Loyola

# EC CHEMISTRY

11

## Volume - I & II

This special guide is prepared on the basis of New Syllabus

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# PREFACE

Dear loving brothers and sisters our blessing to all of you.

- This guide has been prepared based on the updated new textbook.
- The questions with answers given in each less has been designed as follows.
  1) Textual Questions 1, 2, 3, 5 marks
  2) Additional Questions 1, 2, 3, 5 marks
  3) Solved textual problems Evaluate Yourself and additional problems.
- Not only answers are given for objective type questions but the necessary derivations are also given.
- The 2, 3 mark questions are prepared according to the questions based on NCERT question type.
- A great effort has been taken to bring out this guide without any mistakes or corrections. I hope and believe that this guide will be an indeed friend to all students.
- To make this guide more effective your suggestions are kindly welcomed.

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# CONTENTS

# UNIT 1 BASIC CONCEPTS OF CHEMISTRY AND CHEMICAL CALCULATIONS

## Part I – Evaluation (Book Back Questions)

### 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**

**Solution :**

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

| Content | $CH_4$ | $O_2$ | $CO_2$ |
|---|---|---|---|
| Stoichiometric coefficient | 1 | 2 | 1 |
| Volume of reactants allowed to react | 40 mL | 80 mL | |
| Volume of reactant reacted and product formed | 40 mL | 80 mL | 40 mL |
| Volume of gas after cooling to the room temperature | - | - | 40 mL |

Since the product was cooled to room temperature, water exists mostly as liquid.

Hence, option (a) is correct.

**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

**Solution :** **Ans: d) 200 u**

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

$$\simeq 200 \text{ u}$$

**3. Assertion : Two mole of glucose contains $12.044 \times 10^{23}$ molecules of glucose**

**Reason : Total number of entities present in one mole of any substance is equal to $6.02 \times 10^{22}$**

(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**

**Solution :**

Correct reason : Total number of entities present in one mole of any substance is equal to $6.022 \times 10^{23}$.

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

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

**Ans: b) oxygen**

**Solution :**

**Reaction 1 :**

$$2C + O_2 \rightarrow 2CO$$

2 x 12g carbon combines with 32g of oxygen. Hence,

$$\text{Equivalent mass of carbon} = \frac{2 \times 12}{32} \times 8 = 6$$

**Reaction 2 :**

$$C + O_2 \rightarrow CO_2$$

12g carbon combines with 32g of oxygen. Hence,

$$\text{Equivalent mass of carbon} = \frac{12}{32} \times 8 = 3$$

**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**

**Solution :**

Let the trivalent metal be $M^{3+}$
Equivalent mass
= mass of the metal / valance factor
9g $eq^{-1}$ = mass of the metal / 3 eq
Mass of the metal = 27g
Oxide formed $M_2O_3$ ;
Mass of the oxide = (2 × 27) + (3 × 16)
= 102g

**6. The number of water molecules in a drop of water weighing 0.018 g is**

a) $6.022 \times 10^{26}$ b) $6.022 \times 10^{23}$
c) $6.022 \times 10^{20}$ d) $9.9 \times 10^{22}$

**Ans: c) $6.022 \times 10^{20}$**

**Solution :**

Weight of the water drop = 0.018g
No. of moles of water in the drop
= Mass of water / molar mass
= 0.018 / 18 = $10^{-3}$ mole
No. of water molecules present in 1 mole of water = $6.022 \times 10^{23}$
No. water molecules in one drop of water ($10^{-3}$ mole)
= $6.022 \times 10^{23} \times 10^{-3} = 6.022 \times 10^{20}$

**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%**

**Solution :**

$MgCO_3 \rightarrow MgO + CO_2 \uparrow$
$MgCO_3$ : (1×24) + (1×12)+(3×16) = 84g
$CO_2$ : (1×12) + (2×16) = 44g
100% pure 84g $MgCO_3$ on heating gives 44g $CO_2$.
Given that 1g $MgCO_3$ on heating gives 0.44g $CO_2$.
Therefore, 84g $MgCO_3$ sample on heating gives 36.96g $CO_2$
Percentage of purity of the sample =

$$\frac{100\%}{44g CO_2} \times 36.96g\ CO_2 = 84\%$$

Percentage of impurity = 16%

**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**

**Solution :**

$$\underset{6.3\ g}{NaHCO_3} + \underset{+\ 30g}{CH_3COOH} \rightarrow \underbrace{CH_3COONa + H_2O}_{33g} + CO_2 \uparrow + x$$

The amount of $CO_2$ released x = 3.3g
No. of moles of $CO_2$ released = 3.3/44 = 0.075 mol

**9. When 22.4 litres of $H_{2\,(g)}$ is mixed with 11.2 litres of $Cl_{2\,(g)}$, each at 273 K at 1 atm the moles of $HCl_{(g)}$, formed is equal to**

a) 2 moles of $HCl_{(g)}$ b) 0.5 moles of $HCl_{(g)}$
c) 1.5 moles of $HCl_{(g)}$
d) 1 moles of $HCl_{(g)}$

**Ans: d) 1 moles of $HCl_{(g)}$**

**Solution :**

$H_2(g) + Cl_2(g) \rightarrow 2\ HCl\ (g)$

| Content | $H_2(g)$ | $Cl_2(g)$ | HCl (g) |
|---|---|---|---|
| Stoichiometric coefficient | 1 | 1 | 2 |
| No. of moles of reactants allowed to react at 273 K and 1 atm pressure | 22.4 L (1mol) | 11.2L (0.5mol) | - |

| | | | |
|---|---|---|---|
| No. of moles of reactant reacted and product formed | 0.5 | 0.5 | 1 |
| Amount of HCl formed = 1 mol | | | |

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

a) $Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O$

b) $C + 2H_2SO_4 \rightarrow CO_2 + 2SO_2 + 2H_2O$

c) $BaCl_2 + H_2SO_4 \rightarrow BaSO_4 + 2HCl$

d) none of the above

**Ans: c) $BaCl_2 + H_2SO_4 \rightarrow BaSO_4 + 2HCl$**

**Solution :**

$\overset{+2\ -1}{BaCl_2} + \overset{+1\ +6\ -2}{H_2SO_4} \rightarrow \overset{+2\ +6\ -2}{BaSO_4} + \overset{+1\ -1}{2HCl}$

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

a) $3Mg(s) + N_2(g) \rightarrow Mg_3N_2(s)$

b) $P_4(s) + 3NaOH + 3H_2O \rightarrow PH_3(g) + 3NaH_2PO_2(aq)$

c) $Cl_2(g) + 2KI(aq) \rightarrow 2KCl(aq) + I_2$

d) $Cr_2O_3(s) + 2Al(s) \rightarrow Al_2O_3(s) + 2Cr(s)$

**Ans: b) $P_4(s) + 3NaOH + 3H_2O \rightarrow PH_3(g) + 3NaH_2PO_2(aq)$**

**Solution :**

$\overset{0}{P_4} + 3NaOH + 3H_2O \rightarrow \overset{-3}{PH_3} + 3\overset{+1}{NaH_2PO_2}$

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

**$MnO^-_4 + 2H_2O + 3e^- \rightarrow MnO_2 + 4OH^-$**

a) 31.6 b) 52.7

c) 79 d) None of these

**Ans: b) 52.7**

**Solution :**

The reduction reaction of the oxidising agent ($MnO^-_4$) involves gain of 3 electrons. Hence the equivalent mass = (Molar mass of $KMnO_4$)/3 = 158.1/3 = 52.7.

**13. Which one of the following represents 180g of water?** QY-2019 AUG-2021

a) 5 Moles of water

b) 90 moles of water

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

d) $6.022 \times 10^{24}$ molecules of water

**Ans: d) $6.022 \times 10^{24}$ molecules of water**

**Solution :**

No. of moles of water present in 180g.

