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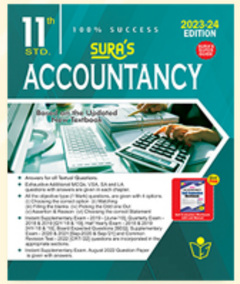

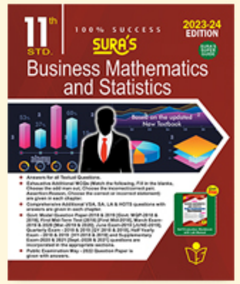

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Mrs. P. Thilagam PGT (Chemistry)

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

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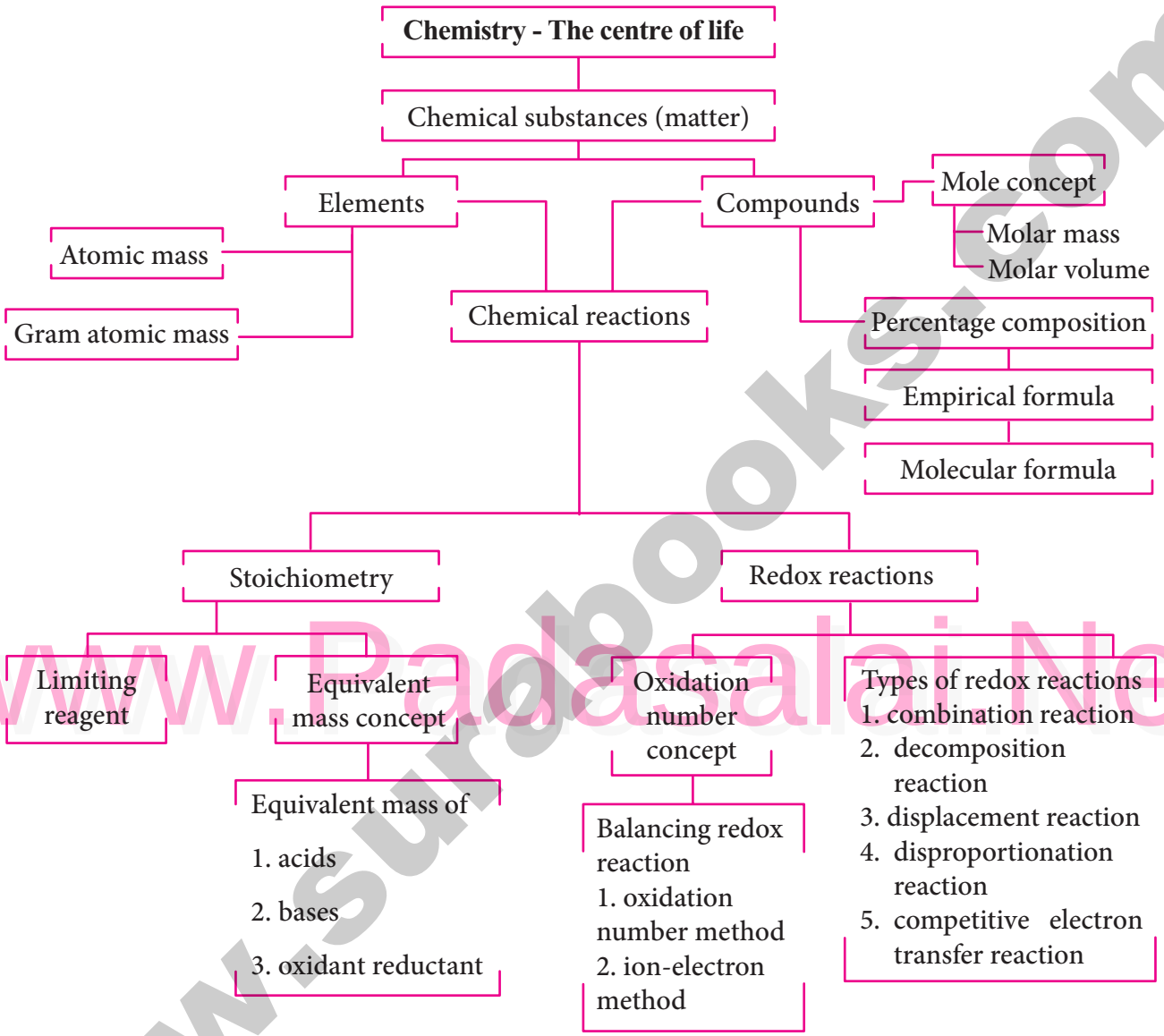
CHAPTER SNAPSHOT

CONCEPT MAP



FORMULAE TO REMEMBER

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

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

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

MUST KNOW DEFINITIONS

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

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

EVALUATION

I. Choose The Best Answer :

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

(a) 40 ml CO_2 gas
(b) 40 ml CO_2 gas and 80 ml H_2O gas
(c) 60 ml CO_2 gas and 60 ml H_2O gas
(d) 120 ml CO_2 gas **[Ans. (a) 40 ml CO_2 gas]**

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

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

(a) 201 u (b) 202 u (c) 199 u (d) 200 u
[Ans. (d) 200 u]

Hint: $= \frac{(200\times 90)+(199\times 8)+(202\times 2)}{100}$
$= 199.96 = 200u$

3. Assertion : Two mole of glucose contains 12.044×10^{23} molecules of glucose
Reason : Total number of entities present in one mole of any substance is equal to 6.02×10^{22} ***[FIRST MID-2018]***

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

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

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

(a) Carbon (b) oxygen ***[CRT - '22]***
(c) both carbon and oxygen
(d) neither carbon nor oxygen **[Ans. (b) oxygen]**

Hint: **React 1 :** $2C + O_2 \longrightarrow 2CO$
2 × 12g carbon combines with 32g of oxygen
$\therefore$ Equivalent mass of carbon $= \frac{2\times 12}{32}\times 8 = 6$

React 2 : $C + O_2 \longrightarrow CO_2$
12g carbon combines with 32g of oxygen
$\therefore$ Equivalent mass of carbon $\frac{12}{32}\times 8 = 3$

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

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

[Ans. (a) 102 g]

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

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

(a) 6.022×10^{26} (b) 6.022×10^{23}

(c) 6.022×10^{20} (d) 9.9×10^{22}

[Ans. (c) 6.022×10^{20}]

Hint: $0.001 \times 6.022 \times 10^{23}$

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

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

[Ans. (c) 16%]

Hint: impurity is equal to $1 \times 100/1.84$.

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

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

[Ans. (c) 0.075]

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

9. **When 22.4 litres of H_2 (g) is mixed with 11.2 litres of Cl_2(g), each at 273 K at 1 atm the moles of HCl (g), formed is equal to** *[CRT - '22]*

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

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

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

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

1 mole of an ideal gas occupies at 22.4 *l*.

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

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

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

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

(d) none of the above

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

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

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

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

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

(d) $Cr_2O_{3(s)} + 2Al_{(s)} \longrightarrow Al_2O_{3(s)} + 2Cr_{(s)}$

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

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

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

(a) 31.6 (b) 52.7

(c) 79 (d) None of these

[Ans. (b) 52.7]

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

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

13. **Which one of the following represents 180g of water?** *[QY-2019; Sep-2021]*

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

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

(d) 6.022×10^{24} molecules of water

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

Hint: $10 \times 6.022 \times 10^{23}$

14. **7.5 g of a gas occupies a volume of 5.6 litres at 0° C and 1 atm pressure. The gas is** *[HY-2018; May-'22]*

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

[Ans. (a) NO]

Hint: $\frac{7.5g}{5.6l} \cdot 22.4l = 30g$

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

15. **Total number of electrons present in 1.7 g of ammonia is** *[FIRST MID-2018; Aug-'22]*

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

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

[Ans. (a) 6.022×10^{23}]

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

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

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

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

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

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

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

Hint: $\overset{+3}{S_2}O_4^{2-} < \overset{+4}{SO_3^{2-}} < \overset{+5}{S_2}O_6^{2-} < \overset{+6}{SO_4^{2-}}$

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

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

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

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

(d) none of these

[Ans. (c)] $\frac{\text{molar mass of ferrous oxalate}}{3}$

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

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

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

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

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

(c) the definition of mass in units of grams

(d) the mass of one mole of carbon

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

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

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

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

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

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

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

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

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

[Ans. (a) 3.59 g]

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

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

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

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

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

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

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

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

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

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

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

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

23. **Which of the following compound(s) has/have percentage of carbon same as that in ethylene (C_2H_4)** *[QY-2019; Sep-2021]*

(a) propene (b) ethyne

(c) benzene (d) ethane

[Ans. (a) propene]

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

(a) relative atomic mass is 12 u

(b) oxidation number of carbon is +4 in all its compounds.

(c) 1 mole of carbon-12 contain 6.022×10^{22} carbon atoms.

(d) all of these

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

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

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

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

II. Write Brief Answer To The Following Questions.

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

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

$$\text{Relative atomic mass } (A_r) = \frac{\text{Average mass of the atom}}{\text{Unified atomic mass}}$$

27. What do you understand by the term mole?

[June-2019; CRT - '22]

Ans. The mole is defined as the amount of a substance which contains 6.022×10^{23} particles such as atoms, molecules or ions. It is denoted by the symbol "*n*".

28. Define equivalent mass.

[Govt. MQP-2018; QY-2018 & 19]

Ans. Gram equivalent mass is defined as the mass of an element (compound or ion) that combines or displaces 1.008g hydrogen or 8g oxygen or 35.5g chlorine.

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

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

30. Distinguish between oxidation and reduction.

[HY-2019; Sep-2021]

Ans.

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

31. Calculate the molar mass of the following compounds.

i) Urea $[CO(NH_2)_2]$

ii) Acetone $[CH_3COCH_3]$

iii) Boric acid $[H_3BO_3]$

iv) Sulphuric acid $[H_2SO_4]$

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

C : 1×12.01 = 12.01

O : 1×16 = 16.00

N : 2×14.01 = 28.02

H : 4×1.01 = 4.04

60.07 g mol^{-1}

(ii) acetone $[CH_3COCH_3]$

C : 3×12.01 = 36.03

H : 6×1.01 = 6.06

O : 1×16 = 16.00

58.09 g mol^{-1}

(iii) boric acid $[H_3BO_3]$:

H : 3×1.01 = 3.03

B : 1×10 = 10.00

O : 3×16 = 48.00

61.03 g mol^{-1}

(iv) sulphuric acid $[H_2SO_4]$:

H : 2×1.01 = 2.02

S : 1×32.06 = 32.06

O : 4×16 = 64.00

98.08 g mol^{-1}

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

Ans. **Given :**

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

Molar mass of CO_2 = ?

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

Mass of 1 mole of CO_2

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

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

$$= 44.01\ \text{g}$$

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

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

i) 1 mol of ethanol

ii) 1 mol of formic acid

iii) 1 mol of H_2O

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

46g of ethanol contains 1 × 6.022 × 10^{23} number of oxygen atoms.

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

46g of HCOOH contains 2 × 6.022 × 10^{23} number of oxygen atoms

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

18g of water contains 1 × 6.022 × 10^{23} number of oxygen atoms.

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

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

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

Ans. Isotopes of Mg

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

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

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

Average atomic mass = 24.309

Average atomic mass of Mg = 24.31u.

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

(a) 200 atoms of x + 200 atoms of y + 50 molecules of z_2

(b) 1 mol of x + 1 mol of y + 3 mol of z_2

(c) 50 atoms of x + 25 atoms of y + 50 molecules of z_2

(d) 2.5 mol of x + 5 mol of y + 5 mol of z_2

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

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

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

Ans. **Given :**

mass of one atom = 6.645×10^{-23} g

$\therefore$ mass of 1 mole of atom

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

$= 40$ g

$\therefore$ number of moles of element in 0.320 kg

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

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

$= 8$ mol.

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

Ans.

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

38. What is the empirical formula of the following?

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

ii) Caffeine ($C_8H_{10}N_4O_2$) a substance found in tea and coffee.

[FIRST MID-2018; QY-2018; Sep-2021]

Ans.

Compound	Molecular formula	Empirical formula
Fructose	$C_6H_{12}O_6$	CH_2O
Caffeine	$C_8H_{10}N_4O_2$	$C_4H_5N_2O$

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

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

i) Calculate the mass of Al_2O_3 formed.

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

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

54g 160g 102g 112g

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

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

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

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

$\therefore$ Excess Fe_2O_3 - unreacted Fe_2O_3

$= 1120 - 960 = 160$g.

$\therefore$ 160 g of excess reagent is left at the end of the reaction.

40. How many moles of ethane is required to produce 44 g of $CO_{2(g)}$ after combustion.

[FIRST MID-2018; QY. 19]

Ans. Balanced equation for the combustion of ethane

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

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

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

$\therefore$ To produce 1 mole (44 g) of CO_2 required number of moles of ethane

$$= \frac{2 \text{ mol ethane}}{4 \cancel{\text{ mol } CO_2}} \times 1 \cancel{\text{mol } CO_2}$$

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

= 0.5 mole of ethane.

Evaluate Yourself

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

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

Ans. **(i) Element** - Copper wire, Silver plate
(ii) Compound - Sugar, distilled water, carbon dioxide, Table salt, Naphthalene balls
(iii) Mixture - Sea water

2. Calculate the relative molecular mass of the following.

(i) Ethanol(C_2H_5OH)
(ii) Potassium permanganate ($KMnO_4$)
(iii) Potassium dichromate ($K_2Cr_2O_7$)
(iv) Sucrose ($C_{12}H_{22}O_{11}$)

Ans. **(i)** C_2H_5OH : $(2\times12)+(5\times1)+(1\times16)+(1\times1)=$ **46 g**

(ii) $KMnO_4$: $(1\times39)+(1\times55)+(4\times16)=$ **158 g**

(iii) $K_2Cr_2O_7$: $(2\times39)+(2\times52)+(7\times16)=$ **294 g**

(iv) $C_{12}H_{22}O_{11}$: $(12\times12)+(22\times1)+(11\times16)=$ **342 g**

3. a) Calculate the number of moles present in 9 g of ethane.

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

Ans. **(a)** Molar mass of ethane,

$C_2H_6 = (2\times12)+(6\times1) = 30\ g\ mol^{-1}$

$$\text{No of moles} = \frac{\text{mass}}{\text{molar mass}} = \frac{9g}{30g\ mol^{-1}} = 0.3\ \text{mole}$$

(b) At 273 K and 1 atm pressure 1 mole of a gas occupies a volume of 22.4 L

Therefore,

number of moles of oxygen, that occupies a volume of 224 ml at 273 K and 3 atm pressure

$$= \frac{1\ \text{mole}}{273\ \text{K}\times1\ \text{atm}\times22.4\ \text{L}}\times0.224\ \text{L}\times273\ \text{K}\times3\ \text{atm}$$

$= 0.03$ mole

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

0.03 mole of oxygen contains $= 6.022\times10^{23}\times0.03$

$=$ **1.807×10^{22} molecules of oxygen**

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

Ans. Mass of the metal $= W_1 = 0.456$g

Mass of the metal chloride $= W_2 = 0.606$g

$\therefore$ Mass of chlorine $= W_2 - W_1 = 0.606 - 0.456 = 0.15$g

0.15g of chlorine combine with 0.456g of metal

$\therefore$ 35.5g of chlorine will combine with

$$\frac{0.456}{0.15}\times35.5 = 107.92\ g\ eq^{-1}$$

b) Calculate the equivalent mass of potassium dichromate. The reduction half reaction in acid medium is,

$$Cr_2O_7^{-2} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$$

Ans. Equivalent mass of a oxidising agent

$$= \frac{\text{Molar mass}}{\text{No. of moles of electrons gained by one mole of the reducing agent}}$$

$$= \frac{294.18\ mol^{-1}}{6\ eq\ mol^{-1}} = 49.03$$

$= 49.0\ g\ eq^{-1}$

Government Exam Questions and Answers

Choose the Correct Answer 1 MARK

1. The equivalent mass of a divalent metal element is 10 g eq^{-1}. The molar mass of its anhydrous oxide is *[Govt. MQP-2018]*

(a) 46 g (b) 36 g
(c) 52 g (d) none of these

[Ans. (c) 52 g]

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

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

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

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

[Ans. (d) 2 1 4 3]

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

3. The oxidation number of chromium in dichromate (ion) is *[QY-2018]*

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

[Ans. (b) +6]

4. The empirical formula of glucose is : *[HY-2019]*

(a) CH_2O (b) CHO (c) CH_2O_2 (d) CH_3O_2

[Ans. (a) CH_2O]

5. The oxidation number of carbon in CH_2F_2 is ____. *[June-2019]*

(a) +4 (b) –4 (c) 0 (d) +2

[Ans. (c) 0]

6. The relative molecular mass of ethanol is *[Sep-2020]*

(a) 0.46 g (b) 4.6 g (c) 460 g (d) 46 g

[Ans. (d) 46 g]

Answer the Questions 2 MARKS

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

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

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

The reaction involving gain of electron is termed reduction.

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

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

Ans. **(i)** The balanced stoichiometric equation for the formation of ammonia is

$$N_2(g) + 3\,H_2(g) \longrightarrow 2\,NH_3(g)$$

(ii) To produce 2 moles of ammonia, 3 moles of hydrogen are required

∴ To produce 10 moles of ammonia

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

= 15 moles of hydrogen are required.

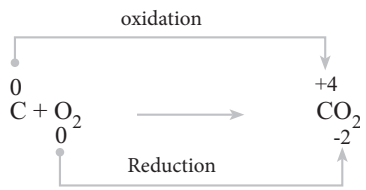
3. Calculate oxidation number of oxygen in H_2O_2. *[Mar-2019]*

Ans. Hydrogen peroxide (H_2O_2)

$2(+1) + 2x = 0; \Rightarrow 2x = -2; \Rightarrow x = -1$

4. What is combination reaction? Give example. *[HY-2019]*

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



5. Calculate the oxidation states of oxygen in H_2O_2 and KO_2. *[QY-2019]*

Ans. Hydrogen peroxide (H_2O_2) is –1.

