 2022)

Boyle's law $V \propto \frac{1}{P}$

Charles law $V \propto T$

Avogadro law $V \propto n$

$$V \propto \frac{nT}{P}$$

$$PV \propto nT$$

$$PV = nRT$$

P = Pressure R = Gas constant T = Temperature V = Volume

23. Give the difference between diffusion and effusion (Sept 2022 & June 2023)

S.No	Diffusion	Effusion
1	The spreading of the molecules of a gas throughout the available space is called as Diffusion.	The escaping of gas molecules through a very small hole is called as Effusion
2	This occurs due to difference in concentration	This occurs due to difference in pressure

CEO CHENNAI

Unit – 7 Thermodynamics

1. What are System, Surrounding and Boundary in thermodynamics?

The system is the part of universe which is under thermodynamic consideration.

Everything in the universe that is not the part of the system is called surroundings.

Anything which separates the system from its surrounding is called boundary.

2. What is isolated system?

A system which can exchange neither matter nor energy with its surroundings is called an isolated system. Eg. Thermos flask.

3. What is closed system?

A system which can exchange only energy but not matter with the surroundings is called closed system. Eg. Hot water contained in a closed beaker.

4. What is open system?

A system which can exchange both matter and energy is transferred to the surrounding.

Eg. Hot water contained in an open beaker.

5. What is reversible process?

The process in which the system and surrounding can be restored to the initial state from the final state without producing any changes in the thermodynamic properties of the universe is called a reversible process.

6. What is irreversible process?

The process in which the system and surrounding cannot be restored to the initial state from the final state is called an irreversible process.

7. What is an adiabatic process?

Those processes in which no heat can flow into or out of the system are called adiabatic process. Here $q = 0$.

8. What is isothermal process?

It is defined as one in which the temperature of the system remains constant, during the change from its initial to final state. Here $dT = 0$.

9. What is isobaric process?

It is defined as one in which the pressure of the system remains constant during its change from the initial to final state. Here $dP = 0$.

10. What is isochoric process?

It is defined as one in which the volume of the system remains constant during its change from the initial to final state. Here $dV = 0$.

11. What is 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 cyclic process. For this $dU=0, dH=0, dP=0, dV=0$ and $dT=0$.

12. What is internal energy?

The internal energy of a system is equal to the energy possessed by all its constituents. Or the total energy of all the molecules of the system is called internal energy.

13. What is heat?

The heat (q) is regarded as an energy in transit across the boundary separating a system from its surrounding.

14. What is work?

Work is defined as the force (F) multiplied by the displacement (x). $-w = F \cdot x$

15. What is enthalpy?

Enthalpy (H) is defined as the sum of the internal energy (U) of a system and the product of

pressure and volume of the system. $H = U + PV$.

16. What is standard heat of formation?

It is defined as the change in enthalpy that takes place when one mole of a compound is formed from its elements, present in their standard states.

17. What is heat 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.

18. What is entropy? Give its unit. (April 2023 & Sept 2022)

Entropy is a measure of the molecular disorder (randomness) of a system. Or energy (q) divided by constant temperature (T). $dS = q_{rev}/T$.

SI unit = JK^{-1} . cgs unit = $calK^{-1}$.

19. What is standard entropy of formation?

It is defined as the entropy of formation of 1 mole of a compound from the elements under standard conditions.

20. What is entropy of fusion?

It is defined as the entropy change during the heat absorbed when one mole of a solid melts at its melting point reversibly.

21. What is entropy of vapourisation?

It is defined as the entropy change during the heat absorbed when one mole of liquid is boiled at its boiling point reversibly.

22. What is entropy of transition?

The heat change, when one mole of a solid changes reversibly from one allotropic form to another at its transition temperature is called entropy of transition.

23. What is efficiency and efficiency in percentage for an engine?

$$\text{Efficiency} = \frac{\text{Work performed}}{\text{heat absorbed}}$$

$$\text{Efficiency in percentage} = \left[1 - \frac{T_c}{T_h} \right] \times 100$$

T_h = temperature of hot reservoir & T_c = temperature of cold reservoir.

24. What is standard entropy change for a chemical equation?

Standard entropy change is the difference between the sum of entropies of product and the sum of entropies of reactants at standard condition

$$\Delta S_r^0 = \sum S_{\text{products}}^0 - \sum S_{\text{reactants}}^0$$

25. What is Gibb's free energy?

The isothermally available energy associated with a chemical reaction that can be used to do work.