= Mass of water / Molar mass of water

= 180g / 18g $mol^{-1}$ = 10 moles

One mole of water contains

= $6.022 \times 10^{23}$ water molecules

10 mole of water contains

= $6.022 \times 10^{23} \times 10 = 6.022 \times 10^{24}$ water molecules

**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-2022

a) NO b) $N_2O$

c) CO d) $CO_2$

**Ans: a) NO**

**Solution :**

7.5 g of gas occupies a volume of 5.6 liters at 273K and 1 atm pressure. Therefore, the mass of gas that occupies a volume of 22.4 liters

$$= \frac{7.5g}{5.6L} \times 22.4L = 30g$$

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

**15. Total number of electrons present in 1.7 g of ammonia is** AUG - 2022

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

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

**Solution :** **Ans: a) $6.022 \times 10^{23}$**

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

No. of moles of ammonia =

$$\frac{\text{Mass}}{\text{Molar mass}} = \frac{1.7\text{g}}{17\text{gmol}^{-1}}$$

$$= 0.1\text{mol}$$

No. of molecules present in 0.1 mol of ammonia = $0.1 \times 6.022 \times 10^{23} = 6.022 \times 10^{22}$

No. of electrons present in 0.1 mol of ammonia = $10 \times 6.022 \times 10^{22} = 6.022 \times 10^{23}$

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

**Solution :**

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

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

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

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

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

d) none of these

**Ans: c)** $\frac{\text{molar mass of ferrous oxalate}}{3}$

**Solution :**

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

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

**18. If Avogadro number were changed from $6.022 \times 10^{23}$ to $6.022 \times 10^{20}$, 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**

**Solution :**

No. of moles of oxygen = 8g/32g

= 0.25 moles of oxygen

No. of moles of sulphur dioxide = 8g / 64g

= 0.125 moles of sulphur dioxide

Ratio between the no. of molecules

= 0.25 : 0.125 = 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

**Solution :** **Ans: a) 3.59 g**

$AgNO_3 + KCl \rightarrow KNO_3 + AgCl$

50 mL of 8.5% solution contains 4.25g of $AgNO_3$

No. of moles of $AgNO_3$ present in 50mL of 8.5% $AgNO_3$ solution

= Mass/ Molar mass

= 4.25 / 170 = 0.025 moles

Similarly, No. of moles of KCl present in 100 mL of 1.865% KCl solution

= 1.865 / 74.5

= 0.025 moles

So total amount of AgCl formed is 0.025 moles (based on the stoichiometry)

Amount of AgCl present in 0.025 moles of AgCl = no. of moles × molar mass

= 0.025 × 143.5 = 3.59g

**21. The mass of a gas that occupies a volume of 612.5 ml at room temperature and pressure (25$^0$C and 1 atm pressure) is 1.1g. The molar mass of the gas is**

a) 66.25g mol$^{-1}$ b) 44 g mol$^{-1}$
c) 24.5 g mol$^{-1}$ d) 662.5 g mol$^{-1}$

**Solution :** **Ans: b) 44 g mol$^{-1}$**

No. of moles of a gas that occupies a volume of 612.5 mL at room temperature and pressure (25$^o$C and 1 atm pressure)

= 612.5 × 10$^{-3}$ L/24.5 Lmol$^{-1}$

= 0.025 moles

We know that,

Molar mass = Mass / no. of moles

= 1.1 g/ 0.025 mol = 44g 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

**Solution :** **Ans: c) both (a) and (b)**

No. of moles of carbon present in 6g of C - 12 = Mass/ Molar mass

= 6/12 = 0.5 moles

= 0.5 × 6.022 × 10$^{23}$ carbon atoms.

No. of moles in 7.5g of ethane

= 7.5/30 = 0.25 moles

= 2 × 0.25 × 6.022 × 10$^{23}$ carbon atoms.

No. of moles in 7.5g

ethane = 7.5 / 30 = 0.25 moles

= 2 × 0.25 × 6.022 × 10$^{23}$ carbon atoms.

**23. Which of the following compound (S) has/ have percentage of carbon same as that in ethylene ($C_2H_4$)** Qy-2019 March-2019 & 2023

a) propene b) ethyne
c) benzene d) ethane

**Solution :** **Ans: a) propene**

Percentage of carbon in ethylene ($C_2H_4$) =

$$= \frac{\text{mass of carbon}}{\text{Molar mass}} \times 100$$

$$= \frac{24}{28} \times 100 = 85.71\%$$

Percentage of carbon in propene ($C_3H_6$)

$$= \frac{36}{42} \times 100 = 85.71\%$$

**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**

**Solution :**

relative atomic mass of C - 12 is 12 u

**25. Which one of the following is used as a standard for atomic mass ?** GMQ - 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.**

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

Relative atomic mass (Ar) :

$$= \frac{\text{Average mass of the atom}}{\text{Unified atomic mass}}$$

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

One mole is the amount of substance of a system, which contains as many elementary particles as there are atoms in 12g of C-12 isotopes.

**28. Define equivalent mass.**

GMQ - 2018 QY - 2018 & 19 May - 2022

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

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

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

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

HY - 2019 March 2023

| | Oxidation | Reduction |
|---|---|---|
| 1. | Addition of Oxygen | Removal of Oxygen |
| 2. | Removal of Hydrogen | Addition of Hydrogen |
| 3. | Loss of Electrons | Gain of Electrons |
| 4. | Increases in Oxidation number | Decreases in Oxidation number |

**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 [$H_2SO_4$]**

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

| | | | | | |
|---|---|---|---|---|---|
| N = | 2 | x | 14 | = | 28 |
| H = | 4 | x | 1 | = | 4 |
| C = | 1 | x | 12 | = | 12 |
| O = | 1 | x | 16 | = | 16 |
| | | | | | 60 |

Molar mass of urea : 60g $mol^{-1}$

**(ii) Acetone [$CH_3COCH_3$]**

| | | | | | |
|---|---|---|---|---|---|
| C = | 3 | x | 12 | = | 36 |
| H = | 6 | x | 1 | = | 6 |
| O = | 1 | x | 16 | = | 16 |
| | | | | | 58 |

Molar mass of acetone = 58g $mol^{-1}$

**(iii) Boric acid [$H_3BO_3$]**

| | | | | | |
|---|---|---|---|---|---|
| B = | 1 | x | 11 | = | 11 |
| H = | 3 | x | 1 | = | 3 |
| O = | 3 | x | 16 | = | 48 |
| | | | | | 62 |

Molar mass of Boricacid : 62g $mol^{-1}$

**(iv) Sulphuric acid [$H_2SO_4$]**

| | | | | | |
|---|---|---|---|---|---|
| S = | 1 | x | 32 | = | 32 |
| H = | 2 | x | 1 | = | 2 |
| O = | 4 | x | 16 | = | 64 |
| | | | | | 98 |

Molar mass of $H_2SO_4$ = 98g $mol^{-1}$

**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 $CO_2$.**

Given :

The density of $CO_2$ at 273K 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*

$$\text{Mass of 1 mole of } CO_2 = \frac{1.965\text{Kg}}{1\text{m}^3} \times 22.4\text{L}$$

$$= \frac{1.965 \times 10^3\text{g} \times 22.4 \times 10^{-3}\ \cancel{\text{m}^3}}{\cancel{1\text{m}^3}} = 44.01\text{ g}$$

molar mass of $CO_2$ = 44.01 g $mol^{-1}$

**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 $H_2O$**

Given :

| Compound | Given no. of moles | No. of oxygen atoms |
|---|---|---|
| Ethanol - $C_2H_5OH$ | 1 | $1 \times 6.022 \times 10^{23}$ |
| Formic acid - HCOOH | 1 | $2 \times 6.022 \times 10^{23}$ |
| Water - $H_2O$ | 1 | $1 \times 6.022 \times 10^{23}$ |
| **Answer : Formic acid** | | |