$2(+1) + 2x = 0; \Rightarrow 2x = -2; \Rightarrow x = -1$

Super oxides such as KO_2 is –1/2

$+1 + 2x = 0; \Rightarrow 2x = -1; \Rightarrow x = -1/2$.

4. Distinguish between the following.

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

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

Ans.

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

NUMERICAL PROBLEMS

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

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

Sol: **(i)** 1 mol of He ≡ 4g ≡ 6.022×10^{23} He atoms

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

$$\therefore \text{ 52g of He contains } = \frac{6.022\times10^{23}\times52}{4}$$

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

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

(ii) 1 mol of He contains 6.022×10^{23} He atoms

$$\therefore \text{ 52 moles of He contains } = \frac{6.022\times10^{23}\times52}{1}$$

$$= 3.131\times10^{25}$$

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

2. Calculate the mass of the following :

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

(iii) 1 molecule of water.

Sol: **(i)** Molecular mass of silver (Ag) = 107.87 u

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

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

$$= \frac{107.87 \text{ g mol}^{-1}}{6.022\times10^{23} \text{ mol}^{-1}}$$

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

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

(ii) Molecular mass of benzene (C_6H_6) = (6 × 12.01 u) + (6 × 1u) = 78.06 u

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

Then, mass of 1 molecule of benzene

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

$$= \frac{78.06 \text{ g mol}^{-1}}{6.022\times10^{23} \text{ mol}^{-1}} = 12.96 \times 10^{-23} \text{ g}$$

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

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

= 18 u

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

Mass of 1 molecule of water

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

$$= \frac{18\text{g mol}^{-1}}{6.022\times10^{23} \text{ mol}^{-1}} = 2.99 \times 10^{-23} \text{ g}$$

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

27. The organic compound Vitamin-C, has the following composition by mass: 40.92% C, 4.58% H, and the rest is oxygen. Determine its molecular formula. Molar mass of the substance is 176 g mol^{-1}.

Sol:

Element	Percentage	Atomic mass	Relative No. of moles	Simplest whole Number Ratio
C	40.92	12	$\frac{40.92}{12} = 3.41$	3
H	4.58	1	$\frac{4.58}{1} = 4.58$	4
O	100 – [40.92 +4.58] =54.5	16	$\frac{54.5}{16} = 3.406$	3

Empirical formula is $C_3H_4O_3$

Empirical formula mass = (12 × 3) + (1 ×4)+ (3 × 16) = 36 + 4 + 48 = 88

Molecular formula = n × empirical formula

$$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}} = \frac{176}{88} = 2$$

n = 2

∴ Molecular formula = n × (emp. formula) = 2 × ($C_3H_4O_3$) = $C_6H_8O_6$

REDOX REACTION ACTIVITY

1. A piece of cut apple becomes brown. Why? Can you prevent it by a simple method?

Ans. Apple turns brown when cut since the surface is exposed to air and undergoes oxidation. It can be prevented by dipping sliced apples in lemon juice. Lemon juice is an antioxidant which takes in all the available oxygen and prevents it from reaching the apple's tissues.

2. Place an iron piece in a moist atmosphere and observe it after two days. Is there any deposition of new substance? Why does it happen? What is this phenomenon called?

Ans. When iron is exposed to moist air, the iron reacts with oxygen in the presence of moisture to from a reddish - brown chemical compound, iron - oxide. This phenonaenon is called rusting. A new substance Iron (III) oxide is formed.

$4\,Fe + 3O_2 + 6H_2O \rightarrow 4\,Fe(OH)_3$

3. Calculate the oxidation number of underlined atoms of the following:

1. $\underline{K_2Mn}O_4$
2. $\underline{K_2Cr}O_4$
3. $\underline{N}O_3^-$
4. $H_4\underline{P_2}O_7$
5. $\underline{Cl}O_3^-$
6. $\underline{As}O_3^{3-}$

Ans.

1. $\underline{K_2Mn}O_4$

Oxidation number of Mn be x

$2(1) + x + 4(-2) = 0$

$2 + x - 8 = 0$

$x - 6 = 0$

$x = 6$

Oxidation number of Mn in K_2MnO_4 is +6.

2. $\underline{K_2Cr}O_4$

$2(1) + x + 4(-2) = 0$

$2 + x - 8 = 0$

$x - 6 = 0$

$x = +6$

Oxidation number of Cr in K_2CrO_4 is +6.

3. $\underline{N}O_3^-$

$x + 3(-2) = -1$

$x - 6 = -1$

$x = -1 + 6 = +5$

Oxidation number of N in NO_3^- is +5.

4. $H_4P_2O_7$

$4(1) + 2x + 7(-2) = 0$

$4 + 2x - 14 = 0$

$2x - 10 = 0$

$2x = 10$

$x = 5$

Oxidation number of P in $H_4P_2O_7$ is +5.

5. ClO_3^-

$x + 3(-2) = -1$

$x - 6 = -1$

$x = +5$

Oxidation number of Cl in ClO_3^- is +5.

6. AsO_3^{3-}

$x + 3(-2) = -3$

$x - 6 = -3$

$x = -3 + 6$

$x = +3$

Oxidation number of As in AsO_3^{3-} is +3.

4. An iron nail is placed in copper sulphate solution taken in the beaker. Observe it for some time? Find the changes that takes place and why?

Ans. When iron nail is dipped in copper sulphate solution, the colour of copper sulphate tuns from blue to light green and reddish brown deposits is formed on iron nail. This is because iron is more reactive than copper, so it displaces Cu from $CuSO_4$ solution.

The displacement reaction can be written as

$CuSO_4 + Fe \rightarrow FeSO_4 + Cu$

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

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

$$\text{No of moles (n)} = \frac{\text{Mass of the substance}}{\text{Molar mass of the substance}}$$

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

$= 4 \times 10^6$ moles

Mass of $CH_3OH = 320 \times 10^6$g

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

$$= \frac{320 \times 10^6}{32} = 10 \times 10^6 \text{ moles}$$

Methyl alcohol is produced more.

6. Find the molecular mass of $FeSO_4 7H_2O$.

Ans. Molecular mass of $FeSO_4 7H_2O$

Atomic mass of Fe = 55.845

Atomic mass of S = 32.065

Atomic mass of O_4 = $16 \times 4 = 64$

Atomic mass of H_2 = $1.00794 \times 2 = 2.01588$

Atomic mass of O = 16

Molecular mass of $FeSO_4.7H_2O$ = $55.845 + 32.065 + 64 + 7(2.01588 + 16)$

= 278.02g/mol

7. The density of CO_2 is 1.977 kgm^{-3} at STP. Calculate the molecular mass of CO_2.

Ans. Density of $CO_2 = 1.977\ Kgm^{-3}$

$PV = nRT$

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

$$PV = \frac{\text{Mass}}{\text{Molar Mass}} \times R \times T$$

$$\text{Molar Mass} = \frac{\text{Mass}}{V} \times \frac{R \times T}{P}$$

$$\text{Density} = \frac{\text{Mass}}{V}$$

$$\text{Molar Mass of } CO_2 = \frac{D \times R \times T}{P}$$

Standard Temperature = 273 K

Standard Pressure = 760mm of Hg = 1amu

$$= \frac{1.977 \times 0.0821 \times 273}{1}$$

$= 44$

8. How many moles of glucose are present in 720 g of glucose?

Ans.

Mass of glucose = 720g

Molecular weight of glucose ($C_6H_{12}O_6$) = 180

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

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

9. Calculate the weight of 0.2 mole of sodium carbonate.

Ans. No. of moles of Na_2CO_3 = 0.2 mole

Molar mass of Na_2CO_3 = 106g/mol

Mass = No of moles × molar mass of Na_2CO_3

= 0.2 × 106 = 21.2g

10. Calculate the equivalent mass of bicarbonate ion.

Ans.

Bicarbonate ion = HCO^-_3

Molar mass of HCO^-_3 = 61

$$\text{Equivalent mass of ion} = \frac{\text{Molar mass}}{\text{Charge of ion}}$$

$$\text{Equivalent mass of } HCO^-_3 = \frac{61}{1} = 61$$

11. Calculate the equivalent mass of barium hydroxide

Ans. Equivalent mass of $Ba(OH)_2$

Molar mass of $Ba(OH)_2$ = 171.34 g/mol

Acidity of the $Ba(OH)_2$ = 2

Equivalent mass of the $Ba(OH)_2$

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

$$= \frac{171}{2} = 85.5$$

12. Boric acid, H_3BO_3 is a mild antiseptic and is often used as an eye wash. A sample contains 0.543 mol H_3BO_3. What is the mass of boric acid in the sample.

Ans.

Formula mass of boric acid H_3BO_3 = 61.834 amu

1 mole of H_3BO_3 = Molar mass of H_3BO_3 = 61.834 g

0.543 mole of H_3BO_3 = 61.834 × 0.543 = 33.57 g of H_3BO_3

The mass of 0.543 moles of H_3BO_3 = 33.57g

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

Ans.

Decrease in O.N (Reduction)
Decreases by +3
$K_2Cr_2O_7 + KI + H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + I_2 + H_2O$
+6 −1 Increases by +1 0
Increase in O N (oxidation)

Equalise the increase / decrease in O N by multiplying I species by 1

$K_2Cr_2O_7 + 3KI + H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 3I_2 + H_2O$

Balance all other atoms except H and O

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

Balance O atom by adding H_2O on the the side falling short of oxygen

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

So the balanced equation is

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

(ii) $KMnO_4 + Na_2SO_3 \longrightarrow MnO_2 + Na_2SO_4 +$ KOH (Alkaline medium)

Decrease in O.N (Reduction)
Decreases by +3
$KMnO_4 + Na_2SO_3 \rightarrow MnO_2 + Na_2SO_4 + KOH$
+7 +4 Increases by +2 +6
Increase in O N (oxidation)

Equalise the increase / decrease in O N by multiplying Mn species by 2 and S species by 3

$2KMnO_4 + 3Na_2SO_3 \longrightarrow 2MnO_2 + 3Na_2SO_4 + KOH$

Balance all other atoms except H and O

$2KMnO_4 + 3Na_2SO_3 \longrightarrow 2MnO_2 + 3Na_2SO_4 + 2KOH$

Balance O atoms by adding H_2O molecules on the side falling short of oxygen atom.

$2KMnO_4 + 3Na_2SO_3 + H_2O \longrightarrow 2MnO_2 + 3Na_2SO_4 + 2KOH$

Balance H atom by adding H+ ion on the side falling short of hydrogen.

$$S_2O_3^{2-} + 3I_2 + 3H_2O \longrightarrow S_2O_6^{2-} + 6I^- + 6H^+$$

Add equal number of OH– ion on the both side since the medium is alkaline

$$S_2O_3^{2-} + 3I_2 + 3H_2O + 6OH^- \longrightarrow S_2O_6^{2-} + 6I^- + 6H^+ + 60H^-$$

$$S_2O_3^{2-} + 3I_2 + 3H_2O + 6OH^- \longrightarrow S_2O_6^{2-} + 6I^- + 6H_2O$$

15. A compound contains 50% of X (atomic mass 10) and 50% Y (atomic mass 20). Give its molecular formula.

Ans.

Element	Percentage	Atomic mass	Relative No. of moles	Simple Ratio Moles	Simplest whole number Ratio
X	50	10	$\frac{50}{10} = 5$	$\frac{5}{2.5} = 2$	2
Y	50	20	$\frac{50}{20} = 2.5$	$\frac{2.5}{2.5} = 1$	1

Its simplest formula = X_2Y

16. Determine the empirical formula of a compound containing K = 24.75%, Mn = 34.77% and rest is oxygen.

Ans.

Element	Percentage	Atomic mass	Relative No. of moles	Simple Ratio Moles	Simplest whole number Ratio
K	24.75	39	$\frac{24.75}{39} = 0.63$	$\frac{0.63}{0.63} = 1$	1
Mn	34.77	55	$\frac{34.77}{55} = 0.63$	$\frac{0.63}{0.63} = 1$	1
O	100 – (24.75 + 34.77) = 40.48	16	$\frac{40.48}{16} = 2.53$	$\frac{2.53}{0.63} = 4$	4

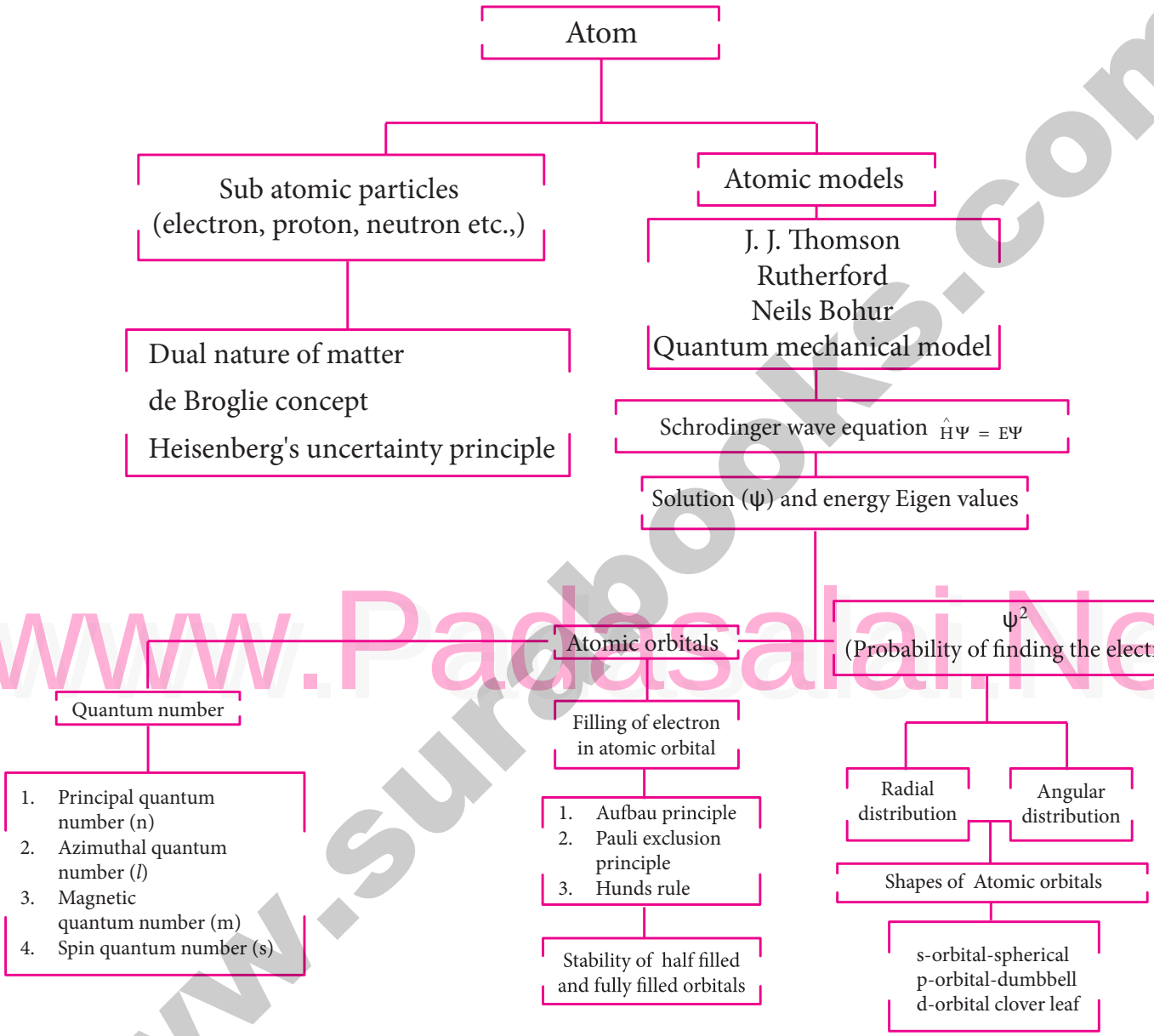
The empirical formula is $KMnO_4$

✶ ✶ ✶

02 Quantum Mechanical Model of Atom

CHAPTER SNAPSHOT

CONCEPT MAP



FORMULAE TO REMEMBER

- Mass Number = No. of protons + No. of neutrons
- Atomic Number = No. of protons + No. of neutrons
- **Planck's Quantum theory :** $E = h\nu$
  E = energy ; h = plank's constant ; ν = frequency
- **Einstein's equation :** $E = mc^2$
  E = energy ; m = mass ; c = velocity of light
- **de-Broglie equation :** $\lambda = \frac{h}{mc}$ (or) $\frac{h}{mv}$ (or) $\frac{h}{p}$
  $p = mv$
  p = momentum of the particle ; m = mass ; v = Velocity
- **Kinetic energy :** $K.E = \frac{1}{2}mv^2$
  K.E = kinetic energy; m = mass ; v = Velocity
- **Heisenberg's Uncertainty Principle :** $\Delta x.\Delta p \geq \frac{h}{4\pi}$ (or) $\Delta x.m\Delta v \simeq \frac{h}{4\pi}$
  Δx = uncertainty in position
  Δp = uncertainty in momentum
  h = plank's constant
- **Schrodinger wave equation :** $\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} + \frac{8\pi^2 m}{h^2}(E - V)\psi = 0$
  ψ = amplitude of wave; E = total energy of electron
  V = potential energy; m = mass of electron
- **Bohr's atomic model :**
  (i) Energy of electron in n^{th} orbit $(E_n) = \frac{-2\pi^2 mz^2e^4}{n^2h^2}$
  (ii) Angular momentum of n^{th} orbit : $mvr = \frac{nh}{2\pi}$
- **de-Broglie wavelength :** $\lambda = \frac{h}{mv} = \frac{h}{p}$ (p-momentum)
- Maximum no. of electrons that a shell can accommodate is $2n^2$
- Total number of nodes = $n - 1$
- Radial nodes = $n - l$
- Angular nodes = l

MUST KNOW DEFINITIONS

Characteristics of Fundamental Particles :

	ELECTRON	PROTON	NEUTRON
Discoverer	J.J. Thomson (1897)	Goldstein (1919)	James Chadwick (1932)
Symbol	${}_{-1}e^{0}$	${}_{1}p^{1}$	${}_{1}n^{0}$
Location	Around the nucleus	Within the nucleus	Within the nucleus
Charge	Negative	Positive	Neutral
Mass	9.11×10^{-31} kg	1.6726×10^{-27} kg	1.6749×10^{-27} kg

Atom : The smallest particle that can take part in chemical reaction.