$G = H - TS$. G = Gibb's free energy; H = enthalpy and S = entropy.

26. What is spontaneous and nonspontaneous process?

A process that occurs under the given set of conditions without any external driving force is called a spontaneous process. Otherwise it is said to be non-spontaneous process.

27. What are the conditions for the spontaneity of a process? (Sept 2021 & May 2022)

ΔH and ΔG should have negative sign and ΔS should have positive sign are the conditions for the spontaneity of a process.

28. What is Lattice energy?

It is defined as the amount of energy required to completely remove the constituent ions from its crystal lattice to an infinite distance.

29. Predict the feasibility of a reaction when

i) Both ΔH and ΔS positive

ii) both ΔH and ΔS negative

iii) ΔH decreases but ΔS increases

	ΔH	ΔS	$\Delta G = \Delta H - T\Delta S$	Description	Example
i	+ve	+ve	+ (at low T)	non-spontaneous at low temperature	Melting of a solid
			- (at high T)	spontaneous at high temperature	
ii	-ve	-ve	- (at low T)	spontaneous at low temperature	Adsorption of gases
			+ (at high T)	non-spontaneous at high temperature	
iii	-ve	+ve	- (at all T)	Spontaneous at all temperature	$2O_3(g) \rightarrow 3O_2(g)$

30. Define molar heat capacity. Give its unit. (June 2019)

“The amount of heat absorbed by one mole of the substance to raise its temperature by 1 kelvin”.

The SI unit of molar heat capacity is $JK^{-1}mol^{-1}$

31. 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.

The SI unit of calorific value is $J kg^{-1}$.

It is usually expressed in $cal g^{-1}$.

32. Define Heat of neutralization.

It is the amount of heat liberated when one gm-equivalent of acid completely neutralizes by one gm equivalent of base.

Enthalpy of neutralization for strong acid and strong base is constant. $\Delta H = -57.27 kJ/mol$

33. The equilibrium constant of a reaction is 10, what will be the sign of ΔG ? Will this reaction be spontaneous?

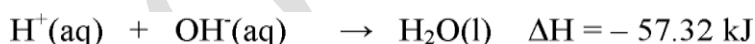
Van't Hoff equation. $\Delta G = -2.303RT \log K$

Equilibrium constant $K = 10$ $\Delta G = -2.303 RT \log 10 = -2.303RT$

ΔG is -ve; so the reaction is *Spontaneous*.

34. 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.



35. Identify the state and path functions out of the following: a) Enthalpy b) Entropy

c) Heat d) Temperature e) Work f) Free energy.

a)	Enthalpy	state function
b)	Entropy	state function
c)	Heat	path function
d)	Temperature	state function
e)	Work	path function
f)	Free energy	state function

Definition:

1. State zeroth law of thermodynamics. (Sept 2020)

It states that if two systems are separately in thermal equilibrium with a third one, then they tend to be in thermal equilibrium with themselves.

2. State various statements of first law of thermodynamics. (Sept 2021)

It is also known as law of conservation of mass. It states that the energy can neither be created

nor be destroyed, but may be converted from one form to another.

3. State various statements of second law of thermodynamics. (April 2023)

i. Kelvin-Plank's 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

ii. Clausius statement.

It is impossible to transfer heat from a cold reservoir to a hot without doing some work.

iii. Entropy statement

The entropy of an isolated system increases during a spontaneous process.

4. State third law of thermodynamics. (March 2019)

The third law of thermodynamics states that the entropy of pure crystalline substance at absolute zero is zero.

5. Define Hess's law of constant heat summation. (Sept 2021)

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.

Differentiation / Differences / Distinguish:

1. Differentiate Extensive and intensive properties. (Sept 2020 & June 2023)

Sl.No	Extensive Properties	Intensive Properties
1	Depends on the mass or the size of the system	Independent on the mass or the size of the system
2	Eg. Volume, number of moles, mass, etc.,	Eg. surface tension, density, boiling point, etc.,

2. Differentiate state function and path function. (Sept 2022)

Sl.No.	State function	Path function
1	Thermodynamic property of a system which has a specific value for a given state and does not depend on the path.	Thermodynamic property of a system whose value depends on the path by which the system changes from its initial to final state.
2	Eg. Pressure, Volume, Temperature, etc.,	Eg. work, heat, etc.