**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 |

**Solution :**

Average atomic mass = $\frac{(78.99\times23.99) + (10\times24.99) + (11.01\times 25.98)}{100}$

$= \frac{2430.9}{100}$ **= 24.31u**

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

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

**(b) 1mol 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 $z_2$**

**Solution :**

Reaction : $x + y + z_2 \rightarrow xyz_2$

| 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 atoms | 25 atoms | 50 molecules | 25 atoms | 25 atoms | 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 $6.645 \times 10^{-23}$ g. How many moles of element are there in 0.320 kg.**

**Solution :**

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

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

$\therefore$ number of moles of element in 0.320 kg = $\frac{1\,\text{mole}}{40\,\text{g}} \times 0.320\text{kg} = \frac{1\,\text{mole} \times 320\,\text{g}}{40\,\text{g}}$ **= 8 mol**

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

**Solution :**

| | Molecular mass | Molar mass |
|---|---|---|
| 1. | The relative 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 a one mole of a substance. |
| 2. | The relative molecular mass of any compound can be calculated by adding the relative atomic masses of its constituent atoms. | Molar mass of a compound is equal to sum of the relative masses of its constituents. |
| 3. | It is expressed in 'u'<br>Molecular mass of CO = 12 + 16 = 28 u | It is expressed in $gmol^{-1}$<br>Molar mass of CO = 28 $gmol^{-1}$ |

**38. What is the empirical formula of the following ?** QY - 2018

**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.**

**Solution :**

| 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)**

**$2Al + Fe_2O_3 \rightarrow Al_2O_3 + 2Fe$; 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?**

**Solution :**

$2Al + Fe_2O_3 \rightarrow Al_2O_3 + 2Fe$

| | Reactants | | Products | |
|---|---|---|---|---|
| | Al | $Fe_2O_3$ | $Al_2O_3$ | Fe |
| Amount of reactant allowed to react | 324g | 1.12 kg | - | - |
| Number of moles allowed to react | $\frac{324}{27}$ =12 mol | $\frac{1.12\times10^3}{160}$ = 7mol | - | - |
| Stoichiometric Co-efficient | 2 | 1 | 1 | 2 |
| Number of moles consumed during reaction | 12 mol | 6 mol | - | - |
| Number of moles of reactant unreacted and number of moles of product formed | - | 1 mol | 6 mol | 12 mol |

Molar of $Al_2O_3$ formed

$= 6 \text{ mol} \times 102 \text{ g mol}^{-1} \left[ \begin{matrix} Al_2O_3 \\ (2\times27)+3(\times16) \\ 54+48= 102 \end{matrix} \right]$

$= 612 \text{ g}$

Excess reagent = $Fe_2O_3$

Amount of excess reagent left at the end of the reaction = 1 mol x 160 g mol–1

$= 160 \text{ g} \left[ \begin{matrix} Fe_2O_3 \\ (2\times56)+(3\times16) \\ 112+48= 160 \end{matrix} \right] = 160 \text{ g}$

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

**Solution :** QY - 2019

Balanced equation for the combustion of ethane

$C_2H_6 + 7/2\ O_2 \rightarrow 2CO_2 + 3H_2O \Rightarrow 2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$

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

∴ To produce 1 mole (44 g) of $CO_2$ required

number of moles of ethane $= \frac{2 \text{ mol ethane}}{4 \text{ mol } CO_2} \times 1 \text{ mol } CO_2$

$= 1/2$ mole of ethane **= 0.5 mole of ethane**

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

**Solution :**

$\overset{-1}{H_2O_2} + Fe^{2+} \longrightarrow Fe^{3+} + \overset{-2}{H_2O}$

$\uparrow \quad \downarrow$

$(1e^- \times 2) \quad 1e^-$

$H_2O_2 + 2Fe^{2+} \rightarrow Fe^{3+} + H_2O$

$\Rightarrow H_2O_2 + 2Fe^{2+} + 2H^+ \rightarrow 2Fe^{3+} + 2H_2O$

**42. Calculate the empirical and molecular formula of a compound containing 76.6% carbon, 6.38 % hydrogen and rest oxygen its vapour density is 47.** MAR - 2019 SEP -2020 AUG - 2022

**Solution :**

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

**Empirical formula = $C_6H_6O$**

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

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

$$= \frac{2 \times 47}{94} = 1$$

∴ **Molecular formula ( $C_6H_6O$) × 1 = $C_6H_6O$**

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

**Solution :**

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

**Empirical formula = $Na_2SH_{20}O_{14}$**

$$n = \frac{\text{Molar mass}}{\text{Calculated empirical formula mass}} = \frac{322}{322} = 1$$

$Na_2SH_{20}O_{14}$
$= (2 \times 23) + (1 \times 32) + (20 \times 1) + 14(16)$
$= 46 + 32 + 20 + 224$
$= 322$

Molecular formula = $Na_2SH_{20}O_{14}$

Since all the hydrogen in the compound present as water

∴ Molecular formula is $Na_2SO_4.10H_2O$

**44. Balance the following equations by oxidation number method.** QY 2019 March-2023

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

**(ii) $KMnO_4 + Na_2SO_3 \rightarrow MnO_2 + Na_2SO_4 + KOH$**

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

**(iv) $KMnO_4 + H_2C_2O_4 + H_2SO_4 \rightarrow K_2SO_4 + MnSO_4 + CO_2 + H_2O$**

**Solution :**

(i) $\overset{+6}{K_2Cr_2}O_7 + K\overset{-1}{I} + H_2SO_4 \longrightarrow K_2SO_4 + \overset{+3}{Cr}_2(SO_4)_3 + \overset{0}{I_2} + H_2O$

$2\times3e^-$ ↑ ; $1e^-$ ↓

$\Rightarrow$ $\mathbf{K_2Cr_2O_7 + 6KI} + H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + I_2 + H_2O$

$\Rightarrow$ $K_2Cr_2O_7 + 6KI + H_2SO_4 \rightarrow K_2SO_4 + \mathbf{Cr_2(SO_4)_3} + 3I_2 + H_2O$

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

(ii) $K\overset{+7}{M}nO_4 + Na_2\overset{+4}{S}O_3 \longrightarrow \overset{+4}{M}nO_2 + Na_2\overset{+6}{S}O_4 + KOH$

$3e^-$ ↑ ; $2e^-$ ↓

$\Rightarrow$ $\mathbf{2KMnO_4 + 3Na_2SO_3} \rightarrow MnO_2 + Na_2SO_4 + KOH$

$\Rightarrow$ $2KMnO_4 + 3Na_2SO_3 \rightarrow \mathbf{2MnO_2 + 3Na_2SO_4} + KOH$

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

iii) $\overset{0}{Cu} + H\overset{+5}{N}O_3 \longrightarrow \overset{+2}{C}u(NO_3)_2 + \overset{+4}{N}O_2 + H_2O$

$2e^-$ ↓ ; $1e^-$ ↑

QY 2019

$\Rightarrow$ $\mathbf{Cu + 2HNO_3} \rightarrow Cu(NO_3)_2 + NO_2 + H_2O$

$\Rightarrow$ $Cu + 2HNO_3 + \mathbf{2HNO_3} \rightarrow Cu(NO_3)_2 + \mathbf{2NO_2} + 2H_2O$

$\Rightarrow$ $Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

iv) $K\overset{+7}{M}nO_4 + H_2\overset{+3}{C}_2O_4 + H_2SO_4 \longrightarrow K_2SO_4 + \overset{+2}{M}nSO_4 + \overset{+4}{C}O_2 + H_2O$

$5e^-$ ↓ ; $1e^- \times 2$ ↑

$\Rightarrow$ $\mathbf{2KMnO_4 + 5H_2C_2O_4} + H_2SO_4 \rightarrow K_2SO_4 + MnSO_4 + CO_2 + H_2O$