Nuclear model of an atom :

(i) **Thomson - Model** - atom is spherical in which positive charge is uniformly distributed and electrons are embedded in it.

(ii) **Rutherford's Model :** An atom consists of a tiny positively charged nucleus at its centre. The nucleus is surrounded by electrons that move around the nucleus with very high speed in circular paths called **orbits**. Thus, Rutherford's model of atom resembles the solar system in which the sun plays the role of the nucleus and the planets that of revolving electrons. Electrons and the nucleus are held together by electrostatic forces of attraction.

Atomic Number (Z) : Number of protons or Number of electrons

Mass Number (A) : Number of nucleons (number of protons + number of neutrons)

Isotopes : Atoms of same element having same atomic number and different mass number

Eg : ${}_{1}H^{1}$, ${}_{1}H^{2}$, ${}_{1}H^{3}$

Isobars : Atoms of same element having same mass number and different atomic number

Eg : ${}^{14}_{6}C$, ${}_{7}N^{14}$

Isotones : These species posses same number of neutrons. Their atomic and mass numbers are different. Eg: ${}^{14}_{6}C$, ${}_{7}N^{15}$, ${}_{8}O^{16}$

Isoelectronic species : The species (atoms or ions) containing same number of electrons.

Eg : O^{2-}, F^{-}, Na^{+}, Mg^{2+}, Al^{3+}, Ne

Hydrogen spectrum : It is a line emission spectrum.

Dual nature of electron :

(i) **de-Broglie wavelength :** $\lambda = \frac{h}{mv} = \frac{h}{p}$ (p-momentum)

(ii) **Heisenberg's Uncertainty Principle :** It is impossible to accurately determine both the position as well as the momentum of a microscopic particle simultaneously

$$\Delta x.\Delta p \geq \frac{h}{4\pi}$$

EVALUATION

I. Choose The Best Answer :

1. Electronic configuration of species M^{2+} is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6$ and its atomic weight is 56. The number of neutrons in the nucleus of species M is

(a) 26 (b) 22 (c) 30 (d) 24

[Ans. (c) 30]

Hint: M^{2+} : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6$
M : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8$
Atomic number = 26
Mass number = 56
No. of neutrons = 56 – 26 = 30

2. The energy of light of wavelength 45 nm is **[HY-2018]**

(a) 6.67×10^{15}J (b) 6.67×10^{11}J
(c) 4.42×10^{-18}J (d) 4.42×10^{-15}J

[Ans. (c) 4.42×10^{-18}J]

Hint: $E = h\nu = hc/\lambda$
$= \frac{6.626\times10^{-34}\ \text{Js}\times3\times10^{8}\ \text{ms}^{-1}}{45\times10^{-9}\ \text{m}} = 4.42\times10^{-18}\ \text{J}.$

3. The energies E_1 and E_2 of two radiations are 25 eV and 50 eV respectively. The relation between their wavelengths ie λ_1 and λ_2 will be

(a) $\frac{\lambda_1}{\lambda_2} = 1$ (b) $\lambda_1 = 2\lambda_2$
(c) $\lambda_1 = \sqrt{25\times50}\ \lambda_2$ (d) $2\lambda_1 = \lambda_2$

[Ans. (b) $\lambda_1 = 2\lambda_2$]

Hint: $\frac{E_1}{E_2} = \frac{25\text{eV}}{50\text{eV}} = \frac{1}{2}$

$\frac{hc}{\lambda_1}\times\frac{\lambda_2}{hc} = \frac{1}{2}$

$2\lambda_2 = \lambda_1$

4. Splitting of spectral lines in an electric field is called *[FIRST MID-2018; Mar-2019; CRT & May - '22]*

(a) Zeeman effect (b) Shielding effect
(c) Compton effect (d) Stark effect

[Ans. (d) Stark effect]

Hint: Splitting of spectral lines in magnetic field is called zeeman effect and splitting of spectral lines in electric field is called stark effect.

5. Based on equation $E = -2.178 \times 10^{-18}\text{J}\left(\frac{z^2}{n^2}\right)$, certain conclusions are written. Which of them is not correct ? ***(NEET)***

(a) Equation can be used to calculate the change in energy when the electron changes orbit
(b) For n = 1, the electron has a more negative energy than it does for n = 6 which means that the electron is more loosely bound in the smallest allowed orbit
(c) The negative sign in equation simply means that the energy of electron bound to the nucleus is lower than it would be if the electrons were at the infinite distance from the nucleus.
(d) Larger the value of n, the larger is the orbit radius.

[Ans. (b) For n = 1, the electron has a more negative energy than it does for n = 6 which means that the electron is more loosely bound in the smallest allowed orbit]

6. According to the Bohr Theory, which of the following transitions in the hydrogen atom will give rise to the least energetic photon ?

(a) n = 6 to n = 1 (b) n = 5 to n = 4
(c) n = 5 to n = 3 (d) n = 6 to n = 5

[Ans. (d) n = 6 to n = 5]

7. Assertion : The spectrum of He^+ is expected to be similar to that of hydrogen
Reason : He^+ is also one electron system.

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

[Ans. (a) If both assertion and reason are true and reason is the correct explanation of assertion.]

8. **Which of the following pairs of d-orbitals will have electron density along the axes ?** ***(NEET Phase - II)***

(a) d_{z^2}, d_{xz} (b) d_{xz}, d_{yz}

(c) d_{z^2}, $d_{x^2-y^2}$ (d) d_{xy}, $d_{x^2-y^2}$

[Ans. (c) d_{z^2}, $d_{x^2-y^2}$]

9. **Two electrons occupying the same orbital are distinguished by**

(a) azimuthal quantum number
(b) spin quantum number
(c) magnetic quantum number
(d) orbital quantum number

[Ans. (b) spin quantum number]

10. **The electronic configuration of Eu (Atomic no. 63) Gd (Atomic no. 64) and Tb (Atomic no. 65) are** ***(NEET Phase - II)***

(a) [Xe] $4f^6\ 5d^1\ 6s^2$, [Xe] $4f^7\ 5d^1\ 6s^2$ and [Xe] $4f^8\ 5d^1\ 6s^2$
(b) [Xe] $4f^7$, $6s^2$, [Xe] $4f^7\ 5d^1\ 6s^2$ and [Xe] $4f^9\ 6s^2$
(c) [Xe] $4f^7$, $6s^2$, [Xe] $4f^8\ 6s^2$ and [Xe] $4f^8\ 5d^1\ 6s^2$
(d) [Xe] $4f^6\ 5d^1\ 6s^2$, [Xe] $4f^7\ 5d^1\ 6s^2$ and [Xe] $4f^9\ 6s^2$

[Ans. (b) [Xe] $4f^7$, $6s^2$, [Xe] $4f^7\ 5d^1\ 6s^2$ and [Xe] $4f^9\ 6s^2$]

11. **The maximum number of electrons in a sub shell is given by the expression**

(a) $2n^2$ (b) $2l + 1$

(c) $4l + 2$ (d) none of these

[Ans. (c) $4l + 2$]

Hint: $2(2l + 1) = 4l + 2$

12. **For d-electron, the orbital angular momentum is**

(a) $\frac{\sqrt{2}h}{2\pi}$ (b) $\frac{\sqrt{2}h}{2\pi}$

(c) $\frac{\sqrt{2\times 4}h}{2\pi}$ (d) $\frac{\sqrt{6}h}{2\pi}$ **[Ans. (d) $\frac{\sqrt{6}h}{2\pi}$]**

Hint: Orbital angular momentum

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

For d orbital $= \frac{\sqrt{(2\times 3)}h}{2\pi} = \frac{\sqrt{6}h}{2\pi}$

13. **What is the maximum numbers of electrons that can be associated with the following set of quantum numbers ? n = 3, l = 1 and m = –1**

(a) 4 (b) 6 (c) 2 (d) 10

[Ans. (c) 2]

14. **Assertion : Number of radial and angular nodes for 3p orbital are 1, 1 respectively.**

Reason : Number of radial and angular nodes depends only on principal quantum number.

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

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

Hint: Radial nodes is equal to n–l–1 and angular nodes is equal to n – 1

15. **The total number of orbitals associated with the principal quantum number n = 3 is** ***[CRT & Aug -'22]***

(a) 9 (b) 8 (c) 5 (d) 7

[Ans. (a) 9]

16. **If n = 6, the correct sequence for filling of electrons will be,**

(a) ns → (n – 2) f → (n – 1)d → np
(b) ns → (n – 1) d → (n – 2) f → np
(c) ns → (n – 2) f → np → (n – 1) d
(d) none of these are correct

[Ans. (a) ns → (n – 2) f → (n – 1)d → np]

17. **Consider the following sets of quantum numbers :**

	n	l	m	s
(i)	3	0	0	$+\frac{1}{2}$
(ii)	2	2	1	$-\frac{1}{2}$
(iii)	4	3	–2	$+\frac{1}{2}$
(iv)	1	0	–1	$+\frac{1}{2}$
(v)	3	4	3	$-\frac{1}{2}$

25. Which of the following does not represent the mathematical expression for the Heisenberg uncertainty principle ?

(a) $\Delta x.\Delta p \geq \frac{h}{4\pi}$ (b) $\Delta x.\Delta v \geq \frac{h}{4\pi m}$

(c) $\Delta E.\Delta t \geq \frac{h}{4\pi}$ (d) $\Delta E.\Delta x \geq \frac{h}{4\pi}$

[Ans. (d) $\Delta E.\Delta x \geq \frac{h}{4\pi}$**]**

II. Write Brief Answer To The Following Questions.

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

Ans. Magnetic quantum number reveal information about the shape, energy orientation and size of orbitals.

27. How many orbitals are possible for n = 4?

[May-'22]

Ans. If n = 4, the possible number of orbitals are calculated as follows.

n = 4 main shell = N

If n = 4 L values are 0, 1, 2, 3

If $l = 0$ 4s orbital = 1 orbital

If $l = 1$ m = –1, 0, +1 = 3 orbitals.

If $l = 2$ m = –2, –1, 0, +1, +2 = 5 orbitals.

If $l = 3$ m = –3, –2, –1, 0, +1, +2 , +3 = 7 orbitals

∴ Total number of orbitals = 16 orbitals.

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

Ans.

Orbital	n	l	Radial node $n - l - 1$	Angular node l
2s	2	0	1	0
4p	4	1	2	1
5d	5	2	2	2
4f	4	3	0	3

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

Ans. **(i) Symmetry :** The half filled orbitals are more symmetrical than partially filled orbital and this symmetry leads to greater stability.

(ii) Exchange energy : The electrons with same spin in the different orbitals of the same subshell can exchange their position. Each such exchange releases energy and this is known as exchange energy. Greater the number of exchanges, greater the exchange energy and greater the stability.

In d-orbital 10 exchanges are possible but in p-orbital 6 exchanges are possible.

30. Consider the following electronic arrangements for the d^5 configuration.

(a) (b) (c)

(i) which of these represents the ground state

(ii) which configuration has the maximum exchange energy.

Ans. **(i) ground state :**

(ii) maximum exchange energy :

31. State and explain pauli's exclusion principle.

[FIRST MID-2018; HY-2018; Mar. 19]

Ans. Pauli's exclusion principle states that "No two electrons in an atom can have the same set of values of all four quantum numbers. H(Z = 1) $1s^{-1}$.

one electron is present in hydrogen atom, the four quantum numbers are: $n = 1$; $l = 0$; $m = 0$ and $s = +½$.

For helium Z = 2. He : $1s^2$

In this one electron has the quantum number. Same as that of hydrogen $n = 1$, $l = 0$, $m = 0$ and $s = –½$. For the other quantum number it is different i.e., $n = 1$, $l = 0$, $m = 0$ and $s = –½$.

32. Define orbital? what are the n and l values for $3p_x$ and $4d_{x^2-y^2}$ electron?

[FIRST MID-2018; QY-2018; June-2019]

Ans. **(i)** Orbital is a three dimensional space where the probability of finding the electron is maximum.

(ii) For $3p_x$ electron n value = 3, l value = 1

(iii) For $4d_{x^2-y^2}$ electron n value = 4, l value = 2

33. Explain briefly the time independent schrodinger wave equation? *[QY-2019]*

Ans. Erwin Schrödinger expressed the wave nature of electron in terms of a differential equation. This equation determines the change of wave function in space depending on the field of force in which the electron moves. The time independent Schrödinger equation can be expressed as,

$$\hat{H}\psi = E\psi$$

de broglie equation = $\frac{6.626\times10^{-34}\times \cancel{Kg}\ \cancel{m^2}\ \cancel{s^{-1}}}{0.16\ \cancel{Kg}\times38.88\ \cancel{ms^{-1}}}$

$\lambda = \frac{6.626\times10^{-34}}{6.2208}$

$\lambda = 1.065\times10^{-34}$ m.

Wave length in cm $= 1.065\times10^{-34}\times100$

$= 1.065\times10^{-32}$ cm (or)

1.065×10^{-34} m

48. Suppose that the uncertainty in determining the position of an electron in an orbit is 0.6 Å. What is the uncertainty in its momentum?

Ans. Δx = uncertainty in position of an electron = 0.6 Å $= 0.6\times10^{-10}$ m

Δp = uncertainty in momentum = ?

Heisenberg's uncertainty principle states that

$\Delta x.\Delta p \geq \frac{h}{4\pi}$

$\Delta p \geq \frac{h}{4\pi.\Delta x}$

h ≥ Planck's constant

$\geq 6.626\times10^{-34}$ Kg m^2 s^{-1}

$\Delta p \geq \frac{6.626\times10^{-34}\ \text{Kg m}^2\ \text{s}^{-1}}{4\times3.14\times0.6\times10^{-10}\ \text{m}}$

$\geq \frac{6.626\times10^{-34}\times10^{10}}{7.536}$

Uncertainty in momentum = $\Delta p \geq 0.8792\times10^{-24}$ Kg ms^{-1}

(or) 8.792×10^{-25} Kg ms^{-1}

$\Delta p \geq 8.8\times10^{-25}$ Kg ms^{-1}

49. 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 (ΔV) is equal to 1/ 4π of its velocity(V). *[FIRST MID-2018]*

Ans. Given Δx =

Δv = ?

$\Delta x.\Delta p \geq \frac{h}{4\pi}$

$\lambda(m\Delta v) \geq \frac{h}{4\pi}$

$\Delta v \geq \frac{h}{4\pi(m\lambda)}$

$\Delta v \geq \frac{h}{4\pi\times m\times\frac{h}{mv}}$ $\left[\because \lambda = \frac{h}{mv}\right]$

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

∴ Minimum uncertainty in velocity = $\frac{v}{4\pi}$.

50. What is the de Broglie wave length of an electron, which is accelerated from the rest, through a potential difference of 100 V? *[Govt. MQP-2018]*

Ans. Potential difference= V = 100 V

Potential energy = eV = $100\times1.6\times10^{-19}$

de Broglie wave length of an electron

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

$= \frac{6.626\times10^{-34}\ \text{kgm}^2\text{s}^{-1}}{\sqrt{2\times9.1\times10^{-31}\times100\times1.6\times10^{-19}}}$

$\boxed{\lambda = 1.22\times10^{-10}\ \text{m}}$

$\boxed{\lambda = 1.22\text{A}^{\circ}}$

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

n	*l*	m	Sub energy level
?	?	0	4d
3	1	0	?
?	?	?	5p
?	?	–2	3d

Ans.

n	*l*	m	Sub energy level
4	2	0	4d
3	1	0	3p
5	1	any one value –1, 0, +1	5p
3	2	–2	3d

✶ ✶ ✶

Evaluate Yourself

1. Calculate the de-Broglie wavelength of an electron that has been accelerated from rest through a potential difference of 1 keV.

Ans.

Given: accelerated potential = 1 keV

The kinetic energy of the electron = the energy due to accelerating potential.

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

$mv^2 = 2eV$

$m^2v^2 = 2meV \Rightarrow (mv)^2 = 2meV$

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

de Broglie wavelength $\lambda = \frac{h}{mv} \Rightarrow \lambda = \frac{h}{\sqrt{2meV}}$

m = mass of the electron $= 9.1 \times 10^{-31}$ kg

h = Planck constant $= 6.626 \times 10^{-34}$ Js

[1 eV = 1.6×10^{-19} J, 1 keV = $10^3 \times 1.6 \times 10^{-9}$]

$[\therefore \frac{Js}{\sqrt{J\,kg}} = J^{1/2}kg^{1/2}.S$

$= (kgm^2s^{-2})^{1/2}.kg^{1/2}\,S$

$= m]$

$$\lambda = \frac{6.626 \times 10^{-34}\,Js}{\sqrt{2\times9.1\times10^{-31}\times1\times10^{3}\times1.6\times10^{-19}\,kgJ}}$$

$$= \frac{6.626\times10^{-34}}{\sqrt{29120\times10^{-50}}}m = \frac{6.626\times10^{-34}}{170.645\times10^{-25}}m$$

$\lambda = 0.0388 \times 10^{-9}$ m $= 3.88\times10^{-2}\times10^{-9}$ m

$\lambda = 3.88\times10^{-11}$ m

2. Calculate the uncertainty in the position of an electron, if the uncertainty in its velocity is 5.7×10^5 ms^{-1}. *[June-2019]*

Ans. **Given :**

$\Delta v = 5.7 \times 10^5 ms^{-1}$ $\Delta x = ?$

According to Heisenberg's uncertainty principle,

$$\Delta x.\Delta p \geq \frac{h}{4\pi}$$

$$\frac{h}{4\pi} = \frac{6.626\times10^{-34}}{4\times3.14}\,kgm^2s^{-1}$$

$$\frac{h}{4\pi} = 5.28\times10^{-35}$$

$\Delta x.\Delta p \geq 5.28 \times 10^{-35}$

$\Delta x.m.\Delta v \geq 5.28 \times 10^{-35}$

$$\Rightarrow \Delta x \geq \frac{5.28\times10^{-35}\,kgm^2s^{-1}}{9.1\times10^{-31}\,k\,g\times5.7\times10^{5}\,ms^{-1}}$$

$\Rightarrow \Delta x \geq 1.017\times10^{-10}$ m

3. How many orbitals are possible in the 4th energy level? (n=4)

Ans. n = 4 ; l = 0, 1, 2, 3

$\therefore$ 4 sub shells s, p, d & f.

l = 0 ml = 0 $\Rightarrow$ one 4s orbital.

l = 1 ml = –1, 0, + 1 $\Rightarrow$ three 4p orbitals.

l = 2 ml = –2, –1, 0, +1, +2 $\Rightarrow$ five 4d orbitals.

l = 3 ml = –3, –2, –1, 0, +1, +2, +3 $\Rightarrow$ seven 4f orbitals.