Explain / Explanation / Prove:

1. Explain how the lattice energy of a crystal is calculated using Born – Haber cycle. (or) Explain Born-Haber cycle.

The Born – Haber cycle is an approach to analyze reaction energies. The cycle is considered with the formation of an ionic compound from the reaction of a metal with a halogen or other non-metallic element such as oxygen. This cycle is primarily used in calculating lattice energy, which cannot be measured directly. This cycle applies Hess's law to calculate the lattice enthalpy. For example consider the formation of a simple ionic solid such as an alkali metal halide MX, the following steps are considered.

ΔH_1 – enthalpy change for the sublimation $M_{(s)}$ to $M_{(g)}$

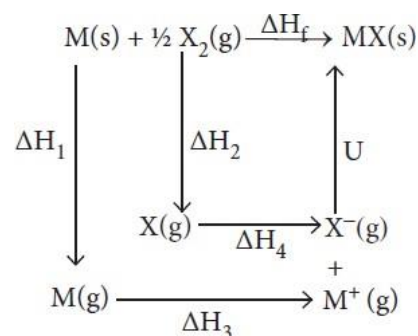
ΔH_2 – enthalpy change for the dissociation of $\frac{1}{2} X_{2(g)}$ to $X_{(g)}$

ΔH_3 – Ionisation energy for $M_{(g)}$ to $M^+_{(g)}$

ΔH_4 – electron affinity for the conversion of $X_{(g)}$ to $X^-_{(g)}$

U – the lattice enthalpy for the formation of solid MX

ΔH_f – enthalpy change for the formation of solid MX directly from elements.

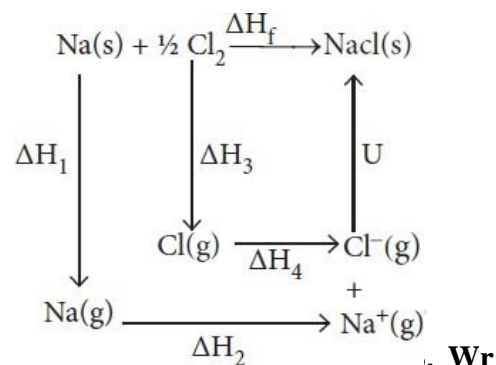


According to Hess's law of heat of summation

$$\Delta H_f = \Delta H_1 + \Delta H_2 + \Delta H_3 + \Delta H_4 + U$$

2. Suggest and explain an indirect method to calculate lattice enthalpy of sodium Chloride crystal.

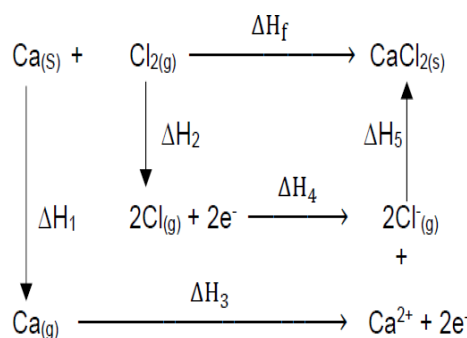
- ΔH_1 – enthalpy change for the sublimation of sodium
- ΔH_2 – Ionisation energy for sodium
- ΔH_3 – enthalpy change for the dissociation of Chlorine
- ΔH_4 – electron affinity for the conversion of Chlorine
- U – Lattice enthalpy of NaCl
- ΔH_f – enthalpy change for the formation of NaCl



$$\Delta H_f = \Delta H_1 + \Delta H_2 + \frac{1}{2} \Delta H_3 + \Delta H_4 + U$$

$$\therefore U = (\Delta H_f) - (\Delta H_1 + \Delta H_2 + \frac{1}{2} \Delta H_3 + \Delta H_4)$$

Write down the Born – Haber cycle for the formation of CaCl₂.



- ΔH_1 = heat of sublimation of Ca(s)
- ΔH_2 = dissociation energy of Cl₂(g)
- ΔH_3 = ionization energy of Ca(s)
- ΔH_4 = electron affinity of Cl(g)
- ΔH_5 = the lattice enthalpy for the formation of CaCl₂(s)
- ΔH_f = enthalpy change for the formation of CaCl₂(s) directly from elements

$$\Delta H_f = \Delta H_1 + \Delta H_2 + \Delta H_3 + \Delta H_4 + \Delta H_5$$

4. List the characteristics of internal energy. (May 2022)

1. It is an extensive property.
2. It is a state function
3. Change in internal energy is $\Delta U = U_f - U_i$
4. In cyclic process, $\Delta U = 0$.
5. $\Delta U = U_f - U_i = -ve$ ($U_f < U_i$)
6. $\Delta U = U_f - U_i = +ve$ ($U_f > U_i$).