$\Rightarrow$ $2KMnO_4 + 5H_2C_2O_4 + H_2SO_4 \rightarrow K_2SO_4 + \mathbf{2MnSO_4 + 10CO_2} + H_2O$

$\Rightarrow$ $2KMnO_4 + 5H_2C_2O_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 10CO_2 + 8H_2O$

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

**(i)** $\mathbf{KMnO_4 + SnCl_2 + HCl \rightarrow MnCl_2 + SnCl_4 + H_2O + KCl}$

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

**(iii)** $\mathbf{Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + NaI}$

**(iv)** $\mathbf{Zn + NO_3^- \rightarrow Zn^{2+} + NO}$ **(in acid medium)**

**Solution :**

i) Half reaction are

$\overset{+7}{MnO_4^-} \rightarrow Mn^{2+}$ ..... (1)

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

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

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

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

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

(1) + (2) $\Rightarrow 2MnO_4^- + 5Sn^{2+} + 16H^+ \rightarrow 2Mn^{2+} + 5Sn^{4+} + 8H_2O$

$\Rightarrow 2KMnO_4 + 5SnCl_2 + 16HCl \rightarrow 2MnCl_2 + 5SnCl_4 + 8H_2O$

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

$\overset{+6}{Cr_2}O_7^{2-} \longrightarrow Cr^{3+}$ ..... (2)

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

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

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

$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$ ..... (4)

(5) + (4) $Cr_2O_7^{2-} + 3C_2O_4^{2-} + 14H^+ \rightarrow 2Cr^{3+} + 6CO_2 + 7H_2O$

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

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

Half reaction $I_2 \rightarrow I^-$ ..... (2)

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

(2) $\Rightarrow \quad I_2 + 2e^- \longrightarrow 2I^-$ .....(4)

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

$2Na_2S_2O_3 + I_2 \rightarrow 2Na_2S_4O_6^{2} + 2NaI$

iv) $Zn + NO_3^- \rightarrow Zn^{2+} + NO$

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

$\overset{+5}{N}O_3^- \longrightarrow \overset{+2}{NO}$ ..... (2)

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

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

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

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

(5) + (6) $\Rightarrow$ $\boxed{3Zn + 2NO_3^- + 8H^+ \longrightarrow 3Zn^{2+} + 2NO + 4H_2O}$

## III. 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**

**Solution :**

i) Element - Copper wire, Silver plate

ii) Compound - Sugar, distilled water, carbon dioxide, Table salt, Naphthalene balls.

iii) Mixture - Sea water

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**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 ($C_{12}H_{22}O_{11}$)**

**Solution :**

i) $C_2H_5OH$ : (2×12)+(5×1) + (1×16) + (1×1) = 46 g

ii) $KMnO_4$ : (1×39) + (1×55) + (4×16) = 158 g

iii) $K_2Cr_2O_7$ : (2×39) + (2×52) + (7×16) = 294 g

iv) $C_{12}H_{22}O_{11}$ : (12×12) + (22×1) + (11×16) = 342 g

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

**Solution :**

a) Molar mass of ethane, $C_2H_6$ = (2 x 12) + (6 x 1) = 30 g $mol^{-1}$

n = mass / molar mass = 9g / 30 $mol^{-1}$ = 0.3 mole

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

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

$$= \frac{1 \text{ mole}}{273 \text{ K} \times 1 \text{ atm} \times 22.4\text{L}} \times 0.224 \text{ L} \times 273\text{K} \times 3 \text{ atm} = 0.03 \text{ mole}$$

1 Mole of oxygen contains 6.022x $10^{23}$ molecules

0.03 mole of oxygen contains = 6.022 x $10^{23}$ x 0.03

= 1.807 x $10^{22}$ molecules of oxygen

**4. a) 0.456g of a metal gives 0.606g of its chloride Calculate the equivalent mass of the metal.**
**b) Calculate the equivalent mass of potassium dichromate. The reduction half-reaction in acid medium is $Cr_2O^{2-}_7 + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$**

**Solution :**

a) Mass of the metal = 0.456g
Mass of the metal chloride = 0.606g
0.456g of the metal combines with 0.15g of chlorine.
Mass of the metal that combines with 35.5g of chlorine is $\frac{0.456}{0.15} \times 35.5 = 107.92g\ eq^{-1}$

b) Equivalent mass of an oxidising agent = $\frac{\text{Molar mass}}{\text{number of moles of electrons gained by one mole of the reducing agent}}$

$= \frac{294.18\ mol^{-1}}{6\ eq\ mol^{-1}} = 49.0g\ eq^{-1}$

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

**Solution :**

| Element | Percentage Composition | Atomic Mass | Relative no. of atoms= $\frac{\text{Percentage}}{\text{Atomic mass}}$ | Simple ratio |
|---|---|---|---|---|
| C | 54.55% | 12 | 54.55 / 12 = 4.55 | 4.55/2.27 = 2 |
| H | 9.09% | 1 | 9.09 / 1 = 9.09 | 9.09 / 2.27 = 4 |
| O | 36.36% | 16 | 36.36 / 16 = 2.27 | 2.27 / 2.27 = 1 |

**6. Experimental analysis of a compound containing the elements x,y,z on analysis gave the following data. x = 32%, y = 24%, z = 44%. The relative number of atoms of x,y, and z are 2, 1 and 0.5, respectively. (Molecular mass of the compound is 400 g) find out.**
**i) The atomic masses of the element x,y,z ii) Empirical formula of the compound and iii) Molecular formula of the compound.**

**Solution :**

| Element | Percentage Composition | Relative no. of atoms= $\frac{\text{Percentage}}{\text{Atomic mass}}$ | Atomic mass = $\frac{\text{Percentage}}{\text{Relative no. of atoms}}$ | Simple ratio |
|---|---|---|---|---|
| X | 32% | 2 | 16 | 4 |
| Y | 24% | 1 | 24 | 2 |
| Z | 44% | 0.5 | 88 | 1 |
| Empirical formula $(X_4Y_2Z)$ | | | | |

calculated empirical formula mass = (16×4) + (24×2) + 88
= 64 + 48 + 88 = 200

$n = \frac{\text{Molar mass}}{\text{Calculated empirical formula mass}} \quad \therefore n = \frac{400}{200} = 2$

$\therefore$ Molecular formula $(X_4Y_2Z)_2 = X_8Y_4Z_2$

**7. The balanced equation for a reaction is given below 2x + 3y → 4l + m. When 8 moles of x react with 15 moles of y, then**

**I) Which is the limiting reagent?**

**ii) Calculate the amount of products formed.**

**iii) Calculate the amount of excess reactant left at the end of the reaction.**

**Solution :**

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

Limiting reagent : x

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

Amount of excess reactant : 3 moles of y

**8. Balance the following equation using oxidation number method**

**$As_2S_3 + HNO_3 + H_2O \rightarrow H_3AsO_4 + H_2SO_4 + NO$** GMQ - 2018

**Solution :**

$$\overset{+3}{As_2}\overset{-2}{S_3} + \overset{+5}{HNO_3} \rightarrow \overset{+5}{H_3AsO_4} + \overset{+6}{H_2SO_4} + \overset{+2}{NO}$$