Over all 16 orbitals are possible.

4. Calculate the total number of angular nodes and radial nodes present in 3d and 4f orbitals. *[Sep-2020]*

Ans.

Orbital	n	*l*	Radial node n-*l*-1	Angular node *l*	Total node n – 1
3*d*	3	2	0	2	2
4*f*	4	3	0	3	3

5. 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? *[HY-2019]*

Ans. $E_n = \frac{-13.6}{n^2}$ eV

Second excited state

n = 3 $\therefore E_3 = \frac{-13.6}{9}$ eV

$E_3 = -1.51$ eV

6. How many unpaired electrons are present in the ground state of Fe^{3+} (z=26), Mn^{2+} (z=25) and argon (z=18)?

Ans. Electronic configuration of Fe^{3+} is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^0\ 3d^5$

Five unpaired electrons.

$3d^5$

Electronic configuration of Mn^{2+} is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^0\ 3d^5$

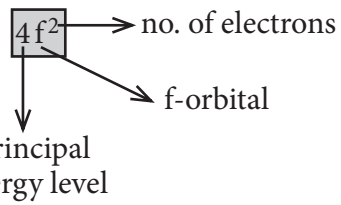
$\therefore$ Five unpaired electrons.

Electronic configuration of Ar: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

no unpaired electrons.

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

Ans.



n = 4 ; f orbital $l = 3 \Rightarrow m_l = -3, -2, -1, 0, +1, +2, +3$

Out of two electrons, one electron occupies 4f orbital with $m_l = -3$ and another electron occupies 4f orbital with $m_l = -2$.

$\therefore$ All the four quantum numbers for the two electrons are

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

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

Ans. Electronic configuration of Fe^{3+} : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^0\ 3d^5$

Electronic configuration of Ni^{2+} : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^0\ 3d^8$

Ni^{2+}[Ar] $3d^8$

Fe^{3+} [Ar] $3d^5$

Half filled and completely filled orbitals are more stable compared to partially filled orbitals. Therefore Fe^{3+} is more stable compared to Ni^{2+}.

Government Exam Questions and Answers

Choose the Correct Answer 1 MARK

1. Consider the following sets of quantum numbers

	n	*l*	*m*	*s*
(i)	2	1	–1	3/2
(ii)	1	1	1	+1/2
(iii)	1	0	+1	–1/2
(iv)	1	0	0	–1/2

Which of the following sets of quantum numbers is not possible ? *[Govt. MQP-2018]*

(a) (i) and (ii) (b) (ii) and (iv)

(c) (i), (ii) and (iii) (d) (i), (ii), (iii) and (iv)

[Ans. (a) (i) and (ii)]

2. Based on equation $E = -2.178 \times 10^{-18} \left(\frac{z^2}{n^2}\right)$ J certain conclusions are written. Which of them is not correct? *[Govt. MQP-2018]*

(a) Equation can be used to calculate the energy change when the electron changes orbit.

(b) For n = 3, the electron has more negative energy than it does for n = 5 which means that the electron is more tightly bound in the smallest allowed orbit.

(c) The negative sign in the equation simply means that the energy of electron bound to the nucleus is lower it would be if the electrons were at the infinite distance from nucleus.

(d) Smaller the value of n, the larger is the orbit radius.

[Ans. (d) Smaller the value of n, the larger is the orbit radius.]

3. Match the list I with List II correctly by using the code given below: *[HY-2018]*

List I		List II	
A	4 s orbital	1	Rutherford's experiment
B	$3d^6$	2	3 nodal planes
C	Limitation of Bohr theory	3	Partially filled orbital
D	Existence of nucleus	4	Multi electron atom

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

[Ans. (b) 2 3 4 1]

4. The electrons identified by quantum numbers *n* and *l*

(i) $n = 4, l = 1$, (ii) $n = 4, l = 0$, (iii) $n = 3, l = 2$

(iv) $n = 3, l = 1$ can be placed in the order if increasing energy as *[QY-2018]*

(a) (iv) < (ii) < (iii) < (i) (b) (ii) < (iv) < (i) < (iii)

(c) (i) < (iii) < (ii) < (iv) (d) (iii) < (i) < (iv) < (ii)

[Ans. (a) (iv) < (ii) < (iii) < (i)]

5. Match the following. *[QY-2019]*

A	$1s^2\ 2s^2\ 2p_x^1\ 2p_y^1\ 2p_z^1$	1	Heisenberg's uncertainty principle
B	1s<2s<2p<3s<3p	2	Hund's rule
C	$n = 1; l = 1;$ $m = 0\ s = +½$	3	Aufbau principle
D	$\Delta x.\Delta p \geq \frac{h}{4\pi}$	4	Pauli's exclusion principle

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

[Ans. (a) 2 3 4 1]

6. How many electrons is an atom with atomic number 30 can have (n + l) = 4 ? *[QY-2019]*

(a) 5 (b) 6 (c) 7 (d) 8

[Ans. (d) 8]

7. The effective nuclear charge decreases with increase in _____ quantum number. *[HY-2019]*

(a) Principal

(b) Azimuthal

(c) Magnetic

(d) Spin

[Ans. (b) Azimuthal]

8. **The maximum number of electrons that can be accommodated in L orbitis :** *[Sep-2020]*

(a) 8 (b) 2
(c) 4 (d) 6 **[Ans. (a) 8]**

9. **de-Broglie equation is** *[CRT - '22]*

(a) $\lambda = h/mv$ (b) $\lambda = mv/h$
(c) $\lambda = hmv$ (d) $\lambda = hmv^2$
[Ans. (a) $\lambda = h/mv$]

Answer the Questions 2 MARKS

1. **Consider the following electronic arrangement for p^3 configuration.** *[Govt. MQP-2018]*

(a) | | | | **(b)** | | | |
(c) | | | | **(d)** | | | |

Which of these represents the ground state? Substantiate your answer with a proper reason.

Ans.

(a)	(b)	(c)	(d)
1 1 1	↿⇂ 1	1 ↿⇂	1 ↿⇂

(i) Among these the electronic configurations **(a)** represents the ground state.

(ii) It is considered to be the most **stable state**.

2. **Calculate the De-Broglie wavelength of a particle whose momentum is 66.26×10^{-28} kgms^{-1}.** *[Govt. MQP-2018]*

Ans. $\lambda = \frac{h}{p} = \frac{6.626 \times 10^{-34}}{66.26 \times 10^{-28}} = 1 \times 10^{-7}\, m$

3. **Calculate the total number of angular and radial nodes present in 3d and 4f orbitals.** *[QY-2018]*

Ans.

Orbital	n	*l*	Radial node n-l-1	Angular node l	Total Nodes
3*d*	3	2	0	2	2
4*f*	4	3	0	3	3

4. **State Heisenberg's uncertainty principle and give its mathematical expression.**

[FIRST MID-2018; Sep-2020; CRT & Aug-'22]

Ans. **(i)** Heisenberg's uncertainty principle states that 'It is impossible to accurately determine both the position and the momentum of a microscopic particle simultaneously'.

(ii) The product of uncertainty (error) in the measurement is expressed as follows.

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

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

5. **Write the descending order of electrons releasing tendencies of the Zn, Cu and Ag metals. Arrange the metals Zn, Cu and Ag in the descending order of their effective nuclear charge.**

[QY-2019]

Ans. Zinc, copper and silver the electro releasing tendency is the following order.

6. **State Aufbau principle.** *[HY-2019; Sep-2021]*

Ans. In the ground state of the atoms, the orbitals are filled in order of their increasing energies.

7. **In degenerate orbitals, why do the completely filled and half filled configurations are more stable than the partially filled configuration?** *[Sep-2020 & 2021]*

Ans. The exactly half filled and completely filled orbitals have greater stability than other partially filled configurations in degenerate orbitals.

This can be explained on the basis of symmetry and exchange energy.

Symmetry leads to stability. The half filled and fully filled configurations have symmetrical distribution of electrons and hence they are more stable than the unsymmetrical configurations.

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 it is called exchange energy. More number of exchanges are possible only in case of half filled and fully filled configurations.

8. **Calculate the maximum number of electrons that can be accommodated in L shell.** *[May-'22]*

Ans. 'L' shell refers to the prinicipal quantum no, n = 2
There are 4 orbital associated with
n = 2 ⇒ 2x, 2px, 2py and 2pz = 2(2)2 = 8

9. **State Hund's rule.** *[CRT-'22]*

Ans. Hand's rule states that electron pairing in the degenerate orbitals does not take place until all the available orbitals contains one electron each.

Answer the Questions 3 MARKS

1. **Enlist the postulates of Bohr's atom model.**

[FIRST MID-2018; HY-2018 & 2019; CRT - '22]

Ans. **Bohr's atom is based on the following assumptions :**

- The energies of electrons are quantised
- The electron is revolving around the nucleus in a certain fixed circular path called stationary orbit.

45. What is the maximum number of orbitals that can be identified with the following quantum numbers? n = 3, l = 1, m_l = 0

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

[Ans. (a) 1]

46. Assertion (A) : Bohr's orbits are also called stationary states.

Reason (R) : Electrons are stationary is an orbit.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is not the correct explanation of A

(c) A is true but R is false

(d) Both A and R are false

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

47. The wavelength associated with an electron moving with velocity 10^{10} ms^{-1} is

(a) 6.62×10^{-10} m (b) 7.28×10^{-14} m

(c) 3.69×10^{-12} m (d) 4.92×10^{-11} m

[Ans. (b) 7.28×10^{-14} m]

Sol : $\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}}{9.1 \times 10^{-31} \times 10^{10}} = 7.28 \times 10^{-14}\, m$

48. The electronic configuration of copper is _____

(a) $[Ar]4s^2\ 3d^9$ (b) $[Ar]4s^1\ 3d^{10}$

(c) $[Ar]4s^0\ 3d^{10}$ (d) All

[Ans. (b) $[Ar]4s^1\ 3d^{10}$]

49. Assertion (A) : Angular momentum of an electron in an atom is quantized

Reason (R) : In an atom only those orbits are permitted in which angular momentum of the electron is natural number multiple of $\frac{h}{2\pi}$

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is not the correct explanation of A

(c) A is true but R is false

(d) Both A and R are false [Ans. (a) Both A and R are true and R is the correct explanation of A]

50. Which one of the following orbitals is spherical in shape?

(a) 4s (b) 3p (c) 3d (d) 4f

[Ans. (a) 4s]

51. Assertion (A) : The orbitals having equal energy are known as degenerate orbitals.

Reason (R) : The three 2p orbitals are degenerate is the presence of external magnetic field.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is not the correct explanation of A

(c) A is true but R is false

(d) Both A and R are false

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

52. The de-Broglie wavelength associated with a matter particle is

(a) Directly proportional to the momentum of the particle

(b) Directly proportional to the velocity of the particle

(c) Inversely proportional to the momentum of the particle

(d) Inversely proportional to Plank's constant.

[Ans. (c) Inversely proportional to the momentum of the particle]

53. The subsidiary quantum number decides _____

(a) the shape of the orbital

(b) the orientation of the orbital

(c) energy level of the orbital

(d) the spin of the electron

[Ans. (a) the shape of the orbital]

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

List I		List II	
A	p orbital	1	Clover leaf
B	s orbital	2	Dumb bell with doughnut
C	dz^2	3	Dumb bell
D	d_{xy}	4	Spherical

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

[Ans. (c) 3 4 2 1]

55. Which of the following has maximum number of unpaired d-electrons?

(a) N^{3+} (b) Fe^{2+} (c) Zn^{+} (d) Cu^{+}

[Ans. (b) Fe^{2+}]

56. **Consider the following statements and pick the incorrect statement(s).**
1. **Schrodinger wave equation is used to determine the probability of finding a electron at a given point in space.**
2. **The energy of a electron at infinity is positive**
3. **Angular momentum quantum number gives information regarding subshells.**

(a) 1 & 3 (b) only 1 (c) only 2 (d) 1, 2 & 3
[Ans. (c) only 2]

57. **As per Aufbau principle, arrange the orbitals in increasing order of energy.**
(a) 4p > 4d > 5s > 5p (b) 4p < 4d < 5s < 5p
(c) 4d < 4p < 5s < 5p (d) 4p < 5s < 4d < 5p
[Ans. (d) 4p < 5s < 4d < 5p]

58. **In multi-electron atom, 4*s*-orbital is lower in energy than**
(a) 3*d*-orbital (b) 3*p*-orbital
(c) 2*s*-orbital (d) 2*p*-orbital **[Ans. (a) 3*d*-orbital]**

59. **Shape of an orbital is given by**
(a) Principal quantum number
(b) Spin quantum number
(c) Azimuthal quantum number
(d) Magnetic quantum number
[Ans. (c) Azimuthal quantum number]

60. **Orientation of orbitals is given by**
(a) Magnetic quantum number
(b) Spin quantum number
(c) Azimuthal quantum number
(d) Principal quantum number
[Ans. (a) Magnetic quantum number]

61. **Which of the following configuration is correct for iron?**
(a) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^7$
(b) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^5$
(c) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5$
(d) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^6$
[Ans. (d) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^6$]

62. **Which of the following electronic configuration represent the element in ground state?**
(a) $1s^2\ 2s^1\ 2p^1$ (b) $1s^2\ 2s^2\ 2p^1$
(c) $1s^2\ 2s^1\ 2p_x^1\ 2p_y^1\ 2p_z^1$
(d) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p_x^1\ 3p_y^1\ 3p_z^1\ 3d^1$
[Ans. (b) $1s^2\ 2s^2\ 2p^1$]

63. **The number of nodes in s orbital of any energy level is equal to**
(a) n (b) $2n^2$ (c) n – 1 (d) n – 2
[Ans. (c) n – 1]

64. **Assertion (A) : In a multi-electron atom, the electrons in different subshell have different energies.**
Reason (R) : Energy of an orbital depends upon $n + l$ value.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is not the correct explanation of A
(c) A is true but R is false
(d) Both A and R are false
[Ans. (a) Both A and R are true and R is the correct explanation of A]

65. **Match the quantum numbers with the information provided by these.**

Quantum number		Information Provided	
A	Principal quantum number	1	orientation of the orbital
B	Azimuthal quantum number	2	energy and size of orbital
C	Magnetic quantum number	3	spin of electron
D	Spin quantum number	4	shape of the orbital

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

[Ans. (b) 2 4 1 3]

66. **Match species given in List-I with the electronic configuration of list-II.**

List-I		List-II	
A	Cr	1	[Ar] $3d^8\ 4s^0$
B	Fe^{2+}	2	[Ar] $3d^{10}\ 4s^1$
C	Ni^{2+}	3	[Ar] $3d^6\ 4s^0$
D	Cu	4	[Ar] $3d^5\ 4s^1$

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

[Ans. (c) 4 3 1 2]

67. **In an atom _____ charged nucleus is there.**
(a) large positively (b) tiny positively
(c) large negatively
(d) tiny negatively **[Ans. (b) tiny positively]**

68. **De Broglie and Bohr's concepts are in _____ with each other.**
(a) oppose (b) agreement
(c) neglect (d) a & c
[Ans. (b) agreement]

69. **The dual nature of matter imposes a limitation on the simultaneous determination of _____ and _____ of a microscopic particle.**
(a) position, velocity (b) energy, effect
(c) orientation, level (d) wavelength, velocity
[Ans. (a) position, velocity]

70. **Which of the following is incorrect?**
(a) Heisenberg arrived at his uncertainty principle
(b) The uncertainty principle significant
(c) The uncertainty principle determining effect for macroscopic objects.
(d) All the above are correct
[Ans. (c) The uncertainty principle determining effect for macroscopic objects.]

71. **What leads to the development of electron microscope?**
(a) The finding of velocity of electron
(b) The finding of particle nature of electron
(c) The finding of wave nature of electron
(d) None of these above
[Ans. (c) The finding of wave nature of electron]

72. **The solutions of Schrödinger wave equation gives the allowed _____.**
(a) Energy levels (b) Eiger values
(c) equation (d) a & b
[Ans. (a) Energy levels]

73. **What is the integral values can take azimuthal quantum number?**
(a) Zero to n (b) Zero to n – 1
(c) Zero to n + 1 (d) zero to n^2
[Ans. (b) Zero to n – 1]

74. **Which effect provides the experimental justification for magnetic quantum number?**
(a) Altitude effect (b) Latitude effect
(c) Stoke effect (d) Zeeman effect
[Ans. (d) Zeeman effect]

75. **How many nodes are possible for 2s orbital?**
(a) 1 (b) 2 (c) 3 (d) zero
[Ans. (a) 1]

76. **Different values of 'm' for a given 'l' value represent different _____ of orbitals in space.**
(a) orientation (b) energy levels
(c) displacement (d) b & c
[Ans. (a) Orientation]

77. **During exchange process the energy is _____.**
(a) Released (b) Gained
(c) Returned (d) refuse
[Ans. (a) Released]

Additional Short Answers

1. **Write a note on Thomson's plum pudding model of an atom.**

Ans. According to this theory, atom was assumed to consist of a sphere of uniform distribution of about 10^{-10} m positive charge with electrons embedded in it such that the number of electrons equal to the number of positive charges and the atom as a whole is electrically neutral.