5. List the characteristics of Gibbs free energy? (Sept 2021 & Sept 2022)

1. Free energy is defined as $G = H - TS$. G is a state function.
2. G is an extensive property. But ΔG is the intensive property when mass remains constant between

initial and final states.

- G has a single value for the thermodynamic state of system.
- G and ΔG values correspond to the system only.
- There are three cases of ΔG predicting the nature of process

Process	Spontaneous	Non - spontaneous	Equilibrium
ΔG	- ve	+ve	zero

6. $\Delta G = \Delta H - T\Delta S$.

$$\Delta H = \Delta E + P\Delta V \text{ and } \Delta E = q - w.$$

$$\text{But } T\Delta S = q$$

$$\Delta G = q - w + P\Delta V - q.$$

$$\Delta G = -w + P\Delta V = \text{network}$$

Derive / Derivation:

1. Derive the relation between enthalpy H and internal energy U. (Sept 2020 & June 2023)

$$\text{Enthalpy } H = U + PV$$

$$\text{In the initial state } H_1 = U_1 + PV_1$$

$$\text{In the final state } H_2 = U_2 + PV_2$$

$$\text{Change in Enthalpy } (H_2 - H_1) = (U_2 - U_1) + P(V_2 - V_1)$$

$$\text{Therefore } \Delta H = \Delta U + P\Delta V \text{ ----- (1)}$$

As per the first law of thermodynamics

$$\Delta U = q + w$$

$$\text{Hence } \Delta H = q + w + P\Delta V$$

$$\Delta H = q_p$$

$$\Delta H = q_p - P\Delta V + P\Delta V$$

$$(w = -P\Delta V)$$

q_p = heat absorbed at constant pressure and is considered as heat content.

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,

$$\text{For reactants } PV_i = n_i RT$$

$$\text{For products } PV_f = n_f RT$$

$$P(V_f - V_i) = (n_f - n_i)RT$$

$$P\Delta V = \Delta n_{(g)}RT$$

Substitute this in equation (1)

$$\Delta H = \Delta U + \Delta n_{(g)}RT$$

2. Derive the relationship between Gibbs free energy and the net work done by the system.

$$\text{For any system at constant temperature and pressure } \Delta G = \Delta H - T\Delta S$$

$$\Delta H = \Delta E + P\Delta V \text{ and } \Delta E = q - w.$$

$$\text{But } T\Delta S = q$$

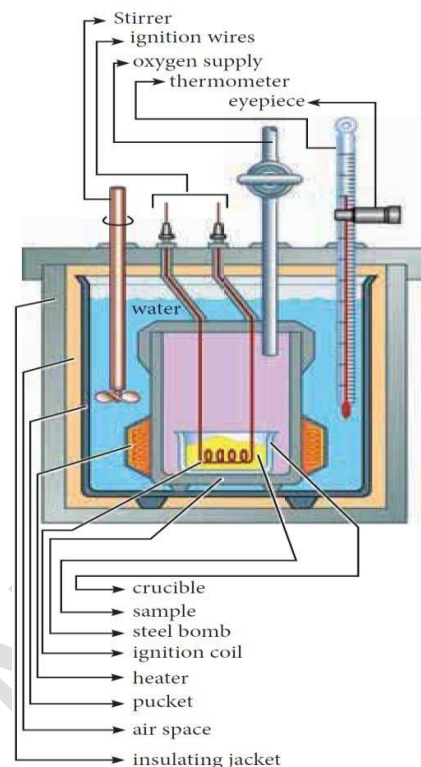
$$\Delta G = q - w + P\Delta V - q.$$

$$\Delta G = -w + P\Delta V = \text{network}$$

$-P\Delta V$ represents the work done due to expansion against a constant external pressure.

3. 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 and pressurized with excess oxygen.
- The bomb is immersed in water, in the inner volume of the calorimeter.
- The reaction is started by striking the substance through electrical heating.
- 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^0).
- The amount of heat produced in the reaction ΔU^0 is equal to the sum of the heat absorbed by the calorimeter and water.



Heat absorbed by the calorimeter:-

$$q_1 = k \Delta T$$

k- calorimeter constant

$$k = m_c C_c$$

m_c - mass of the calorimeter; C_c - heat capacity of calorimeter.