$\frac{2 \times 2e^-}{4e^-} + \frac{3 \times 8e^-}{24e^-}$ $3e^-$

$28e^-$

Equate the total no. of electrons in the reactant side by cross multiplying,

$\Rightarrow 3As_2S_3 + 28HNO_3 \rightarrow H_3AsO_4 + H_2SO_4 + NO$

Based on reactant side, balance the products

$\Rightarrow 3As_2S_3 + 28HNO_3 \rightarrow 6H_3AsO_4 + 9H_2SO_4 + 28\ NO$

Product side : 36 hydrogen atoms & 88 oxygen atoms

Reactant side : 28 hydrogen atoms & 84 oxygen atoms

Difference is 8 hydrogen atoms & 14 oxygen atoms

$\therefore$ Add $4H_2O$ molecule on the reactant side. Balanced equation is,

$3As_2S_3 + 28HNO_3 + 4H_2O \rightarrow 6H_3AsO_4 + 9H_2SO_4 + 28\ NO$

## IV. PROBLEMS -(2/3/5 Marks)

### BOOK EXAMPLE PROBLEMS

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

**Solution :**

| Element | Percentage | Molar Mass | Relative no. of moles | Simplest ratio | Simplest ratio (in whole nos) |
|---|---|---|---|---|---|
| C | 32 | 12 | $\frac{32}{12} = 2.66$ | $\frac{2.66}{2.66} = 1$ | 2 |
| H | 4 | 1 | $\frac{4}{1} = 4$ | $\frac{4}{2.66} = 1.5$ | 3 |
| O | 64 | 16 | $\frac{64}{16} = 4$ | $\frac{4}{2.66} = 1.5$ | 3 |

The empirical formula is $C_2H_3O_3$

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

**Solution :**

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

The empirical formula is $CH_2O_3$

**3. How many moles of hydrogen (H) is required to produce 10 moles of ammonia?**

**Solution :**

The balanced stoichiometric equation for the formation of ammonia is

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

As per the stoichiometric equation, to produce 2 mole of ammonia, 3 moles of hydrogen are required ∴ to produce 10 moles of ammonia.

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

= 15 Moles of hydrogen are required

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

**Solution :**

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

As per the stoichiometric equation,

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

C H$_4$

$(12)+(4\times1) = 16 g\ mol^{-1}$

$H_2$ O

$(2\times1)+(1\times16) = 18 g\ mol^{-1}$

Combustion of 32g $CH_4$ produces

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

**5. How much volume of carbon dioxide is produced when 50 g of calcium carbonate is heated completely under standard conditions?**

**Solution :**

The balanced chemical equation is,

$$CaCO_3(s) \xrightarrow{\Delta} CaO(s) + CO_2(g)$$

$CaCO_3$

$(40) + (12) + (3\times16) = 100\ g\ mol^{-1}$

As per stoichiometric equation, 1 mole (100g) $CaCO_3$ on heating produces 1 moles $CO_2$.

At STP, 1 mole of $CO_2$ occupies a volume of 22.71 litres.

∴ At STP, 50g of $CaCO_3$ on heating produces,

$$\frac{22.71 \text{ litres of } CO_2 \times 50\ g\ CaCO_3}{100 g\ CaCO_3}$$

$$= 11.35 \text{ litres of } CO_2$$

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

**Solution :**

The balanced equation for the formation of HCl is

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$$

As per the stoichiometric equation, under given conditions,

To produce 2 moles of HCl,

1 mole of chlorine gas is required

To produce 44.8 litres of HCl,

22.4 litres of chlorine gas are required.

∴ To produce 11.2 litres of HCl,

$$\frac{22.4\ L\ Cl_2}{44.8\ L \text{ of HCl}} \times \frac{1}{4}\ 11.2\ L \text{ of HCl}$$

= 5.6 litres of chlorine are required.

**7. Calculate the percentage composition of the elements present in magnesium carbonate. How many kilogram of $CO_2$ can be obtained by heating 1 kg of 90% pure magnesium carbonate.**

**Solution :**

The balanced chemical equation is

$$MgCO_3 \xrightarrow{\Delta} MgO + CO_2$$

Molar mass of $MgCO_3$ is $84 g\ mol^{-1}$

$$= \frac{\text{Mass of the element in the compound}}{\text{Molar mass of the compound}} \times 100$$

$$\% \text{ of Mg} = \frac{24}{84} \times 100 = 28.57\%$$

$$\% \text{ of C} = \frac{12}{84} \times 100 = 14.29\%$$

% of O = 100 - (% of Mg + %C)

= 100 - (28.57+14.29)

= 100 - 42.86

% of O = 57.14%

90% of pure of 1kg $MgCO_3$

$$= \frac{90}{100} \times 1kg = 0.9kg$$

$$MgCO_3 \xrightarrow{\Delta} MgO + CO_2$$

As per equation, 84g of pure $MgCO_3$ on heating gives 44g of $CO_2$

0.9 kg of pure $MgCO_3$ on heating

$$\frac{44g \times 0.9kg}{84g} = 0.471kg \text{ of } CO_2$$

**8. In a process**
**646g of ammonia is allowed to react with 1.144kg of $CO_2$ to form urea.**

**1. If the entire quantity of all the reactants is not consumed in the reaction which is the limiting reagent?**

**2. Calculate the quantity of urea formed and unreacted quantity of the excess reagent.**

The balanced equation is $2NH_3 + CO_2 \rightarrow H_2NCONH_2 + H_2O$

**Solution :**

1. The entire quantity of ammonia is consumed in the reaction. So ammonia is the limiting reagent. Some quantity of $CO_2$ remains unreacted, so $CO_2$ is the excess reagent.

| | Reactants | | Products | |
|---|---|---|---|---|
| | $NH_3$ | $CO_2$ | Urea | $H_2O$ |
| Stoichiometric coefficients | 2 | 1 | 1 | 1 |
| Number of moles of reactants allowed to react $n = \frac{\text{Mass}}{\text{Molar mass}}$ | $\frac{646}{17}$ = 38 moles | $\frac{1144}{44}$ = 26 moles | - | - |
| Actual number of moles consumed during reaction Ratio (2:1) | 38 moles | 19 moles | - | - |
| No. of moles of product thus formed | - | - | 19 moles | 19 moles |
| No. of moles of reactant left at the end of the reaction | - | 7 moles | - | - |

2. Quantity of urea formed

= number of moles of urea formed × molar mass of urea

= 19 moles x 60 g $mol^{-1}$

= 1140 g = 1.14 kg

Excess reagent leftover at the end of the reaction is carbon dioxide.

Amount of carbon dioxide leftover

= number of moles of $CO_2$ left over × molar mass of $CO_2$

= 7 moles x 44g $mol^{-1}$ = 308 g.

## Part-II – GMQ & GOVT. EXAM QUESTION AND ANSWERS

### I. Choose the correct answer

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

a) 46g b) 36g

c) 52g d) none of these

**Ans: c) 52 g**

**Solution :**

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 | $1.51 \times 10^{23}$ molecules of oxygen |

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

**Ans: d) A - 2, B - 1, C - 4, D - 3**

**Solution :**

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 relative molecular mass of ethanol is** SEP - 2020

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

**Ans: d) 46g**

## II. Two and Three Marks Questions

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

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

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

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

To produce 10 moles of ammonia

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

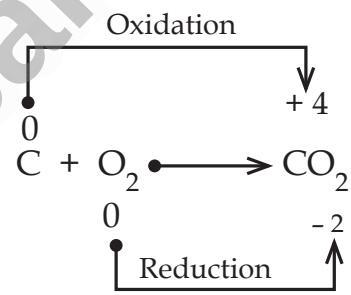
= 15 moles of hydrogen are required

**3. Define limiting reagent.** GMQ-2018 QY-2018 AUG - 2022

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

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

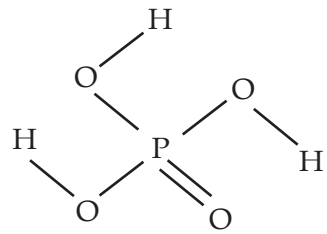
When two or more substance combine to form a single substance, the reactions are combination reactions.




**5. Define basicity. Find the basicity of ortho-phosphoric acid.** SEP - 2020

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

(ii) Basicity of ortho-phosphoric acid - $H_3PO_4$




The number of Hydrogen atoms bonded to the oxygen atoms in this compound is 3. Therefore, the basicity of ortho-phosphoric acid is 3.