2. **What are the defects of Rutherford's model?**

Ans. According to J. C. Maxwell, whenever an electron is subjected to acceleration, it emits radiation and loses energy. As a result of this, its orbit should become smaller and smaller and finally it should drop into the nucleus by following a spiral path. This means that atom would collapse and thus Rutherford's model failed to explain stability of atoms. Another drawback of the Rutherford's model is that it gives no information about the electronic structure of an atom.

3. **How many neutrons and protons are there in the following nuclei?**
$^{13}_{6}C$, $^{16}_{8}O$, $^{24}_{12}Mg$, $^{56}_{26}Fe$, $^{88}_{38}Sr$

Sol :

Nucleus	Atomic number (Z)	Mass number (A)	Number of protons = Z	Number of neutrons = A – Z
$^{13}_{6}C$	6	13	6	13 – 6 = 7
$^{16}_{8}O$	8	16	8	16 – 8 = 8
$^{24}_{12}Mg$	12	24	12	24 – 12 = 12
$^{56}_{26}Fe$	26	56	26	56 – 26 = 30
$^{88}_{38}Sr$	38	88	38	88 – 38 = 50

4. After the execution of the α-ray scattering experiment, what were the observations made by Rutherford? What did he conclude from his observations?

Ans.

	OBSERVATION	CONCLUSION
1.	Most of the α-particles passed through the foil.	Presence of large empty space in the atom.
2.	Few α-particles were deflected by small angles.	Positive charge is concentrated at a very small region and not uniformly distributed in whole atom.
3.	Very few α-particles reflected completely at 180°.	Positively charged core is known as nucleus.

5. In a chemical reaction, chlorine atom undergoes reduction and aluminium atom undergoes oxidation. Will this redox reaction affect their initial number of protons, neutrons and electrons?

Ans.
- Chlorine atom on accepting an electron becomes Cl^- and aluminium atom after donating an electron becomes Al^{3+}.
- These changes will affect their number of protons, neutrons and electrons.

Cl^- :

No. of electrons = 17 + 1 = 18
No. of protons = 17
No. of neutrons = 35 – 17 = 18

Al^{3+} :

No. of electrons = 13 – 3 = 10
No. of protons = 13
No. of neutrons = 27 – 13 = 14.

6. What is the difference between atomic mass and mass number?

Ans.
(i) Mass number is a **whole number** because it is the sum of number of protons and number of neutrons.
(ii) Atomic mass is **fractional** because it is the average relative mass of its atom as compared with mass of an atom of C-12 isotope taken as 12.

7. Symbols $^{79}_{35}Br$ and ^{79}Br can be written, where as symbols $^{35}_{79}Br$ and ^{35}Br are not acceptable. Answer briefly. ***[HOTS]***

Ans. The composition of any atom can be represented by using the normal element symbol X with superscript on the left side as the mass number A and subscript Z on the left side as atomic number (ie) $^{A}_{Z}X$.

Hence, the symbols $^{35}_{79}Br$ and ^{35}Br are not acceptable.

8. What is shape of the orbital with (i) n = 2 and l = 0 ; (ii) n = 2 and l = 1?

Ans. **(i)** n = 2 and l = 0. The orbital is 2s. Its shape is symmetrically spherical .
(ii) n = 2 and l = 1. The orbital is 2p. Its shape is dumb bell.

9. What is meant by nodal surface or node?

Ans. The region within the orbital where the probability of finding the electron is zero is called a node.

10. In Rutherford's experiment, generally thin foil of heavy atoms, like gold, platinum etc. have been used to bombard the α-particles.
If the thin foil of light atoms like aluminum is used, what difference would be observed from the above results ? ***[HOTS]***

Ans.
- Heavy atoms like gold, platinum have heavy nucleus. Heavy nucleus contains large amount of positive charge.
- When a beam of a α -particles is shot at a thin gold foil, most of them pass through without much effect.
- Some are deflected back due to enormous repulsive force of heavy nucleus.
- If thin foil is made of light aluminium, then the number of α -particles deflected back will be negligible.

11. Calculate the number of electrons, protons and neutrons in (i) Phosphorous atom (ii) Phosphate ion.

Ans. **(i) Phosphorous atom :**

Atomic number (Z) = No. of protons = 15
= No. of electrons = 15
Number of neutrons = Mass number – Atomic number
= 31 – 15 = 16

(ii) Phosphate ion : (PO_4^{3-})

Number of electron = 15 + 4 × 8 + 3 = 50
Number of protons = 15 + 4 × 8 = 47
Number of neutrons = 10 + 4 × 8 = 48.

12. What is Zeeman effect?

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

13. Orbits are also called as stationary states. Say whether the above statement is true or false. Justify you answer.

Ans. The statement is true. According to Bohr, as long as an electron remains in a particular orbit, it does not lose or gain energy. This means that energy of an electron in a particular path remains constant. Therefore, these orbits are also called stationary states.

14. If the velocity of the electron in Bohr's first orbit is 2.19×10^6 ms^{-1}. Calculate the de-Broglie wavelength with it.

Sol : We know, mass of electron = 9.1×10^{-31} kg;

$h = 6.626 \times 10^{-34}$ Js

$$\therefore \lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}}{9.1 \times 10^{-31} \times 2.19 \times 10^6}$$

$$= 3.32 \times 10^{-10}\ m.$$

15. Calculate the uncertainty in the position of a cricket ball of mass 150 g if the uncertainty in velocity is 3.52×10^{-24} ms^{-1}.

Sol : Mass of the ball = 150 g = 0.150 kg

Uncertainty in velocity (Δv) = 3.52×10^{-24} ms^{-1}

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

$$\Delta x = \frac{6.626 \times 10^{-34} \text{ kg m}^2 \text{ s}^{-1}}{4 \times 3.142 \times (0.150 \text{ kg}) \times (3.52 \times 10^{-24} \text{ ms}^{-1})}$$

$$\Delta x = 10^{-10} \text{ m}$$

Δx = 1Å (1Å = 10^{-10} m).

16. Write the Schrodinger wave equation.

Ans. **Schrodinger Wave Equation :**

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

ψ = amplitude of wave; E = total energy of electron

V = potential energy; m = mass of electron

17. What are the significance of ψ and ψ^2 ***[HOTS]***

Ans. In an atom the wave function ψ for an electron has no physical significance as such. However, its square i.e. ψ^2 at any point gives the intensity of the electron wave at that point.

In view of Heisenberg's uncertainty principle, it shows the probability of finding the electron at that point and therefore, termed as **probability density**.

18. How does the Bohr theory of the hydrogen atom differ from that of Schrodinger? ***[HOTS]***

Ans. Bohr's theory does not consider the de-Broglie concept of dual nature of electron and also contradicts with the Heisenberg's uncertainty principle, while the Schrodinger equation is based on quantum mechanics which deals with the microscopic objects having both the particle as well as wave like character.

19. Can we apply Heisenberg's uncertainty principle to a stationary electron? Why? ***[HOTS]***

Ans. No, for a stationary electron, velocity = 0 and thus, position can be measured accurately.

20. Bring out the main points of difference between orbit and orbital. ***[HOTS]***

Ans.

	ORBIT	ORBITALS
1.	It is a well defined circular path around the nucleus in which the electron revolve.	Its the three dimensional space around the nucleus within which the probability of finding an electron is maximum
2.	The concept of an orbit does not consider the wave character of electrons and uncertainty principle.	The concept of an orbital is in accordance with the wave character of electrons and uncertainty principle.
3.	They do not have any directional characteristics.	Except s-orbitals, all orbitals have directional characteristics.
4.	The maximum number of electrons that an orbit can have is given by $2n^2$ where n is the number of the orbit	The maximum number of electrons that can be occupied by an orbital is always two

21. The effect of uncertainty principle is significant only for motion of microscopic particles and is negligible for the macroscopic particles. Justify the statement with the help of a suitable example. ***[HOTS]***

Ans. If uncertainty principle is applied to an object of mass say about a milligram (10^{-6} kg), then

$$\Delta v.\Delta x = \frac{h}{4\pi m} = \frac{6.626 \times 10^{-34} \text{ kg } m^2 s^{-1}}{4 \times 3.14 \times 10^{-6} \text{ kg}}$$

$$= 0.52 \times 10^{-28}\ m^2\ s^{-1}$$

The value of $\Delta v.\Delta x$ obtained is extremely small and is insignificant. Therefore, for milligram sized or heavier objects, the associated uncertainties are hardly of any real consequence.

22. An electron or a proton which one will have a higher velocity to produce matter waves of the same wavelength? Explain it. ***[HOTS]***

Ans. From de-Broglie equation, wavelength $\lambda = \frac{h}{mv}$

For same wavelength with two different particles, (ie) electron and proton $m_1v_1 = m_2v_2$ (h is constant)

Lesser the mass of the particle, greater will be the velocity.

Hence electron will have higher velocity.

23. Explain why the uncertainty principle is significant only for the motion of sub-atomic particles but is negligible for the macroscopic objects? [HOTS]

Ans. **(i)** The energy of photon is sufficient to disturb a sub-atomic particle so that there is uncertainty in the measurement of position and momentum of the sub-atomic particle.

(ii) However, the energy is insufficient to disturb a macroscopic object.

24. What is the maximum number of electrons that can be accommodated in a shell?

Ans. Maximum number of electrons in any shell is given by the expression $2n^2$, where n is the principal quantum number.

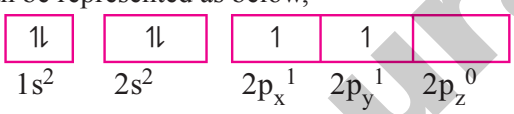
25. Write note on the necessity for Hund's rule. [HOTS]

Ans. Aufbau's principle does not deal with the filling of electrons in the degenerate orbitals (i.e. orbitals having same energy) such as px, py and pz.

26. Discuss the filling of electron in a carbon atom. [HOTS]

Ans. The carbon atom has six electrons. According to Aufbau principle, the electronic configuration is $1s^2$, $2s^2$, $2p^2$

It can be represented as below,

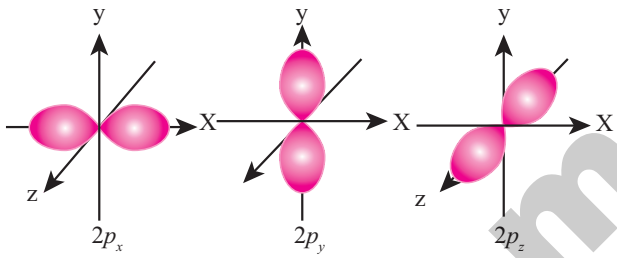


In this case, in order to minimise the electron-electron repulsion, the sixth electron enters the unoccupied $2p_y$ orbital as per Hunds rule. i.e. it does not get paired with the fifth electron already present in the $2P_x$ orbital.

27. Explain the shapes of p orbitals.

Ans. **p-orbitals :**

- For p orbitals l = 1 and the corresponding m values are –1, 0 and +1. The angular distribution functions are quite complex
- The three different m values indicates that there are three different orientations possible for p orbitals. These orbitals are designated as p_x, p_y and p_z and the angular distribution for these orbitals shows that the lobes are along the x, y and z axis respectively.
- The 2p orbitals have one nodal plane.



28. (i) What is common between d_{xy} and $d_{x^2-y^2}$ orbitals?

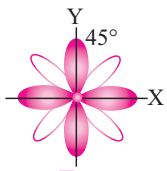
(ii) What is the difference between them?

(iii) What is the angle between the lobes of the above two orbitals? [HOTS]

Ans. **(i)** Both have identical shape, consisting of four lobes.

(ii) Lobes of $d_{x^2-y^2}$ lie along the *x* and *y*-axes where those of d_{xy} lie between *x* and *y*-axes.

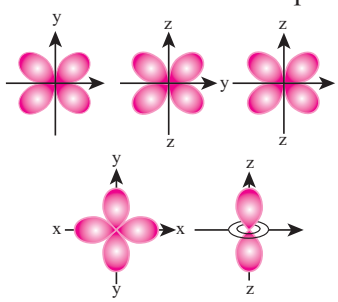
(iii) 45°



29. Discuss the shapes of d orbitals.

Ans. **d-orbitals :**

- For 'd' orbital 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}.
- The 3d orbitals contain two nodal planes.



Additional Long Answers 5 MARKS

1. Define the following terms with examples.

(i) Isotopes (ii) Isotones (iii) Isobars

(iv) Isoelectronic species (v) Nucleon

Ans. **(i)** **Isotopes :** Atoms of same element having same atomic number and different mass number

Eg : $_1H^1$, $_1H^2$, $_1H^3$ ($_1T^3$)

(ii) Isotones : These species posses same number of neutrons. Their atomic and mass numbers are different.

Eg: $^{14}_{6}C$, $_{7}N^{15}$, $_{8}O^{16}$

(iii) Isobars : Atoms of same element having same mass number and different atomic number

Eg : $^{14}_{6}C$, $_{7}N^{14}$

(iv) Isoelectronicspecies: Thespecies(atomsorions) containing same number of electrons.

Eg : O^{2-}, F^{-}, Na^{+}, Mg^{2+}, Al^{3+}, Ne

(v) Nucleon : Protons and neutrons present in the nucleus are collectively called **nucleons**. The total number of nucleons is termed as **mass number** (A) of an atom.

Eg : $^{16}_{8}O$ → Mass number / Nucleon

2. Write a note on limitations of Bohr's atom model.

Ans. **Limitation of Bohr's atom model :**

- The Bohr's atom model is applicable only to species having one electron such as hydrogen, Li^{2+} etc... and not applicable to multi electron atoms.
- It was unable to explain the splitting of spectral lines in the presence of magnetic field (Zeeman effect) or an electric 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 the angular momentum of the electron is equal to $nh/2\pi$.

3. The quantum numbers of six electrons are given below. Arrange them in order of increasing energies. If any of these combination(s) has/have the same energy lists.

(i) $n = 4, l = 2, m_l = -2, m_s = -\frac{1}{2}$

(ii) $n = 3, l = 2, m_l = 1, m_s = +\frac{1}{2}$

(iii) $n = 4, l = 1, m_l = 0, m_s = +\frac{1}{2}$

(iv) $n = 3, l = 2, m_l = -2, m_s = -\frac{1}{2}$

(v) $n = 3, l = 1, m_l = -1, m_s = +\frac{1}{2}$

(vi) $n = 4, l = 1, m_l = 0, m_s = +\frac{1}{2}$

Sol :

	Quantum number	Subshell notation	$n + l$
(i)	$n = 4, l = 2, m_l = -2, m_s = -\frac{1}{2}$	$4d$	$4 + 2 = 6$
(ii)	$n = 3, l = 2, m_l = 1, m_s = +\frac{1}{2}$	$3d$	$3 + 2 = 5$
(iii)	$n = 4, l = 1, m_l = 0, m_s = +\frac{1}{2}$	$4p$	$4 + 1 = 5$
(iv)	$n = 3, l = 2, m_l = -2, m_s = -\frac{1}{2}$	$3d$	$3 + 2 = 5$
(v)	$n = 3, l = 1, m_l = -1, m_s = +\frac{1}{2}$	$3p$	$3 + 1 = 4$
(vi)	$n = 4, l = 1, m_l = 0, m_s = +\frac{1}{2}$	$4p$	$4 + 1 = 5$

$\because$ (v) < (ii) = (iv) < (iii) = (vi) < (i)

$\therefore 3p < 3d = 3d < 4p = 4p < 4d$.

4. By applying Bohr's postulates, arrive at the radius of n^{th} orbit for hydrogen like atom.

Ans. Applying Bohr's postulates to a hydrogen like atom (one electron species such as H, He^{+} and Li^{2+} etc..) the radius of the n^{th} orbit and the energy of the electron revolving in the n^{th} orbit were derived. The results are as follows:

$$r_n = \frac{(0.529)n^2}{z} \text{ Å} \quad \text{.....(1)}$$

$$E_n = \frac{-13.6(z^2)}{n^2} \text{ ev atom}^{-1} \quad \text{.....(2)}$$

(or)

$$E_n = \frac{(-1312.8)Z^2}{n^2} \text{ kJ mol}^{-1} \quad \text{.....(3)}$$

5. A neutral atom of an element has 2K, 8L and 5M electrons. Find out the following.

(i) Atomic number of the element
(ii) Total number of *s*-electrons
(iii) Total number of *p*-electrons
(iv) Number of protons in the nucleus
(v) Valency of the element

Ans. The electronic configuration of the element with 2K, 8L and 5M electrons will be

$1s^2 2s^2 2p_x^2 2p_y^2 2p_z^2 3s^2 3p_x^1 3p_y^1 3p_z^1$

(i) Total number of electrons = 2+ 8 + 5 =15
∴ Atomic number of the element =15
(ii) Total number of *s*-electrons = 2+ 2+ 2=6
(iii) Total number of *p*-electrons =6 + 3=9
(iv) Since, the atom is neutral,
∴ Number of protons = Number of electrons = Atomic number =15
(v) valency of the element = 3.