Heat absorbed by the water:-

$$q_2 = m_w C_w \Delta T$$

m_w - molar mass of water

C_w - molar heat capacity of water ($75.29 \text{ JK}^{-1} \text{ mol}^{-1}$)

$$\Delta U^0 = q_1 + q_2$$

$$\Delta U^0 = k \Delta T + m_w C_w \Delta T$$

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

- 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 equation.

$$\Delta H^0 (\text{Pressure}) = \Delta(\text{volume}) + RT \Delta n_{(g)}$$

4. Calculate the work involved in expansion and compression process.

Work involved in compression processes:

- The essential condition for expansion or compression of a system is that there should be difference between external pressure (P_{ext}) and internal pressure (P_{int}).
- 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*

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

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

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

Substituting (2) in (1)

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

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

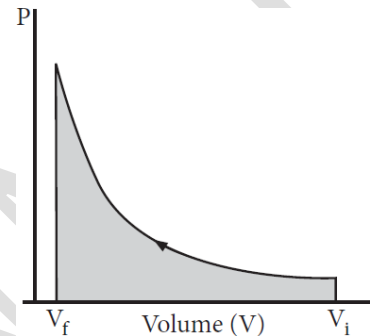
$$(P_{\text{ext}}) = (P_{\text{int}} + dP)$$

Work involved in expansion processes:-

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

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

- 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 the fig
- 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

Problem / Calculation:

1. Calculate the entropy change during the melting point of one mole of ice into water at 0°C and 1atm pressure. Enthalpy of fusion of ice is 6008 Jmol⁻¹. (March 2019, Sept 2020 & April 2023)

$$\Delta H_{\text{fusion}} = 6008 \text{ Jmol}^{-1}$$

$$T_f = 0^\circ \text{ C} = 273 \text{ K}$$

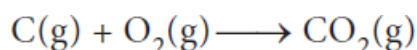


$$\Delta S_{\text{fusion}} = \frac{\Delta H_{\text{fusion}}}{T_f}$$

$$\Delta S_{\text{fusion}} = \frac{6008}{273}$$

$$\Delta S_{\text{fusion}} = 22.007 \text{ J K}^{-1} \text{ mole}^{-1}$$

2. Calculate the standard entropy change for the following reaction (ΔS°), given the standard entropies of CO₂(g), C(s), O₂(g) as 213.6, 5.740 and 205JK⁻¹ respectively. (March 2019)



$$\Delta S_r^\circ = \sum S_{\text{products}}^\circ - \sum S_{\text{reactants}}^\circ$$

$$\Delta S_r^\circ = \{S_{\text{CO}_2}^\circ\} - \{S_{\text{C}}^\circ + S_{\text{O}_2}^\circ\}$$

$$\Delta S_r^\circ = 213.6 - [5.74 + 205]$$

$$\Delta S_r^\circ = 213.6 - [210.74]$$

$$\Delta S_r^\circ = 2.86 \text{ JK}^{-1}$$

3. List the application of the bomb calorimeter.

It is used to determine the amount of heat released in a combustion reaction

It is used to determine the calorific value of food

It is used in food processing and explosive testing industries

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?**

- Eutrophication and Algae bloom are responsible for the reduction of dissolved oxygen in water.
- Microorganisms present in water decompose these organic matter and consume dissolved oxygen in water.
- Moreover during night, photosynthesis stops but the aquatic plants continue to respire, resulting in reduction of dissolved oxygen.

2. **What would happen, if the greenhouse gases were totally missing in the earth's atmosphere?**

- Earth's most abundant greenhouse gases are CO_2 , CH_4 , O_3 , CFC's and water vapour. These gases are present near the earth surface.
- In the absence of greenhouse gases, the average temperature of the earth will decrease (-18°C) drastically making it uninhabitable. As a result life on earth would be impossible.

3. **Define: Smog.**

- Smog is a combination of smoke and fog which forms droplets that remain suspended in the air.
- Smog is mainly consist of ground level ozone, oxides of nitrogen, volatile organic compounds, SO_2 acidic aerosols and gases and particulate matter.

4. **Which is considered to be earth's protective umbrella? Why? (June 2023)**

Ozone (O_3) acts as an umbrella or shield for harmful UV radiation. It protects us from harmful effects such as skin cancer.