## III. PROBLEMS

**1. Statement 1: Two mole of glucose contains $12.044 \times 10^{23}$ molecules of glucose**
**Statement 2 : Total number of entities present in one mole of any substance is equal to $6.02 \times 10^{22}$.**
**Whether the above statements are true ? Is there any relation between these two statements ?** GMQ-2018

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

**2. Calculate the total number of electrons present in 17g of ammonia.** GMQ-2018

**Solution:**
No. of electrons present in one ammonia ($NH_3$) molecule (7 + 3) = 10

$$\text{No. of moles of } NH_3 = \frac{\text{Mass}}{\text{Molar mass}}$$

$$= \frac{17g}{17g\ mol^{-1}} = 1 \text{ mol}$$

No. of molecules present in 1 mol of $NH_3$
$= 6.023 \times 10^{23}$

No. of electrons present in 1 mol of $NH_3$
$= 10 \times 6.023 \times 10^{23}$
$= 6.023 \times 10^{24}$

**3. Calculate the oxidation states of oxygen in $H_2O_2$ and $KO_2$.** QY - 2019 MAR - 2019

**Solution:**
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. Calculate the empirical and molecular formula of the compound containing 80% Carbon, 20% Hydrogen. If the molecular mass of the compound is 30 then determine the molecular formula.** QY - 2019

**Solution:**
For C $\Rightarrow$ 80/12 = 6.6
for H $\Rightarrow$ 20/1 = 20 now divide 6.6 and 20 by 6.6 to get simple whole no. ratio of C and H which will come 1:3 so empirical formula is $CH_3$ and its mass is 15
Now to calculate *n* we have 30/15 = 2
so molecular formula is $CH_3 \times 2 = C_2H_6$

**5. $X_2 + 3Y_2 \rightarrow 2XY_3$ In this reaction 2 moles of $X_2$ and 4.5 moles of $Y_2$ react to give products. Which is the limiting agent and calculate the no. of moles of $X_2$. $Y_2$ and $XY_3$ in the reaction mixture?** QY - 2019

**Solution:**

| | $X_2$ | + $3Y_2$ | $\rightarrow$ $2XY_3$ |
|---|---|---|---|
| No. of moles | 2 | 4.5 | ? |
| SC | 1 | 3 | 2 |
| ratio | 2/1 | 4.5/3 | - |
| | 2(ER) | 1.5(LR) | - |

$$\text{mole} - \text{mole} = \frac{nX_2}{1} = \frac{nY_2}{3} = \frac{nXY_3}{2}$$

$$= \frac{2}{1} = \frac{4.5}{3} = \frac{nXY_3}{2} = 3\text{moles}$$

No. of moles of $2XY_3$ = 3 moles.

**6. Calculate the equivalent mass of $H_2SO_4$.**
**Solution:** MAR - 2019

$H_2SO_4$ basicity = 2eq $mol^{-1}$
Molar mass of $H_2SO_4 = (2\times 1)+(1 \times 32)+(4 \times 16)$
$= 98\ g\ mol^{-1}$

Gram equivalent of $H_2SO_4 = \frac{98}{2} = 49\ g\ eq^{-1}$.

**7. A compound having the empirical formula $C_6H_6O$ has the vapour density 47. Find its Molecular formula.** March - 2019

**Solution:**
Empirical Formula = $C_6H_6O$

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

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

Molecular formula $(C_6H_6O)\times 1 = C_6H_6O$

**8. Calculate the oxidation number of underlined elements.** MAY - 2022

**(i) $\underline{C}O_2$ (ii) $H_2\underline{S}O_4$**

i) $\underline{C}O_2 = X + 2(-2) = 0 \Rightarrow X = +4$

ii) $H_2\underline{S}O_4 = 2(+1) + X + 4(-2) = 0$
$2 + X - 8 = 0, X = +6$

## Part-III – ADDITIONAL QUESTIONS

### I. Choose the best answer

**1. Which of the following contains maximum number of molecules at STP?**

a) 100 cc of $CO_2$ b) 150 cc of $N_2$
c) 50 cc of $SO_2$ d) 200 cc of $NH_3$

**Solution :** **Ans: d) 200 cc of $NH_3$**

d) 22,400cc of any gas at STP contains same number of molecules ie., $6.022 \times 10^{23}$. Hence, larger volume at STP, greater is the number of molecules.

**2. Number of atoms of oxygen present in 10.6g $Na_2CO_3$ will be**

a) $6.02 \times 10^{22}$ b) $12.04 \times 10^{22}$
c) $1.806 \times 10^{23}$ d) $31.80 \times 10^{28}$

**Solution :** **Ans: c) $1.806 \times 10^{23}$**

c) Molar mass of $Na_2CO_3$ = 106g $mol^{-1}$

No. of moles of $Na_2CO_3$

$= \frac{10.6}{106} = 0.1$ mol

$= 0.1 \times 6.022 \times 10^{23}$ molecules

$= 3 \times 0.1 \times 6.022 \times 10^{23}$ atoms of O

$= 1.806 \times 10^{23}$

**3. Which has maximum number of atoms?**

a) 1gm atom of Nitrogen
b) one mole of water
c) one mole of sodium
d) one molecule of $H_2SO_4$

**Solution :** **Ans: c) one mole of sodium**

c) 1gm atom nitrogen = 14g; 1mole Na = 23g
One mole $H_2O$ = 18g

One molecules of $H_2SO_4 = \frac{98}{6.022 \times 10^{23}}$ g

**4. 1g of magnesium is burnt with 0.56g oxygen in a closed vessel. Which reactant is left in excess and how much?**

a) Mg 0.16 g b) $O_2$, 0.16 g
c) Mg, 0.44 g d) $O_2$, 0.28 g

**Ans: a) Mg 0.16g**

**Solution :**

| a) $2Mg + O_2 \rightarrow 2MgO$ | Reactant | | Product |
|---|---|---|---|
| | Mg | $O_2$ | MgO |
| Stoichiometric Coefficient | 2 | 1 | 2 |
| No. of moles allowed to burnt | $\frac{1}{24}$ = 0.0416 mol | $\frac{0.56}{32}$ = 0.0175 mol | - |
| No. of moles of reactant reacted and product formed | 0.035 | 0.0175 | 0.035 |
| No. of moles of un-reacted and product formed | 0.0066 | - | 0.035 |

Mass of Mg left in excess = 0.0066 x 24 = 0.16 g

**5. The volume of $CO_2$ released at STP on heating 9.85g of $BaCO_3$ (Atomic mass, Ba=137) will be**

a) 1.12 *l* b) 2.24 *l*
c) 4.06 *l* d) 0.84 *l*

**Solution :** **Ans: a) 1.12 *l***

d) $BaCO_3 \rightarrow BaO + CO_2$
(M.M of $BaCO_3$ = 197g $mol^{-1}$)
As per equation, 197g of $BaCO_3$ gives 1mol of $CO_2$ ie., 22.4L

9.85g of $BaCO_3$ gives = $\frac{22.4L \times 9.85}{197} = 1.12L$

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

a) $1.25 \times 10^{-2}$ b) $2.5 \times 10^{-2}$
c) 0.02 d) $3.125 \times 10^{-2}$

**Solution :** **Ans: d) $3.125 \times 10^{-2}$**

6. b) 1 mol of $Mg_3(PO_4)_2$ contains 8 moles of oxygen atoms
∴ 8 moles of oxygen atoms
= 1 mole of $Mg_3(PO_4)_2$
0.25 mole of oxygen atoms = 1/8 × 0.25
= $3.125 \times 10^{-2}$ mol of $Mg_3(PO_4)_2$

**7. The total number of atoms of all elements present in one mole af ammonium dichromate is**

a) 19 b) $6.023 \times 10^{23}$
c) $114.437 \times 10^{23}$ d) $84.322 \times 10^{23}$