6. Determine the following for the fourth shell of an atom.
(a) The number of subshells
(b) The designation for each subshell
(c) The number of orbitals in each subshell
(d) The maximum number of electrons that can be contained in each subshell

Ans. (a) The number of subshells is the same as the number used to designate the shell ie., n = 4 so contains 4 sub shells.
(b) The subshells in the fourth shell are designated as 4*s*. 4*p*. 4*d* and 4*f*.
(c) The number of orbitals in *s, p, d* and *f* subshell is 1, 3, 5 and 7 respectively.
(d) Each orbital can contain a maximum of two electrons.
4s - 1 orbital - 2 electrons
4p - 3 orbital - 6 electrons
4d - 5 orbital -10 electrons
4s - 7 orbital - 14 electrons

7. Complete the table given below.

S. No	Symbol	Mass No.	Atomic No.	Proton	Neutron	Electrons
1.	Zn^{2+}	64	30	-	-	-
2.	Cl^-	35	-	-	18	18
3.	Ar	-	-	18	22	-

Ans. (i) $^{64}_{30}Zn^{2+}$
No. of protons = 30
No. of electrons = 30 – 2 = 28
No. of neutrons = 64 – 30 = 34

(ii) $^{35}Cl^-$
Atomic number = Mass number – No. of neutrons
= 35 – 18 = 17
Atomic number = No. of protons = 17

(iii) **Ar**
Mass number = No. of protons + No. of neutrons
= 18 + 22 = 40
Atomic number = No. of protons = 18
No. of electrons = No. of protons = 18.

NUMERICAL PROBLEMS

1. Calculate the uncertainty in the velocity of a wagon of mass 3000kg whose position is known to an accuracy of ±10 pm. (Planck's constant = 6.626×10^{-34} kg m^2 s^{-1})

Sol:
Given : $m = 3000$ kg; $\Delta x = 10\ pm$
$= 10 \times 10^{-12}\ m = 10^{-11}\ m$

By uncertainty principle,

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

$$= \frac{6.626 \times 10^{-34}}{4 \times \frac{22}{7} \times 3000 \times 10^{-11}}\ ms^{-1}$$

$$= 1.76 \times 10^{-27}\ ms^{-1}$$

$$\boxed{\Delta v = 1.76 \times 10^{-27}\ ms^{-1}}$$

2. The uncertainty in the position and velocity of a particle are 10^{-2} *m* and 5.27×10^{-24} ms^{-1} respectively. Calculate the mass of the particle.

Sol:
Given : $h = 6.626 \times 10^{-34}$ kg m^2 s^{-1}

$\Delta v = 5.27 \times 10^{-24}\ ms^{-1}$; $\Delta x = 10^{-2}\ m$

Mass of the particle,

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

$$= \frac{6.626 \times 10^{-34}\ \text{kg}\ m^2 s^{-1}}{4 \times 3.143 \times 10^{-2}\ m \times 5.27 \times 10^{-24}\ ms^{-1}}$$

$$= 1 \times 10^{-9}\ \text{kg}$$

$$\boxed{m = 1 \times 10^{-9}\ \text{kg}}$$

3. Calculate the product of the uncertainties of displacement and velocity of a moving electron having a mass of 9.1×10^{-28} g.

Sol:

Given : $h = 6.626 \times 10^{-34}$ kg m^2 s^{-1}

$m = 9.1 \times 10^{-28}$ g $= 9.1 \times 10^{-31}$ kg

Product of uncertainties,

$$\Delta x \Delta v \geq \frac{h}{4\pi m} m^2 s^{-1}$$

$$\geq \frac{6.626 \times 10^{-34} \text{ kg } m^2 \ s^{-1}}{4 \times 3.143 \times 9.1 \times 10^{-31} \text{ kg}}$$

$$\geq 5.77 \times 10^{-5} \ m^2 \ s^{-1}$$

$$\boxed{\Delta x . \Delta v \geq 5.77 \times 10^{-5} \ m^2 \ s^{-1}}$$

4. A beam of helium atoms moves with a velocity of 2.0×10^3 ms^{-1}. Find the wavelength of the particles constituting the beam. ($h = 6.626 \times 10^{-34}$ Js).

Sol: Given, velocity of beam of helium atoms

$= 20 \times 10^3$ m sec^{-1}

Mass of helium atom

$$= \frac{4}{6.022 \times 10^{23}}$$

$$= 6.64 \times 10^{-24} \text{ g} = 6.64 \times 10^{-27} \text{ kg}$$

According to de-Broglie equation, $\lambda = \frac{h}{mv}$

$$= \frac{6.626 \times 10^{-34} \text{ kg } m^2 s^{-1}}{(6.64 \times 10^{-27} \text{ kg}) \times (2.0 \times 10^3 \ ms^{-1})}$$

$$= 4.99 \times 10^{-11} \text{ m} = 49.9 \text{ pm}$$

✶ ✶ ✶

04 HYDROGEN

CHAPTER SNAPSHOT

MUST KNOW DEFINITIONS

Position of hydrogen : The electronic configuration of hydrogen is $1s^1$. As it shows the resemblance with alkali metals and halogens, its position in periodic table is anomalous.

Isotopes of hydrogen :

S. No.	Isotopes of Hydrogen	Symbol	Atomic Number	Mass Number	No. of Protons	No of Neutrons
(i)	Protium	$_1H^1$	1	1	1	0
(ii)	Deuterium	$_1H^2$ or D	1	2	1	1
(iii)	Tritium	$_1H^3$ or T	1	3	1	2

Ortho hydrogen : Hydrogen molecule in which the protons in the nuclei of both H-atoms are known to spin in **same direction** is termed as ortho hydrogen.

Para hydrogen : If the protons in the nuclei of both H-atoms spin in **opposite direction**, it is termed as para hydrogen.

Hydride gap : The metals of **group 7, 8 and 9** do not form hydrides and this region of periodic table is referred as **hydride gap**.

Hydrogen bond : When a hydrogen atom (H) is covalently bonded to a highly electronegative atom (F or O or N), the bond is polarized in such a way is formed a weak bond (electrostatic attraction) between the hydrogen atom of a molecule and the electronegative atom of second molecule. The bond thus formed is called a hydrogen bond.

Intramolecular hydrogen : Intramolecular hydrogen bonds are those which occur within one single molecule. This occurs between two functional groups within a molecule. **Eg:** ortho-nitrophenol and salicylaldehyde.

Intermolecular hydrogen : Intermolecular hydrogen bonds occur between two separate molecules. **Eg:** HF, H_2O, etc,.

Synthetic gas : 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** ($CO + H_2$). This is also called **syngas.**

Water-gas shift reaction : The carbon monoxide of the water gas can be converted to carbon dioxide by mixing the **gas mixture with more steam at 400°C** and **passing over a shift converter containing iron/copper catalyst**. This **reaction is called as water-gas** shift reaction.

Hard water : Presence of these metal salts in the form of bicarbonate, chloride and sulphate in water makes water 'hard'.

Soft water : Water free from soluble salts of **calcium and magnesium** is called soft water.

Temporary hardness : Temporary hardness is primarily due to the presence of soluble **bicarbonates of magnesium and calcium**. This can be removed by boiling the hard water followed by filtration.

Permanent Hardness	:	Permanent hardness of water is due to the presence of **soluble salts** of magnesium and calcium in the form of chlorides and sulphates in it.
Heavy Water	:	Heavy water (D_2O) is the oxide of heavy hydrogen. One part of heavy water is present in 5000 parts of ordinary water.
Covalent (Molecular) hydrides	:	They are compounds in which hydrogen is attached to another element by the sharing of electrons.
Ionic (Saline) hydrides	:	These are hydrides composed of an electropositive metal, generally, an alkali or alkaline-earth metal, except beryllium and magnesium, formed by transfer of electrons from metal to hydrogen atoms.
Metallic (Interstitial) hydrides	:	Metallic hydrides are usually obtained by hydrogenation of metals and alloys in which hydrogen occupies the interstitial sites **(voids)**. Hence, they are called **interstitial hydrides**.

EVALUATION

I. Choose The Best Answer :

1. Which of the following statements about hydrogen is incorrect ? *(NEET 2016)*

(a) Hydrogen ion, H_3O^+ exists freely in solution.
(b) Dihydrogen acts as a reducing agent.
(c) Hydrogen has three isotopes of which tritium is the most common.
(d) Hydrogen never acts as cation in ionic salts.

[Ans. (c) Hydrogen has three isotopes of which tritium is the most common.]

2. Water gas is *[QY-2018; HY-2019]*

(a) $H_2O_{(g)}$ (b) $CO + H_2O$
(c) $CO + H_2$ (d) $CO + N_2$

[Ans. (c) $CO + H_2$]

Hint: $C(s) + H_2O \longrightarrow CO + H_2$

3. Which one of the following statements is incorrect with regard to ortho and para dihydrogen ?

(a) They are nuclear spin isomers
(b) Ortho isomer has zero nuclear spin whereas the para isomer has one nuclear spin
(c) The para isomer is favoured at low temperatures
(d) The thermal conductivity of the para isomer is 50% greater than that of the ortho isomer.

[Ans. (b) Ortho isomer has zero nuclear spin whereas the para isomer has one nuclear spin]

4. Ionic hydrides are formed by

(a) halogens
(b) chalcogens
(c) inert gases
(d) group one elements

[Ans. (d) group one elements]

5. Tritium nucleus contains *[May-'22]*

(a) 1p + 0 n (b) 2 p + 1n
(c) 1p + 2n (d) none of these

[Ans. (c) 1p + 2n]

Hint: ${}_1T^3$ ($1e^-$, 1p, 2n)

6. Non-stoichiometric hydrides are formed by

(a) palladium, vanadium
(b) carbon, nickel
(c) manganese, lithium
(d) nitrogen, chlorine

[Ans. (a) palladium, vanadium]

7. Assertion : Permanent hardness of water is removed by treatment with washing soda.
Reason : Washing soda reacts with soluble calcium and magnesium chlorides and sulphates in hard water to form insoluble carbonates *[Sep-2021]*

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

20. Heavy water is used as
(a) moderator in nuclear reactions
(b) coolant in nuclear reactions
(c) both (a) and (b)
(d) none of these **[Ans. (c) both (a) and (b)]**

21. Water is a *[HY-2018; QY-2019]*
(a) basic oxide (b) acidic oxide
(c) amphoteric oxide (d) none of these
[Ans. (c) amphoteric oxide]

II. Write Brief Answer To The Following Questions.

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

Ans. **(i)** Hydrogen has a tendency to gain one electron to form hydride ion (H^-) whose electronic configuration is similar to the noble gas (He).
(ii) However the electron affinity of hydrogen is much less than that of halogen atoms.
(iii) Hence hydrogen is less reactive as compared to halogens.
(iv) Therefore, due to this unique behaviour hydrogen is not placed with halogens in the periodic table

23. Discuss the three types of Covalent hydrides. *[GMQP-2018; QY-2018; May-'22]*

Ans. **Covalent (Molecular) hydrides :**
- They are compounds in which hydrogen is attached to another element by sharing of electrons.
- Covalent hydrides are further divided into three categories, viz.,
  - electron precise (CH_4, C_2H_6, SiH_4, GeH_4),
  - electron-deficient (B_2H_6) and
  - electron-rich hydrides (NH_3, H_2O).
- Since most of the covalent hydrides consist of discrete, small molecules that have relatively weak intermolecular forces, they are generally gases or volatile liquids.

24. Predict which of the following hydrides is a gas on a solid (a) HCl (b) NaH. Give your reason.

Ans. **(a)** At room temperature, HCl is a calourless gas and the solution of HCl in water is called hydrochloric acid and it is in liquid state.
(b) Sodium hydride NaH is an ionic compound and it is made of sodium cations (Na^+) and hydride (H^-) anion. It has the octahedral crystal structure. It is an alkali metal hydride.

25. 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 ?

Ans. The expected formulas for the hydrides of 4th period elements MH_4 (electron precise) M_2H_6 (electron deficient) and MH_3 (electron rich)
The trend is formula is
(i) Electron precise hydrides - $CH_4C_2H_6$, SiH_4, GeH_4
(ii) Electron deficient hydrides - B_2H_6
(iii) Electron rich hydrides - NH_3, H_2O
- The first two members of the series KH, CaH_2 are ionic hydrides whereas the other members of the series CH_4, C_2H_6, SiH_4, B_2H_6, NH_3 are covalent hydrides.

26. Write chemical equation for the following reactions.
(i) reaction of hydrogen with tungsten (VI) oxide on heating.
(ii) hydrogen gas and chlorine gas.

Ans. **(i)** $3H_2 + WO_3 \longrightarrow W + 3H_2O$
Hydrogen reduces tungsten (VI) oxide. WO_3 to tungsten at high temperature.
(ii) $H_2 + Cl_2 \longrightarrow 2HCl$ (Hydrogen chloride).
Hydrogen reacts with chlorine at room temperature under light to give hydrogen chloride.

27. Complete the following chemical reactions and classify them in to (a) hydrolysis (b) redox (c) hydration reactions. *[Govt. MQP-2018]*
i) $KMnO_4 + H_2O_2 \longrightarrow$
ii) $CrCl_3 + H_2O \longrightarrow$
iii) $CaO + H_2O \longrightarrow$

Ans. **(i)** $2KMnO_4 + H_2O_2 \longrightarrow 2MnO_2 + 2KOH + 3H_2O + 3O_{2(g)}$
This reaction is a redox reaction
(ii) $CrCl_3 + 6H_2O \longrightarrow [Cr(H_2O)_6]Cl_3$
This reaction is a hydration reaction
(iii) $CaO + H_2O \longrightarrow Ca(OH)_2$
This reaction is a hydrolysis reaction.

28. Hydrogen peroxide can function as an oxidising agent as well as reducing agent. substantiate this statement with suitable examples. *[Govt. MQP-2018]*

Ans. Hydrogen peroxide can act both as an oxidizing agent and a reducing agent. Oxidation is usually performed in acidic medium while the reduction reactions are performed in basic medium

In acidic conditions :

$H_2O_2 + 2H^+ + 2e^- \longrightarrow 2H_2O$ ($E^0 = +1.77$ V)
For example
$2FeSO_4 + H_2SO_4 + H_2O_2 \longrightarrow Fe_2(SO_4)_3 + 2H_2O$

In basic conditions :

$HO_2^- + OH^- \longrightarrow O_2 + H_2O + 2e^-$ ($E^0 = +0.08$ V)

For Example,

$2KMnO_{4(aq)} + 3H_2O_{2(aq)} \downarrow$

$2MnO_2 + 2KOH + 2H_2O + 3O_{2(g)}$

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

Ans. **(i)** The chemical reactions shown by water and heavy water are nearly identical.

(ii) However, due to differences in masses of hydrogen and deuterium, such reactions occur at different rates.

(iii) The rates of reactions involving D_2O are slower than those involving H_2O.

(iv) If D_2O is consumed, the enzyme catalysed biochemical reactions will occur slower than their optimum rate.

(v) The enzymes may then lose their ability to catalyse a biochemical reaction.

(vi) Thus heavy water will interfere and disturb the biological process and hence it is not suitable for drinking purposes.

30. What is water-gas shift reaction? *[GMQP-2018]*

Ans. The carbon monoxide of water gas can be converted to carbon dioxide by mixing the gas mixture with more steam at 400°C and passing over a shift converter containing iron/copper catalyst. This reaction is called as water-gas shift reaction.

$$CO + H_2O \longrightarrow CO_2 + H_2\uparrow$$

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

Ans. Hydrogen resembles alkali metals in the following aspects.

(i) Electronic configuration $1s^1$ as alkali metals have ns^{-1}.

(ii) Hydrogen forms unipositive H^+ ion like alkali metals Na^+, K^+

(iii) Hydrogen forms halides (HX), oxides (H_2O), peroxides (H_2O_2) like alkali metals (NaX, Na_2O, Na_2O_2)

(iv) Hydrogen also acts as reducing agent like alkali metals.

32. What are isotopes? Write the names of isotopes of hydrogen.

Ans. **Isotopes :** Atoms of the same element having same atomic number but different mass number are called isotopes.

	Isotopes of Hydrogen	Symbol	Atomic No.	Mass.No
(i)	Protium or hydrogen	$_1H^1$	1	1
(ii)	Deuterium	$_1H^2$	1	2
(iii)	Tritium	$_1H^3$	1	3

33. Give the uses of heavy water.

[Govt. MQP-2018; QY-2018 & 19]

Ans. **(i)** Heavy water is used as moderator in nuclear reactors as it can lower the energies of fast moving neutrons.

(ii) D_2O is commonly used as a tracer to study organic reaction mechanisms and mechanisms of metabolic reactions.

(iii) It is also used as a coolant in nuclear reactors as it absorbs the heart generated.

A	Deuterium	D_2
B	Heavy water	D_2O
C	Propane	C_3H_6
D	Deuteron propane	C_3D_6

34. Explain the exchange reactions of deuterium.

[QY-2018 & 19; Sep-2020]

Ans. Deuterium can replace reversibly hydrogen in compounds either partially or completely depending upon the reaction conditions.

$$CH_4 + 2D_2 \longrightarrow CD_4 + 2H_2$$
$$2NH_3 + 3D_2 \longrightarrow 2ND_3 + 3H_2$$

35. How do you convert para hydrogen into ortho hydrogen? *[HY-2018; Sep-2020 & 2021]*

Ans. **Conversion of para into ortho hydrogen :**

(i) By treatment with catalyst like Pt or Fe.

(ii) By passing an electric discharge

(iii) By heating to 800°C or more.

(iv) By mixing with paramagnetic molecules like O_2, NO, NO_2.

(v) By mixing with nascent hydrogen or atomic hydrogen.

36. Mention the uses of deuterium.

Ans. **(i)** It is used as tracers in the study of mechanism of chemical reactions.

(ii) High speed deuterons are used in artificial radioactivity.

(iii) Deuterium is mainly used in the preparation of heavy water (D_2O). Which is employed as moderator in nuclear reactor to slow down the speed of fast moving neutrons.

37. Explain preparation of hydrogen using electrolysis. *[HY-2018]*

Ans. Hydrogen is obtained by electrolysis of water

(i) **Electrolyte :** Water containing traces of acid or alkali or the electrolysis of aqueous solution of sodium hydroxide or potassium hydroxide.