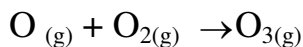
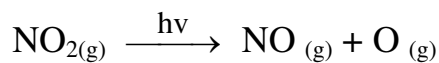
5. **What are degradable and non-degradable pollutants?**

(i) Bio-degradable: The pollutants which can be easily decomposed by the natural biological processes. Eg Plant wastes, animal wastes

(ii) Non bio-degradable: The pollutants which cannot be decomposed by the natural biological processes. Eg metal wastes, D.D.T, plastics, nuclear wastes

6. From where does ozone come in the photo chemical smog?

In the presence of sun light, NO_2 present in the air undergoes, Photolysis to form NO atomic and oxygen. The atomic oxygen then combines with molecular oxygen to form ozone.



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?

The laxative effects is observed only when the sulphates present in water have concentration greater than 500 ppm otherwise at moderate levels it is harmless.

8. What is Green chemistry? (March 2019 & June 2023)

Green chemistry means is chemical philosophy encouraging the design of products and processes that reduce or eliminate the use and generation of hazardous substances.

9. Explain how greenhouse effect causes global warming.

1. The greenhouse effect is intensified by the continuous emission of greenhouse gases into the atmosphere.
2. During the past 100 years, the amount of carbon dioxide in the atmosphere increased by 30% and the amount of methane more than doubled.
3. If these trends continue, the average global temperature will increase which can lead to melting of polar ice caps and flooding of low lying areas.
4. This will increase incidence of infectious disease like dengue malaria.

10. Mention the standard prescribed by BIS for quality of drinking water.

Characteristic	Desirable limit
(i) PHYSIO-CHEMICAL CHARACTERISTICS	
1. pH	6.5 to 8.5
2. Total Dissolved Solids (TDS)	500 ppm
3. Total Hardness (as CaCO_3)	300 ppm
4. Nitrate	45 ppm

5. Chloride	250 ppm
6. Sulphate	200 ppm
7. Fluoride	1 ppm
(ii) BIOLOGICAL CHARACTERISTICS	
1. Escherichia Coli (E. Coli)	Not at all
2. Coliforms	Not to exceed 10 (In 100 ml Water sample)

11. How does classical smog differ from photochemical smog?

Classical smog	Photochemical smog
1. It occurs in cool humid climate	Warm, dry and sunny climate.
2. It occurs in the morning and becomes worsen when the sun rises.	It forms when the sun shines and becomes worse in the afternoon.
3. It consists of coal smoke and fog.	Smoke, dust, fog, and with oxides of nitrogen and hydrocarbons.
4. It is also called Reducing smog.	It is also called Oxidizing smog.

12. What are particulate pollutants? Explain any three. (April 2022)

- Particulate pollutants are small solid particles and liquid droplets suspended in air.
- Eg: dust, smoke, mist and liquid droplets (aerosols).
- Smoke: It consists of solid particles (or) mixture of solid and liquids particles formed by combustion of organic matter. Eg cigarette smoke, oil smoke
- Dust: It composed of fine solid particles produced during crushing and grinding of solid materials. Eg; sand , saw dust
- Mists: They are formed by particles of spray liquids and concentration of vapours in air.
- Eg. Sulphuric acid mist, herbicides

13. Even though the uses pesticides increase the crop production, they adversely affect the living organism. Explain the function and the adverse effects of the pesticides.

- Pesticides are the chemical 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
- Insecticides: They can stay in soil for long period of time and are absorbed by soil. They contaminate root crops like carrot, radish. Eg: DDT, BHC, aldrin
- Fungicides: They can dissociate in soil to produce mercury which is highly toxic.

- Eg; organo mercury compounds
- Herbicides: It is used to control unwanted plants. They are otherwise known as weed killers. Most of the herbicides are toxic to mammals. Eg sodium chlorate, arsenite

14. Ethane burns completely in air to give CO₂. While in a limited supply of air gives CO. The same gases are found in automobile exhaust. Both CO and CO₂ are atmosphere pollutants.

(i) What is the danger associated with these gases.

Carbon monoxide (CO): Head ache, dizziness, tension, loss of consciousness, blurring of eye sight and cardiac arrest

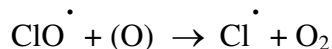
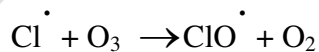
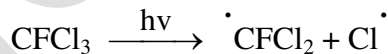
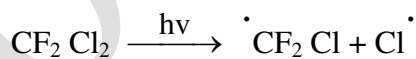
Carbon dioxide (CO₂): Head ache and nausea. It is responsible for global warming.