**Ans: c) $114.437 \times 10^{23}$**

**Solution :**

c) 1 mole $(NH_4)_2Cr_2O_7$ contains 2 atoms of N
8 atoms of H
2 atoms of Cr and 7 atoms of O
So, total $(2 + 8 + 2 + 7) \times 6.022 \times 10^{23}$
$= 114.437 \times 10^{23}$

**8. 25.4g of $I_2$ and 14.2g of $Cl_2$ are made to react completely to yield a mixture of ICl and $ICl_3$. Calculate the moles of ICl and $ICl_3$ formed**

a) 0.1, 0.1 b) 0.2, 0.2 c) 0.1, 0.2 d) 0.2, 0.1

**Ans: c) 0.1, 0.2**

**Solution :**

| **c) $I_2 + 2Cl_2 \rightarrow ICl + ICl_3$** | **Reactant** | | **Product** | |
|---|---|---|---|---|
| | $I_2$ | $Cl_2$ | ICI | $ICI_3$ |
| Stoichiometric coefficient | 1 | 2 | 1 | 1 |
| No. of moles allowed to react | $\frac{25.4}{254} = 0.1$ | $\frac{14.2}{71} = 0.2$ mol | - | - |
| No. of moles of reactant reacted and product formed | 0.1 mol | 0.2 mol | 0.1 | 0.1 |
| No. of moles of unreacted reactant and product formed | - | - | 0.1 | 0.1 |

**9. The amount of Zinc required to produce 224ml of $H_2$ at STP on treatment with dil. $H_2SO_4$ will be**

a) 6.5 g b) 0.65 g
c) 65 g d) 0.065 g

**Ans: b) 0.65 g**

**Solution :**

b) $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$
At STP, 22, 400 ml of $H_2$ is liberated from 65g of Zn with $H_2SO_4$
$\therefore$ 224ml of $H_2$ is liberated from
$\frac{65 \times 224}{22400} = 0.65$g of Zn

**10. 10 g of $CaCO_3$ gives on strong heating $CO_2$ and quick lime. The mass of quick lime is**

a) 5 g b) 4.4 g
c) 5.6 g d) 4 g

**Ans: b) 4.4 g**

**Solution :**

b) $CaCO_3 \rightarrow CaO + CO_2$
As per equation, 100g of $CaCO_3$ on heating gives 44g of $CO_2$
$\therefore$ 10g of $CaCO_3$ on heating gives $\frac{44 \times 10}{100} = 4.4$g

**11. Volume occupied by one molecule of water (Density = 1 g $cm^{-3}$)**

a) $9 \times 10^{-23}$ $cm^3$ b) $6.023 \times 10^{-23}$ $cm^3$
c) $3 \times 10^{-23}$ $cm^3$ d) $5.5 \times 10^{-23}$ $cm^3$

**Ans: c) $3 \times 10^{-23}$ $cm^3$**

**Solution :**

c) Density = $\frac{\text{Mass}}{\text{Volume}}$

Volume = $\frac{1 \text{ gram}}{1 \text{ gram cm}^{-3}} = 1 cm^3$

Volume occupied by
1 gram water = 1 $cm^3$

(or) Volume occupied by $\frac{6.022\times10^{23}}{18}$ molecules of water = $1cm^3$

Thus, Volume occupied by 1 molecule of water is $\frac{1\times18}{6.022\times10^{23}} = 3 \times 10^{-23}\ cm^3$.

**12. One mole of magnesium nitride on the reaction with an excess of water gives.**

a) two moles of ammonia
b) one mole of nitric acid
c) one mole of ammonia
d) two moles of nitric acid

**Ans: a) two moles of ammonia**

**Solution :**

a) $Mg_3N_2 + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3$

**13. A compound made up of two elements A and B is found in contains 25% A (atomic mass = 12.5) and 75% B (atomic mass = 37.5). The simplest formula of the compound is**

a) AB b) $AB_2$
c) $AB_3$ d) $A_3B$

**Ans: a) AB**

**Solution :**

a) The simplest formula is AB

| Element | % | Atomic mass | Relative number of moles | Simplest ratio |
|---|---|---|---|---|
| A | 25 | 12.5 | $\frac{25}{12.5}=2$ | 1 |
| B | 75 | 37.5 | $\frac{75}{37.5}=2$ | 1 |

**14. Two oxides of a metal contain 50% and 40% metal (M) respectively. If the formula of first oxide is $MO_2$ the formula of second oxide will be**

a) $MO_2$ b) $MO_3$
c) $M_2O$ d) $M_2O_5$

**Ans: b) $MO_3$**

**Solution :**

b) Let the atomic mass of metal is M

| Element | % | Atomic mass | Relative number of moles |
|---|---|---|---|
| M | 50 | M | 50/M = 1 |
| O | 50 | 16 | 50/16 = 2 |

Since the formula $MO_2$

$$\therefore \frac{50/M}{50/16} = 1/2$$

Atomic mass of metal = 32

For second oxide

| Element | % | Atomic mass | Relative number of moles | Simplest ratio |
|---|---|---|---|---|
| M | 40 | 32 | $\frac{40}{32}=1.25$ | $\frac{1.25}{1.25}=1$ |
| O | 60 | 16 | $\frac{60}{16}=3.75$ | $\frac{3.75}{1.25}=3$ |

Formula for second oxide is $MO_3$

**15. The mass of water formed by combustion of 16 g of methane is**

a) 36 g b) 0.5 g
c) 22 g d) 18 g

**Ans: a) 36 g**

**Solution :**

a) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

As per equation, 16g of $CH_4$ on combustion gives 2 moles of $CO_2$ ie.,

2 × 18 = 36g

**16. The number of electrons required to balance the following equation $NO_3^- + 4H^+ + e^- \rightarrow 2H_2O + NO$ is**

a) 5 b) 4
c) 3 d) 2

**Ans: c) 3**

**Solution :**

$NO^-_3 + 4H^+ + 3e^- \rightarrow 2H_2O + NO$

**17. Consider the following reaction,**
$5H_2O_2 + XClO_2 + 2OH^- \rightarrow XCl^- + YO_2 + 6H_2O$

a) X = 5, Y = 2 b) X = 2, Y = 5
c) X = 4, Y = 10 d) X = 5, Y =5

**Ans: b) X = 2, Y = 5**

**Solution :**

b) $XC1O_2 + 5H_2O_2 + XOH^- \rightarrow XCl^- + YO_2 + 6H_2O$

$\left(\overset{+4}{Cl}O_2 + 5e^- \rightarrow Cl^-\right) \times 2$

$(H_2O_2^{-1} \rightarrow O_2 + 2e^-) \times 5$

$2ClO_2 + 5H_2O_2 \rightarrow 2Cl^- + 5O_2$

To Balance O, Add $2H_2O$ to RHS

$2ClO_2 + 5H_2O_2 \rightarrow 2Cl^- + 5O_2 + 4H_2O$

To balance H, add $2H_2O$ to

RHS and $2OH^-$ to LHS

$2ClO_2 + 5H_2O_2 + 2OH^- \rightarrow$

$2Cl^- + 5O_2 + 4H_2O + H_2O$

$\underset{(X)}{2ClO_2} + 5H_2O_2 + 2\underset{(X)}{OH^-} \longrightarrow \underset{(Y)}{2Cl^-} + 5O_2 + 6H_2O$

$\therefore$ x = 2 Y = 5

**18. What is the equivalent mass of $IO_4^-$ when it is converted into $I_2$ in acid medium?**

a) M/6 b) M/7
c) M/5 d) M/4

**Solution :** **Ans: b) M/7**

**b)** $2\overset{+7}{I}O_4^- + 16H^+ + 14e^- \rightarrow \overset{0}{I_2} + 8H_2O$

Equivalent mass of $IO_4^- = \frac{2x\,\text{Molar mass}}{14}$

$= \frac{\text{Molar mass}}{7}$

**19. The oxidation state of C in fullerene ($C_{60}$) is**

a) +1 b) ¼+
c) 0 d) 1

**Solution :** **Ans: c) 0**

c) fullerene ($C_{60}$) exist in elemental state the oxidation state of C is Zero