(ii) **Anode :** Nickel

(iii) **Cathode :** Iron

(iv) **At anode :** $2OH^- \longrightarrow H_2O + \frac{1}{2}O_2 + 2e^-$

(v) **At cathode :** $2H_2O + 2e^- \longrightarrow 2OH^- + H_2$

(vi) **Overall reaction :** $H_2O \longrightarrow H_2 + \frac{1}{2}O_2$

38. A group-1 metal (A) which is present in common salt reacts with (B) to give compound (C) in which hydrogen is present in –1 oxidation state. (B) on reaction with a gas (C) to give universal solvent (D). The compound (D) on reacts with (A) to give (E), a strong base. Identify A, B, C, D and E. Explain the reactions.

Ans. (i) Metallic **sodium (A)** reacts with **hydrogen (B)** to give **sodium hydride (C)**.

$$\underset{(A)}{2Na} + \underset{(B)}{H_2} \longrightarrow \underset{(C)}{2NaH}$$

(ii) Hydrogen reacts with a gas (oxygen) to give **water (D)**.

$$\underset{(B)}{2H_2} + O_2 \longrightarrow \underset{(D)}{2H_2O}$$

(iii) Water reacts with sodium to give **sodium hydroxide (E)** and hydrogen (B).

$$\underset{(D)}{2H_2O} + \underset{(A)}{2Na} \longrightarrow \underset{(E)}{2NaOH} + \underset{(B)}{H_2}$$

A	Na	Sodium
B	H_2	Hydrogen
C	NaH	Sodium hydride
D	H_2O	Water
E	NaOH	Sodium hydroxide

39. 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.

Ans. (i) Isotope of hydrogen reacts with oxygen to give **heavy water (B)**.

$$\underset{(A)}{2D_2} + O_2 \longrightarrow \underset{(B)}{2D_2O}$$

(ii) Deuterium (A) undergoes addition reaction with **propene (C)** to give **propane deuteride (D)**.

$$\underset{(C)}{CH_3CH=CH_2} \longrightarrow \underset{(D)}{CH_3-CHD-CH_2D}$$

A	D_2	Deuterium
B	D_2O	Heavy water or deuterium oxide
C	$CH_3–CH=CH_2$	Propene
D	$CH_3–CHD–CH_2D$	Propane deuteride

40. 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. *[GMQP-2018; QY-2019]*

Ans. NH_3 has higher boiling and melting point **compared to** all other hydrides of **group 15** elements due to intermolecular hydrogen bonding.

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

Ans. (i) d-block elements form metallic or interstitial hydrides, on heating with dihydrogen under pressure.

(ii) Hydrogen atoms being small in size occupy some space in the metallic lattice producing distortion without any change in its type

(iii) The densities of these hydrides are lower then those of metals from which they are formed since the crystal lattice expands due to the inclusion of dihydrogen.

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

Ans. In metallic hydrides, hydrogen is absorbed as H-atoms. Due to the absorption of H atoms the metal lattice expands and become unstable. Thus, when metallic hydride is heated, it decomposes to form hydrogen and finely divided metal. The hydrogen evolved can be used as fuel.

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

Ans. (i) The order of increasing magnitude of H-bonding is, $NH_3 < H_2O < HF$

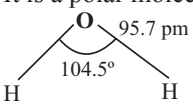
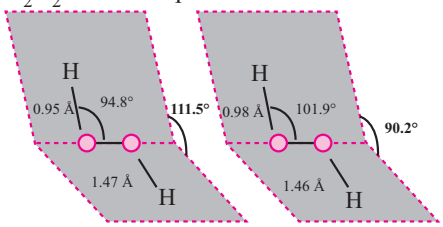
(ii) Strength of H bond depends upon the atomic size and electronegativity of the other atom to which H atom is covalently bonded. Smaller size and higher electronegativity favour H bonding.

(iii) Among N, F and O the order of electronegativity is F > O > N.

(iv) Hence HF will have highest magnitude of H bonding.

44. Compare the structures of H_2O and H_2O_2.

Ans.

STRUCTURE OF H_2O	STRUCTURE OF H_2O_2
H_2O has a bent structure	H_2O_2 has a open book like structure.
The HOH bond angle is 104.5°	The H–O–O bond angle is 94.8° and the dihedral angle 111.5° in gas phase.
It is a polar molecule. 	H_2O_2 has a non polar structure 

Government Exam Questions and Answers

Choose the Correct Answer 1 MARK

1. Ionic hydrides are formed by *[Govt. MQP-2018]*

(a) halogens (b) chalcogens
(c) alkalimetals (d) inert gases

[Ans. (c) alkalimetals]

2. Volume strength of 0.5N H_2O_2 is *[Govt. MQP-2018]*

(a) 2.8 (b) 8.4 (c) 5.6 (d) 16.8

[Ans. (a) 2.8]

3. Intra molecular hydrogen bonding is present in: *[Sep-2020]*

(a) Ortho-nitro phenol (b) ICE
(c) Water (d) Hydrogen fluoride

[Ans. (a) Ortho-nitro phenol]

4. Tritium is a _____ emitter. *[Aug-'22]*

a) α b) β
c) γ d) None of these

[Ans. (b) β]

Answer the Questions 2 MARKS

1. What is meant by intramolecular hydrogen bond? Give one example. *[Govt. MQP-2018]*

Ans. Intramolecular hydrogen bonds are those which occur within one single molecule. This occurs between two functional groups within a molecule.
Eg: ortho-nitrophenol and salicylaldehyde.

2. What is ortho hydrogen? *[QY-2018 & 19]*

Ans. Hydrogen molecule in which protons in the nuclei of both H-atoms are known to spin in same direction is termed as ortho hydrogen.

3. What is para hydrogen? *[QY-2018 & 19]*

Ans. Hydrogen molecule in which protons in the nuclei of both H-atoms spin in opposite direction is termed as para hydrogen.

4. How does iron react with steam? *[HY-2018]*

Ans. Steam passed over red hot iron results in the formation of iron oxide with the release of hydrogen.

$$3Fe + 4H_2O \longrightarrow Fe_3O_4 + H_2$$

5. How is tritium prepared? *[Mar-2019]*

Ans. **(i)** By bombarding lithium with slow neutrons

(ii) $_3Li^6 + {}_0n^1 \longrightarrow {}_1T^3 + {}_2He^4$

6. What is syn gas? How it is prepared? *[June-2019]*

Ans. The mixture of carbon monoxide and hydrogen ($CO+H_2$) is known as water gas. This is also called **syngas (Synthetic gas)** as it is used in the synthesis of organic compounds such as methanol and simple hydrocarbons.

$$C + H_2O \xrightarrow{1000°C} \underbrace{CO + H_2}_{\text{water gas/Syngas}}$$

7. Give an example for Ionic hydride and covalent hydride. *[Aug-'22]*

Ans. **Ionic Hydride :** These are salt-like, high-melting, white crystalline solids having hydride ions (H^-) and metal cations (M^{n+}).

Covalent Hydride : The most common examples of covalent hydrides of non-metals are methane, ammonia, water and hydrogen chloride.

ANSWER THE QUESTIONS 3 MARKS

1. Calcium Hydroxide cannot be used to remove permanent hardness of water. why? *[QY-2018]*

Ans. $MgCl_2 + Ca(OH)_2 \longrightarrow Mg(OH)_2 + CaCl_2$

Removal of permanent hardness means (Mg & Ca) chlorides and sulphates are converted to insoluble carbonates but we can use $Ca(OH)_2$ means formed calcium chlorides only does not form insoluble carbonates

2. Explain the types of hydrogen bonding with an example. *[QY-2018; HY-2018]*

Ans. There are two types of Hydrogen bonding

(i) Intramolecular hydrogen bonding

(ii) Intermolecular hydrogen bonding

Intramolecular hydrogen bonds are those which occur within a single molecule.

Example: Ortho nitrophenol, Salicilaldehyde

Intermolecular hydrogen bonds occur between two separate molecules. For example, intermolecular hydrogen bonds can occur between ammonia molecule themselves or between water molecules themselves or between ammonia and water.

3. Write short notes on Metallic Hydrides.

(or)

Write notes on Interstitial Hydrides. *[QY-2019]*

Ans. **Metallic (Interstitial) Hydrides:** Metallic hydrides usually obtained by hydrogenation of metals and alloys in which hydrogen occupies the interstitial sites (voids). Hence, they are called interstitial hydrides. These hydrides show properties similar to parent metals and hence they are also known as metallic hydrides. Most of the hydrides are non-stoichiometric with variable composition ($TiH_{1.5\text{-}1.8}$ and $PdH_{0.6\text{-}0.8}$), some are relatively light, inexpensive and thermally unstable which makes them useful for hydrogen storage applications.

4. Why hydrogen peroxide is stored in plastic containers, not in glass container? *[June-2019]*

Ans.

- The aqueous solution spontaneously disproportionate to give oxygen and water.
- The reaction is, however, slow but is explosive when catalyzed by metal.
- If it is stored in glass container, it dissolves the alkali metals from the glass, which catalyzes the disproportionation reaction.
- For this reason, H_2O_2 solutions are stored in plastic bottles.

$$H_2O_2 \longrightarrow H_2O + \tfrac{1}{2}O_2$$

5. Write the laboratory method of preparation of hydrogen. *[Sep-2020]*

Ans. Hydrogen is prepared in laboratory by the reaction of metals, such as zinc, iron, tin with dilute acid. $Zn + 2\ HCl \rightarrow ZnCl_2 + H_2\uparrow$

ANSWER ALL THE QUESTIONS 5 MARKS

1. What are hydrides? Write the different types of hydrides with an example for each. *[HY-2019]*

Ans. **Hydrides :** The dihydrogen combines with number of elements to form Hydrides.

Ionic (Saline) hydrides : These are hydrides composed of an electropositive metal, generally, an alkali or alkaline-earth metal, except beryllium and magnesium, formed by transfer of electrons from metal to hydrogen atoms.

Ex: LiH, CaH_2.

Covalent (Molecular) Hydrides: They are compounds in which hydrogen is attached to another element by sharing of electrons. The most common examples of covalent hydrides of non-metals such as methane, ammonia, water and hydrogen chloride. Molecular hydrides of hydrogen are further divided into three categories.

Ex: electron precise (CH_4, C_2H_6, SiH_4, GeH_4), electron-deficient (B_2H_6) and electron-rich hydrides (NH_3, H_2O).

Metallic (Interstitial) Hydrides: Metallic hydrides usually obtained by hydrogenation of metals and alloys in which hydrogen occupies the interstitial sites (voids).

Ex: non-stoichiometric with variable composition ($TiH_{1.5\text{-}1.8}$ and $PdH_{0.6\text{-}0.8}$), some are relatively light, inexpensive and thermally unstable which makes them useful for hydrogen storage applications.

ADDITIONAL QUESTIONS

ADDITIONAL CHOOSE THE CORRECT ANSWER

1 MARK

1. The most abundant element in the universe is _____.
(a) aluminium (b) mica
(c) dihydrogen (d) nitrogen
[Ans. (c) dihydrogen]

2. The number of neutrons in hydrogen atom is _____
(a) three (b) two (c) one (d) zero
[Ans. (d) zero]

3. _____ is known as heavy hydrogen.
(a) protium (b) deuterium
(c) tritium (d) both a and b
[Ans. (b) deuterium]

4. The radioactive isotope used in illumination of wrist watches instead of radium is _____
(a) $_1T^3$ (b) $_1D^2$ (c) $_{10}Ne^{21}$ (d) $_2He^3$
[Ans. (a) $_1T^3$]

5. Deuterium consist of _____
(a) one electron, two proton, three neutron
(b) one electron, one proton, one neutron
(c) two electron, one proton, one neutron
(d) three electron, two proton, one neutron
[Ans. (b) one electron, one proton, one neutron]

6. The radioactive isotope of hydrogen is _____
(a) protium (b) deuterium
(c) tritium (d) nascent hydrogen
[Ans. (c) tritium]

7. The half life period of tritium is _____
(a) 12.33 secs (b) 12.33 mins
(c) 12.33 hrs (d) 12.33 years
[Ans. (d) 12.33 years]

8. Ammonia is manufactured by _____ process.
(a) Contact (b) Bergius
(c) Haber's (d) none of the above
[Ans. (c) Haber's]

9. _____ torches is / are used in cutting and welding of a steel.
(a) Oxy acetylene (b) Oxy hydrogen
(c) both a and b (d) neither a nor b
[Ans. (c) both a and b]

10. Hydrogen is used in _____
(a) hydrogenation of oils
(b) fuel cells (c) gas bags for air ships
(d) all the above
[Ans. (d) all the above]

11. $FeSO_4$ contains _____ molecules of water of hydration.
(a) 5 (b) 7 (c) 10 (d) 12
[Ans. (b) 7]

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

List I		List II	
A	Protium	1	Radio active
B	Tritum	2	Aligned nuclear spins
C	Ortho hydrogen	3	Opposed nuclear spins
D	Para hydrogen	4	No neutron

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

[Ans. (b) 4 1 2 3]

13. Which among the following statement/s given below is/ are incorrect regarding hydrogen?
1. It is diatomic in nature
2. Has only one electron in the outermost shell
3. Very good oxidizing agent
4. Does not form hydrides easily
(a) 1, 2 & 3 (b) only 4
(c) only 3 (d) only 2
[Ans. (c) only 3]

14. The conversion of atomic hydrogen to dihydrogen is a _____ change.
(a) endothermic (b) exothermic
(c) photochemical (d) nuclear
[Ans. (b) exothermic]

15. $CO_{(g)} + H_2O_{(g)} \xrightarrow[X]{400C} CO_{2(g)} + H_{2(g)}$.
'X' is _____
(a) Nickel (b) Iron
(c) Iron oxide (d) Vanadium penta oxide
[Ans. (c) Iron oxide]

16. Hydrogen bomb is based on the principle of _____
(a) fission (b) fusion
(c) both a and b (d) neither a nor b
[Ans. (c) both a and b]

17. Hydrogen can be obtained from water by reaction with *[NEET]*
(a) metal oxides (b) non metal oxides
(c) metals (d) metal hydrides
[Ans. (c) metals]

(ii)

TEMPORARY HARDNESS	PERMANENT HARDNESS
This is due to soluble bicarbonates of a Ca and Mg	This is due to soluble salts in the form of Ca and Mg sulphates and chlorides.
It is easily removed by boiling	Removal of permanent hardness is a tedious process and involves certain chemical methods.

24. Statues coated with white lead turn black on exposure to air. Its original colour is restored on treatment with H_2O_2. Explain

Ans. Statues turn black due to the formation of lead sulphide. Hydrogen peroxide oxidises black coloured lead sulphide to white coloured lead sulphate, thereby restoring the colour.

$$PbS + 4H_2O_2 \longrightarrow PbSO_4 + 4H_2O$$

25. What are binary Hydrides? Give examples.

Ans. A binary hydride is a compound formed by hydrogen with other electro positive elements including metals and non-metals, e.g., LiH or MgH_2.

26. Write short notes on Ionic Hydrides and give suitable examples.

Ans. Ionic (Saline) Hydrides: These are hydrides composed of an electropositive metal, generally, an alkali or alkaline-earth metal, except beryllium and magnesium, formed by transferring of electrons from metal to hydrogen atoms. They can be prepared by the reaction of elements at about 400ºC. These are salt-like, high-melting, white, crystalline solids having hydride ions (H^-) and metal cations (Mn^+).

$$2\ Li\ (s) + H_2\ (g) \longrightarrow 2\ LiH\ (s)$$
$$2\ Ca\ (s) + H_2\ (g) \longrightarrow 2\ CaH_2\ (s)$$

27. Write down the possible applications of H_2O_2 on the basis of its oxidising property.

Ans. (i) Due to its oxidising property, it is used as a valuable bleaching agent, powerful but harmless disinfectant and germicide.

(ii) Delicate materials like silk, wood, hair can be bleached with H_2O_2.

28. What is the nuclear reaction that take place in the sun and other stars?

Ans. The sun and the other stars are composed mainly of 85 – 95% hydrogen which generates their energy by nuclear fusion of hydrogen nuclei into helium.

29. (i) How do metallic hydrides differ from molecular hydrides?

(ii) What do you mean by hydride gap?

Ans. (i)

Metallic Hydrides	Molecular Hydrides
These are formed by d-block elements (except group 7, 8, 9)	These are formed by p-block elements (except group 18).
These are non-stiochiometric compounds.	These are stiochiometric compounds.
Usually they conduct heat and electricity.	They do not conduct heat or electricity.
Eg: $LaH_{2.87}$, $NiH_{0.6-0.7}$,etc.	**Eg:** H_2O. H_2S, etc.

(ii) The metals of **group 7, 8 and 9 do not form hydrides** and this region of periodic table is referred as hydride gap.

30. Why is hydrogen gas used as fuel?

Ans. Hydrogen burns in air, virtually free from pollution and produces significant amount of energy. This reaction is used in fuel cells to generate electricity

$$2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(g)} + \text{energy}$$

31. Why H_2O_2 is used as mild antiseptic?

Ans. The oxidising properly of hydrogen peroxide and harmless nature of its products such as water and oxygen leads to oxidation of pollutants in water and act as mild antiseptic.

32. Identify the following as covalent, ionic or interstitial hydrides CaH_2, LaH_2, TiH_2, NaH, GeH_2, NH_3

Ans. Covalent hydrides : GeH_2, NH_3
Ionic hydrides : CaH_2, NaH
Interstitial hydrides : TiH_2, LaH_2

33. Write note about gas hydrates.

Ans. Gas hydrates are a kind of inclusion compounds where gas molecules are trapped in the crystal lattice having voids of right size, without being chemically bonded. An interesting hydrate is that of the hydronium ion (H_3O) in the gas phase. Similar to methane hydrate. Each water molecule is bonded to three others in the dodecahedron.

34. Give the advantage of future fuel-hydrogen.

Ans. Hydrogen is considered as a potential candidate for this purpose as it is a clean burning fuel. Hydrogen can directly be used as a fuel and can replace existing gasoline (petrol) diesel/Kerosene powered engines and indirectly be used with oxygen in fuel cells to generate electricity.

35. What are ternary Hydrides? Give examples.

Ans. Ternary hydrides are compounds in which the molecule is constituted by hydrogen and two types of elements, e.g., LiB_4 or $LiA1H_4$.