(ii) How does the pollutants affect the human body?

These pollutants cause scaring cancer asthma and white long disease.

15. On the basis of chemical reactions involved explain how CFC'S cause depletion of ozone layer in stratosphere

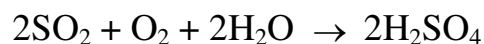
1. The chlorofluoro derivatives of methane and ethane. These are stable, nontoxic, non-corrosive, and non-inflammable
2. CFC's are the exhaust of supersonic air craft's and jumbo jets flying in the upper atmosphere. They slowly pass from troposphere to stratosphere.
3. CFC's stay for very longer period of 50-100 years in the stratosphere CFC's break up into chlorine free radical.



4. Chlorine radical is regenerated in the course of reaction. Due to this continuous attack of Cl. thinning of ozone layer takes place which leads to formation of ozone hole.
5. It is estimated that for every reactive chlorine atom generated in the stratosphere 1,00,000 molecules of ozone are depleted.

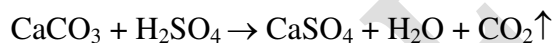
16. How is Acid rain formed? Explain its effect.

1. Acid rain is a by-product of a variety of sulphur and nitrogen oxides in the atmosphere. Burning of fossil fuels (coal and oil) in power stations, furnaces and petrol, diesel in motor engines produce sulphur dioxide and nitrogen oxides vapours.
2. The main contributors of acid rain are SO_2 and NO_2 . They are converted into sulphuric acid and nitric acid respectively by the reaction with oxygen and water.



Effect of Acid rain:

1. Acid rain causes extensive damage to building and structural materials of marbles. This attack on marble is termed as stone leprosy.



2. It affects plants and animal life in aquatic ecosystem.
3. It is harmful for agriculture, trees and plants as it dissolves and removes the nutrients needed for their growth.
4. It corrodes water pipes resulting in the leaching of heavy metals such as iron, lead and copper into the drinking water which have toxic effects.
5. It cause respiratory ailment in humans and animals.

17. (i) Differentiate the following i) BOD ii) COD (June 2023)

BOD	COD
1. The total amount of oxygen in milligrams consumed by microorganism in decomposing the waste in one litre of water at 20°C for a period of 5 days.	The amount of oxygen required by the organic matter in a sample of water for its oxidation by a strong oxidising agent like $\text{K}_2\text{Cr}_2\text{O}_7$ in acid medium for a period of 2 hrs.
2. Expressed in ppm.	Expressed in mg/l

(ii) **Viable and non-viable particulate pollutants.**

Viable particulates	Non- viable particulates
1. The small size living organism such as bacteria, fungi, moulds, algae, which are dispersed in air.	Small solid particles and liquid droplets suspended in air.
2. Some of the fungi cause allergy in human beings and disease in plants.	They help in the transportation of viable particles.

18. Explain how oxygen deficiency is caused carbon monoxide in our blood? Give its effect.

1. Carbon monoxide gas is a poisonous gas. It binds to haemoglobin of the blood to form carboxy haemoglobin complex which is 300 times more stable than oxyhaemoglobin complex.
2. When concentration of carboxy haemoglobin reaches about 3 – 4 % the oxygen carrying capacity of blood is greatly reduced.

Effects: Head ache, dizziness, tension, loss of consciousness, blurring of eye sight and cardiac arrest.

ADDITIONAL QUESTIONS AND ANSWERS

1. What are the various methods you suggest to protect our environment from pollution? (Sept 2020)

- Waste management: Environmental pollution can be controlled by proper disposal of waste
- 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.
- Substitution of less toxic solvents for highly toxic ones used in certain industrial processes. Use of fuels with lower Sulphur content (eg washed coal)
- Growing more trees.
- Control measures in vehicle emissions are adequate.

2. What is importance of measuring BOD of a water body?

- BOD is measure of level of pollution caused by organic biodegradable material present in the sample of given water.
- Low value of BOD indicates that water contains organic matter.

3. Why COD is preferred over BOD?

This is because COD can be found in a few minutes whereas BOD requires at least 5 days.

4. What is PAH?

- Poly nuclear Aromatic Hydrocarbons (PAH)
- They are potential cancer causing (carcinogenic) agents.
- They cause irritation in eyes and mucous membranes.

5. What is meant by global warming?

The heating up of earth through the greenhouse effect.