36. Write a note about saline (or) ionic hydride.

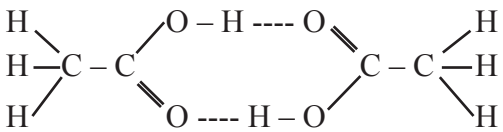
Ans. Ionic hydrides composed of an electro positive metal, generally an alkali or alkaline earth metal (except beryllium and magnesium) formed by transferring of electrons from metal to hydrogen atoms. They can be prepared by the reaction of elements at about 400°C. (M^{n+})

$2Li_{(s)} + H_{2(g)} \longrightarrow 2LiH_{(g)}$ (Lithium hydride)

$2Ca_{(s)} + H_{2(g)} \longrightarrow 2CaH_{2(g)}$ (Calcium hydride)

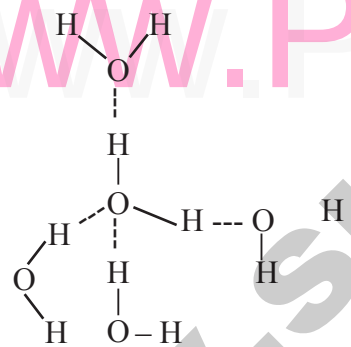
37. Draw the structure of (i) Acetic acid (ii) Water

Ans. **(i) Acetic acid :**



Dimer of Acetic Acid

(ii) Water :



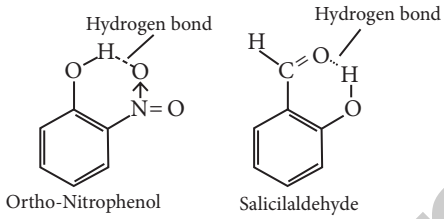
Three dimensional structure

38. What do you understand by the term 'non-stoichiometric hydrides? Do you expect this type of hydrides to be formed by alkali metals? Justify your answer.

Ans. These hydride which do not have fixed composition are called non-stoichiometric hydride and the composition varies with temperature and pressure. This type of hydrides are formed by d and f-block elements. They cannot be formed by alkali metals because alkali metal hydrides form ionic hydrides.

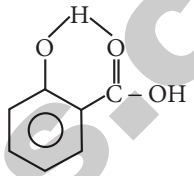
39. What are intra molecular hydrogen bonding? Explain with an example.

Ans. **(i)** Intra molecular hydrogen bonds are those which occur within one single molecule. This occurs between two functional groups within a molecule.



Ortho-Nitrophenol Salicilaldehyde

(ii) An intra molecular hydrogen bond joins the OH group to the doubly bonded oxygen atom of the carboxyl group on the same molecule. Eg., Salicylic acid

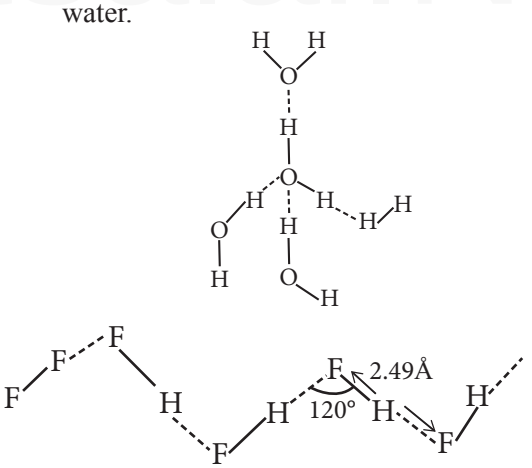


(iii) Salicylic acid act as an analgesic and antipyretic.

40. What are intermolecular hydrogen bonds? Explain with example.

Ans. **(i)** Intermolecular hydrogen bonds occur between two separate molecules. They can occur between any numbers of like a unlike molecules as long as hydrogen donors and acceptors are present in position in which they can interact

(ii) For eg Intermolecular hydrogen bonds can occur between ammonia molecular atom, between water molecules alone or between ammonia and water.



Hydrogen Fluoride Molecule

41. What are clalharate hydrate? Explain if with suitable example.

Ans. **(i)** Gas hydrates in which the guest molecules are not bonded chemically but retained by the structure of host is called clatharates.

(ii) Water forms clatharate hydrates, eg methane hydrates ($CH_4.2OH_2O$) which are a type of ice that will burn when a lit match is held to it.

23. When the first element of the periodic table is treated with dioxygen, it gives a compound whose solid state floats on its liquid state. This compound has an ability to act as an acid as well as a base. What products will be formed when this compound undergoes autoionisation? ***(HOTS)***

Ans. The first element of the periodic table is hydrogen.

$$2H_2 + O_2 \longrightarrow 2H_2O$$

The compound formed is water.

Auto - ionization or auto- protolysis of water proceeds as follows

$$\underset{\text{Acid}}{H_2O(l)} + \underset{\text{Base}}{H_2O(l)} \leftrightarrow \underset{\text{Conjugate Acid}}{H_3O} + (aq) + \underset{\text{Cojugate Acid}}{OH^-}(aq)$$

24. Difference between ortho and para hydrogen.

Ans. **Ortho and para hydrogen :**

	Ortho Hydrogen	Para Hydrogen
1. Definition	Hydrogen molecule in which the protons in the nuclei of both H-atoms are known to spin in same direction is termed as ortho hydrogen.	If the protons in the nuclei of both H-atoms spin in opposite direction, it is termed as para hydrogen.
2. Composition	At room temperature ordinary hydrogen consist of about 75% ortho and 25% para form.	As the temperature is lowered, the equilibrium shifts in favour of para hydrogen. At 25K, there is 99% para and 1% ortho hydrogen
3. Melting Point	Melting point of ortho hydrogen is 13.95 K	Melting point of para hydrogen is 13.83K
4. Boiling Point	Boiling point of ortho hydrogen is 20.39K	Boiling point of para hydrogen 20.26K
5. Vapour Pressure	The vapour pressure of orthohydrogen is lower.	The vapour pressure of liquid para hydrogen is higher than that of ordinary liquid hydrogen.

NUMERICAL PROBLEMS

1. An element (A) belonging to group number 1 and period number 3 reacts with dihydrogen to form an hydride (B). The element (A) reacts with the universal solvent to give a strong base (C). Identify A, B and C.

Sol: **(i)** An element (A) belonging to group number 1 and period number 3 is **sodium (A)**.

(ii) Sodium reacts with hydrogen to form **sodium hydride (B)**

$$\underset{(A)}{2Na} + \underset{(B)}{H_2} \longrightarrow \underset{(C)}{2NaH}$$

(iii) Sodium reacts with water to form **sodium hydroxide (C)**.

$$\underset{(A)}{2Na} + 2H_2O \longrightarrow \underset{(C)}{2NaOH} + H_2$$

A	Na	Sodium
B	NaH	Sodium hydride
C	NaOH	Sodium hydroxide

2. Identify the compound (A) which is a universal solvent. Compound A reacts with chlorine gas to give B and C. Compound A dissolves in an ionic compound of silicon to give compound D. Identify A and write the equations involved in the formation of B, C and D.

Sol: **(i)** The universal solvent is **water (A)**.

(ii) Water reacts with chlorine gas to form **hydro chloric acid (B) and hypo chlorous acid (C).**

$$\underset{(A)}{Cl_2} + H_2O \longrightarrow \underset{(B)}{HCl} + \underset{(C)}{HOCl}$$

(iii) Water reacts with silicon tetra chloride ($SiCl_4$) to give **silicon dioxide (D).**

$$\underset{(A)}{SiCl_4} + 2H_2O \longrightarrow \underset{(D)}{SiO_2} + \underset{(B)}{4HCl}$$

A	H_2O	Water
B	HCl	Hydro chloric acid
C	HOCl	Hypo chlorous acid
D	SiO_2	Silicon dioxide

✶ ✶ ✶

CREATIVE QUESTIONS (HOTS)

2 MARKS

1. (i) Name three natural sources of air pollution.
(ii) What compound will be formed when CO combines with blood?

Ans. (i)
- Volcanic eruptions
- Forest fires
- Pollen grains of flowers

(ii) The presence of CO reduces the amount of available haemoglobin of RBC because of formation of carboxyl haemoglobin. $Hb + CO \longrightarrow HbCO$

2. What is the tolerable limit of fluoride ions in drinking water? What happens if it exceeds 10 ppm?

Ans.
- The tolerable limit of fluoride ions in drinking water is one ppm or 1 mg dm^{-3}
- Higher concentration is harmful to bones and teeth.

3. When does the transport of oxygen to different body cells stop?

Ans. **(i)** Carbon monoxide (CO) combines with haemoglobin (H*b*) of the RBCs about 300 times more readily than oxygen to form **carboxy haemoglobin complex**.

$$Hb + CO \rightleftharpoons HbCO$$

(ii) Thus, Hb will not be able to combine with oxygen to for oxyhaemoglobin complex.

(iii) Hence the transport of oxygen to different body cells does not occur (stops).

4. Why and where do we use freons?

Ans.
- The main reason of ozone layer depletion is due to the release of chlorofluorocarbons (CGCs), also known as freons.
- These compounds are non – reactive, non – flammable, non – toxic organic molecules and therefore used in refrigerators, air – conditioners, in the production of plastic foam and by the electronic industry for cleaning computer parts, etc.

5. Although ozone is heavier than air, it does not settle down near the earth why?

Ans. **(i)** Ozone is thermodynamically unstable and decomposes bask to molecular oxygen before reaching near earth's surface.

(ii) As negligible amount of UV – rays reach near the surface the formation of ozone near the surface of earth is rare.

6. A person consuming metro water suddenly stated consuming well water due to shortage of water supply from municipality. What effect was felt by him? What could be the cause?

Ans.
- He felt laxative effect.
- The laxative effect is observed when the sulphates present in water have concentration greater than 500 ppm. Otherwise at moderate levels it is harmless.

3 MARKS

1. Write the impact of depletion of ozone layer on plants, human and aquatic life.

Ans. **(i) Impact on human:**
Exposure to UV radiation lead to ageing of skin, cataract, sun burn and skin cancer.

(ii) Impact on aquatic life:
Many phytoplanktons are killed and the productivity of fishes are damaged.

(iii) Impact on plant life:
- The plant proteins get easily affected by UV radiation.
- It also increases evaporation of surface water through the stomata of the leaves and decrease the moisture content of the soil.

5 MARKS

1. List out some methods that you suggest to control water pollution in your locality.

Ans. Degradation of water quality by the addition of substances like chemical effluents, metal residues, sewage, oil, detergent, etc. This called water pollution.

Water pollution can be controlled by the following methods :

(i) Industrial waste should not be allowed to get mixed in water bodies such as river, lakes, etc.
(ii) Check the pH of water regularly.
(iii) Excersive usage of fertilizers should be controlled.
(iv) Oil spills must be avoided as much as possible.
(v) Avoid the usage of DDT and malathion at home.
(vi) Waste water should be treated properly.
(vii) Avoid the usage of non – biodegradable detergents for cleaning of clother.

✶ ✶ ✶

11th STD.

INSTANT SUPPLEMENTARY EXAM - August 2022

Part - III

CHEMISTRY

(With Answers)

TIME ALLOWED : 3.00 HOURS] [MAXIMUM MARKS : 70

Instructions : (1) Check the question paper for fairness of printing. If there is any lack of fairness, inform the Hall Supervisor immediately.

(2) Use **Blue** or **Black** ink to write and underline and pencil to draw diagrams.

Note : Draw diagrams and write equations wherever necessary.

PART - I

Note : (i) Answer **all** the questions. **(15 × 1 = 15)**

(ii) Choose the most appropriate answer from the given **four** alternatives and write the option code and the corresponding answer.

1. Total number of electrons present in 1.7 g of ammonia is:
   a) 6.022×10^{23} b) $\frac{6.022 \times 10^{22}}{1.7}$
   c) $\frac{6.022 \times 10^{24}}{1.7}$ d) $\frac{6.022 \times 10^{23}}{1.7}$

2. The total number of orbitals associated with the principal quantum number n = 3 is :
   a) 9 b) 8 c) 5 d) 7

3. Tritium is a _____ emitter.
   a) α b) β
   c) γ d) None of these

4. _____ is used in devising photoelectric cells.
   a) Lithium b) Sodium
   c) Potassium d) Caesium

5. Among the following the least thermally stable is:
   a) K_2CO_3 b) Na_2CO_3 c) $BaCO_3$ d) Li_2CO_3

6. If temperature and volume of an ideal gas is increased to twice its values, the initial pressure P becomes:
   a) 4P b) 2P c) P d) 3P

7. The amount of heat exchanged with the surrounding at constant pressure is given by the quantity:
   a) ΔE b) ΔH c) ΔS d) ΔG

8. I f X is the function of PCl_5 dissociated at equilibrium in the reaction

   $PCl_{5\,(g)} \rightleftharpoons PCl_{3\,(g)} + Cl_{2\,(g)}$

   then starting with 0.5 mole of PCl_5, the total number of moles of reactants and products at equilibrium is :
   a) 0.5 – E b) X + 0.5
   c) 2X + 0.5 d) X + 1

9. Which one of the following binary liquid mixtures exhibit positive deviation from Raoult's law?
   a) Acetone + Chloroform
   b) Water + Nitric acid
   c) HCl + Water
   d) Ethanol + Water

10. The ratio of number of sigma (σ) and pi (π) bonds in 2- butynal is:
    (a) 8/3 (b) 5/3 (c) 8/2 (d) 9/2

11. The IUPAC name of the compound

    $CH_3 - CH_2 - \underset{\displaystyle COOH}{\underset{|}{CH}} - CH = CH_2$ is :

    a) 2-ethylbut-2-enoic acid
    b) 3-ethylbut-3-enoic acid
    c) 3-ethylbut-2-enoic acid
    d) 2-ethylbut-3-enoic acid

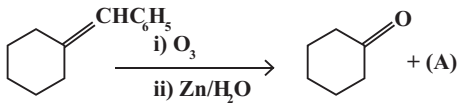
12. Match the following:

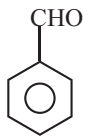
(1) $-NH_2$	(i) Sulpho -
(2) – CN	(ii) Formyl -
(3) $-SO_3H$	(iii) Amino -
(4) – CHO	(iv) Cyano -

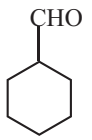
    a) (1) - (i), (2) - (ii), (3) - (iii), (4) - (iv)
    b) (1) - (iv), (2) - (iii), (3) - (ii), (4) - (i)
    c) (1) - (iii), (2) - (iv), (3) - (i), (4) - (ii)
    d) (1) - (iii), (2) - (i), (3) - (iv), (4) - (ii)

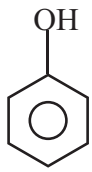
13. – 1 effect is not shown by:
    a) $-CH_2CH_3$ b) $-F$
    c) $-Cl$ d) $-NO_2$

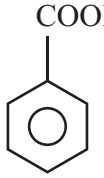
14. Identify the compound (A) in the following reaction:



a) 

b) 

c) 

d) 

15. **Assertion** : Increasing order of boiling points of halo alkanes are
    $CH_3Cl < CH_2Cl_2 < CHCl_3 < CCl_4$.
    Reason : The boiling points of halo alkanes increase with increase in the number of halogen atoms.
    a) **Assertion** is true but **reason** is false.
    b) Both **assertion** and **reason** are true and **reason** is the correct explanation of **assertion**.
    c) Both **assertion** and **reason** are false.
    d) Both **assertion** and **reason** are true but **reason** is not the correct explanation of **assertion.**

Part - II

Note : Answer **any six** questions. Question No. **24** is **compulsory :** **(6 × 2 = 12)**

16. What is meant by limiting reagents?
17. State Heisenberg's uncertainty principle.
18. Give an example for Ionic hydride and covalent hydride.
19. What is path function? Give two examples.
20. Define reaction quotient.
21. 50g of tap water contains 20mg of dissolved solids. What is the TDS value in ppm?
22. How will you prepare ethene by Kolbe's electrolytic method?
23. Mention any two methods of preparation of haloalkanes from alcohols.
24. If an automobile engine burns petrol at a temperature of 1089 K and if the surrounding temperature is 294 K, calculate its maximum possible efficiency.

Part - III

Note : Answer **any six** questions. Question No.**33** is **compulsory:** **(6 × 3 = 18)**

25. Calculate the empirical formula of a compound containing 76.6 % carbon, 6.38 % hydrogen and rest oxygen.
26. Compare the ionisation of energy of Beryllium and Boron.
27. Distinguish between diffusion and effusion.
28. At particular temperature $K_C = 4 \times 10^{-2}$ for the reaction
    $$H_2S(g) \rightleftharpoons H_2(g) + \frac{1}{2} S_2(g)$$
    Calculate K_C for each of the following reactions.
    (i) $2H_2S(g) \rightleftharpoons 2H_2(g) + S_2(g)$
    (ii) $3H_2S(g) \rightleftharpoons 3H_2(g) + \frac{3}{2} S_2(g)$
29. What are the conditions when a solution tends to behave like an ideal solution?
30. Describe Fajan's Rule.
31. Write short notes on hyper conjugation.
32. Explain Birch reduction.
33. Give an example for each of the following type of organic compounds.
    (i) Non-benzonoid aromatic compound
    (ii) Aromatic heterocyclic compound
    (iii) Carbocyclic compound

Part - IV

Note : Answer all the questions: **(5 × 5 = 25)**

34. (a) (i) Describe about magnetic quantum number.
    (ii) Give the electronic configuration of Mn^{2+} and Cr^{3+}.
    (OR)
    (b) (i) What are f-block elements?
    (ii) Sate the trends in the variation of electronegativity in group and periods.
35. (a) Discuss the similarities between lithium and magnesium.
    (OR)
    (b) (i) Define entropy. Give its unit.
    (ii) List any three characteristics of Gibbs free energy.
36. (a) Derive K_C and K_P for synthesis of ammonia.
    (OR)
    (b) Discuss the formation of C_2 molecule using Mo Theory.