6. What is greenhouse effect? Name the gases that causes green house effect. (Sept 2020)

It is defined as the heating up the earth surface due to trapping of infrared radiations reflected by earth's surface by certain gases in the atmosphere.

The gases that causes green house effect are CH_4 , CO_2 , CFCs and water vapour

7. What are the techniques used to reduce particulate pollutants?

Electrostatic precipitators

Gravity settling chambers

Wet scrubbers (or) by cyclone collectors.

8. Write the types of smog?

There are two types

Classical smog caused by coal smoke and fog.

Photo chemical smog caused by photo chemical oxidation.

9. Write the effect of classical smog?

Smog is primarily responsible acid rains.

Smog results in poor visibility and it affects air and road transport.

It also causes bronchial irritation.

10. What are ozone Depletion substances?

The substance that causes depletion of ozone or make it thinner. e.g. NO and CFC

11. What is Eutrophication? (April 2022)

The process in which the nutrient rich water bodies support a dense plant population, kills animal's life by depriving it of oxygen and results in loss of biodiversity.

12. What is the range of BOD in clean water and highly polluted water?

- To measure of degree of water pollution.
- BOD value clean water has less than 5 ppm.
- Highly polluted water has 17ppm or more.

13. Define term Stone leprosy.

Acid rain causes extensive damage on marble is termed as Stone leprosy.



14. What is meant by Depletion of stratospheric ozone?

The loss of ozone molecules in the upper atmosphere is termed as depletion of stratospheric ozone.

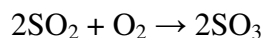
15. What are Freons?

The chlorofluoro derivatives of methane and ethane.

16. What is the role of SO₂ and SO₃ in air pollution.

SO₂ is a poisonous gas to both animals and plants.

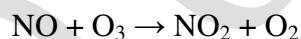
It is oxidized into more harmful Sulphur trioxide in the presence of particulate matter present in polluted air.



SO₃ combines with atmospheric water vapor to form H₂SO₄ which comes down in the form of acid rain.

17. What is role of NO₂ in the air pollution.

The oxidation of Nitrogen in air to form oxides of nitrogen.



Effects:

The oxides of nitrogen are converted into nitric acid which comes down in the form of acid rain.

They also form reddish brown haze in heavy traffic.

18. Write the properties and uses of CFC.

Stable Non - inflammable

Non- toxic Easily liquefiable

Non- corrosive

Uses: Production of plastic foams in refrigerators and air conditioner.

19. What is the impact of Ozone Depletion in the earth? (June 2019)

- 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 protein which leads to harmful mutation of cells.
- UV radiation affects growth of phytoplankton as a result ocean food chain is disturbed and even damage the fish productivity.

20. List out any 5 major water pollutants and their sources.

POLLUTANTS	SOURCES
1. Microorganisms	1. Domestic sewage, domestic wastewater
2. Organic wastes	2. Domestic sewage, animal excreta, food processing factory waste and detergents
3. Plant nutrients	3. Chemical fertilizers
4. Heavy metals	4. factories
5. Sediments	5. Soil erosion by agriculture and strip-mining

20. What is the importance of fluoride in the drinking water?

- Fluoride ion deficiency causes tooth decay.
- It makes the enamel on teeth much harder by converting hydroxyapatite, the enamel on the surface of the teeth into much harder fluorapatite.
- Fluoride ion concentration above 2 ppm causes brown mottling of teeth. Excess fluoride causes damage to bone and teeth.

21. What is meant by TDS?

- The water containing the soluble salt of calcium, magnesium, sodium, potassium, iron and anions like carbonate, bicarbonate, chloride, sulphate, phosphate and nitrate are called total dissolved salts.
- Drinking water having TDS value higher than 500 ppm causes possibilities of irritation in stomach and intestine.

22. Define: Acid Rain.

When the pH of rainwater become lower than 5.6 it is called acid rain. It is a byproduct of various human activities that Sulphur oxides and nitrogen oxides in the atmosphere.

23. Write the uses of Green Chemistry in day to day life.

- Dry cleaning of clothes: H_2O_2 used for bleaching clothes in laundry.
- Bleaching of paper: H_2O_2 can be used for bleaching paper in presence of catalyst.
- Synthesis of chemical: Acetaldehyde is now commercially prepared.
- Instead of petrol: Methanol is used as a fuel in automobiles.
- Neem based pesticides have been synthesized, which are safer than the chlorinated hydrocarbon.

CEO CHENNAI