**20. The oxidation state of S in $Na_2S_4O_6$ is**

a) 1.5 b) 2.5
c) 3 d) 2

**Ans: b) 2.5**

**Solution :**

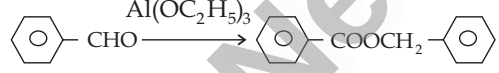
b) $Na_2S_4O_6 \Rightarrow$

$2(1) + 4x + 6(-2) = 0$

$4x = 10$

$x = 10/4 = +2.5$

**21. Which is not disproportionation reaction?**

a) 

b) $\underset{|}{\overset{CHO}{}}_{COOH} + OH^- \rightarrow \underset{|}{\overset{CH_2OH}{}}_{COO^-} + \underset{|}{\overset{COO^-}{}}_{COO^-}$

c) $NaH + H_2O \rightarrow NaOH + H_2$

d) $3ClO^- \rightarrow 3ClO_3^- + 2Cl^-$

**Ans: c) $NaH + H_2O \rightarrow NaOH + H_2$**

**Solution :**

c) $\overset{+1}{Na}\overset{-1}{H} + \overset{+1}{H_2}\overset{-2}{O} \rightarrow \overset{+1}{Na}\overset{-2}{O}\overset{+1}{H} + H_2^0$

In this reaction H atom undergo oxidation. So, it is not disproportionation reaction.

**22. Which one act as both reducing and oxidising agent?**

a) $KMnO_4$ b) $H_2O_2$
c) $Fe_2(SO_4)_3$ d) $K_2Cr_2O_7$

**Ans: b) $H_2O_2$**

**23. Assertion (A) : Fluorine act as the strongest oxidising agent**

**Reason (R) : Fluorine is the most electronegative element.**

a) Both A and R are true and reason (R) is correct explanation of assertion
b) Both A and R are true but reason (R) is not correct explanation of assertion
c) Assertion is true but reason is false
d) Reason is true but assertion is false.

**Ans: b) Both A and R are true but reason (R) is not correct explanation of assertion**

**24. Assertion (A) : Number of moles of $H_2$ in 0.224 litres of hydrogen is 0.01 mole**
**Reason (R) : 22.4 lit of $H_2$ at STP contains $6.023 \times 10^{23}$ moles.**

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

**Ans: c) Assertion is true but reason is false.**

**25. Match the following :**

| | | | | |
|---|---|---|---|---|
| A | 88 gram of $CO_2$ | 1 | 0.25 mole | a) A - 2, B - 4, C - 1, D - 3 |
| B | $6.022 \times 10^{23}$ water molecules | 2 | 2 moles | b) A - 4, B - 3, C - 2, D - 1 |
| C | 5.6 litre of $CO_2$ at STP | 3 | $6.023 \times 10^{23}$ molecules | c) A - 2, B - 4, C - 3, D - 1 |
| D | One mole of any gas | 4 | 1 mole | d) A - 4, B - 3, C - 1, D - 2 |

**Ans: a) A - 2, B - 4, C - 1, D - 3**

## II - Two Marks Questions

**1. Define amu or Unified atomic mass.**
The amu or unified atomic mass is defined as one twelfth of the mass of a carbon –12 atom in its ground state.
1 amu or 1u = $1.6605 \times 10^{-27}$ kg

**2. Define Avogadro number.**
The total number of entities present in one mole of any substance is equal to $6.022 \times 10^{23}$.
This number is called Avogadro number.

**3. Define Molar volume.**
The volume occupied by one mole of any substance in the gaseous state at a given temperature and pressure is called **molar volume.**

**4. Define : Basicity**
The no. of moles of ionisable $H^+$ ion present in 1 mole of the acid.
e.g.: basicity of $H_2SO_4$ = 2

**5. Define : Acidity**
The number of moles of ionisable $OH^-$ ion present in 1 mole of the base.
e.g.: acidity of NaOH = 1

**6. Define : Molar mass.**
It is defined as "the mass of one mole of a substance" (or) The molar mass of a compound is equal to the sum of int relative stomic masses of its constituents expressed in g $mol^{-1}$.

## III. Three Marks Questions

**1. Write various expression for determining the equivalent mass of acids, bases, oxidising agent and reducing agent**

(i) Equivalent mass of acid = $\frac{\text{Molar mass of the acid}}{\text{Basicity of the acid}}$

(ii) Equivalent mass of base = $\frac{\text{Molar mass of the base}}{\text{Acidity of the base}}$

(iii) Equivalent mass of Oxidising agent = $\frac{\text{Molar mass of the Oxidising agent}}{\text{Number of moles of electrons gained}}$

(iv) Equivalent mass of reducing agent = $\frac{\text{Molar mass of the reducing agent}}{\text{Number of moles of electrons lost}}$

**2. Distinguish empirical formula and molecular formula.**

| | Empirical Formula | Molecular Formula |
|---|---|---|
| 1. | Empirical formula of a compound is the formula written with the simplest ratio of the number of different atoms present in one molecule of the compound as sub-script to the atomic symbol | Molecular formula of a compound is the formula written with the actual number of different atoms present in one molecule as a subscript to the atomic symbol. |
| 2. | It is the simplest formula of a compound. | It is the original formula of a compound. |
| 3. | We can determine the empirical formula of a compound from the % composition of elements. | We can calculate molecular formula from empirical formula. |

**3. Identify the type of redox reaction for the following.**

a) $N_2(g) + O_2(g) \rightarrow 2\,NO(g)$

b) $4H_3PO_{3(l)} \rightarrow 3H_3PO_{4(s)} + PH_{3(g)}$

c) $Cu + AgNO_3 \rightarrow Cu(NO_3)_2 + Ag$

d) $2H_2O \rightarrow 2H_2 + O2$

e) $2Fe_{(s)} + 3H_2O_{(l)} \rightarrow Fe_2O_{3(s)} + H_{2(g)}$

f) $Cl_{2(g)} + Kl_{(9)} \rightarrow 2KCl_{(ag)} + I_2$

**Ans :**

a) $\overset{o}{N}_{2(g)} + \overset{o}{O}_{2(g)} \rightarrow 2\overset{+2\,-2}{NO}_{(g)}$ $\Rightarrow$ Combination reaction.

b) $4H_3\overset{+3}{P}O_3 \longrightarrow 3H_3\overset{+5}{P}O_4 + \overset{-3}{P}H_3$ $\Rightarrow$ Disproportionation reaction.

c) $\overset{o}{Cu} + \overset{+1}{Ag}\,NO_3 \longrightarrow \overset{+2}{Cu}(NO_3)_2 + \overset{o}{Ag}$ $\Rightarrow$ Metal displacement reaction

d) $2\overset{+1}{H_2}\overset{-2}{O} \longrightarrow 2\overset{o}{H_2} + \overset{o}{O_2}$ $\Rightarrow$ Decomposition reaction.

e) $2\overset{o}{Fe}_{(S)} + 3\overset{+1\,-2}{H_2O}_{(l)} \longrightarrow \overset{+3\,-2}{Fe_2O_{3(S)}} + 3\overset{o}{H}_{2(g)}$ $\Rightarrow$ Metal displacement reaction.

f) $\overset{o}{Cl}_{2(g)} + KI^{-1}_{(g)} \longrightarrow 2K\overset{-1}{Cl}_{(aq)} + \overset{o}{I}_2$ $\Rightarrow$ Non - metal displacement reaction.

**4. Justify that the following reactions are redox reactions.**

**(a) $Fe_2O_{3(s)} + 3CO_{(g)} \rightarrow 2Fe_{(s)} + 3CO_{2(g)}$**

**(b) $4BCl_{3(g)} + 3LiAlH_{4(s)} \rightarrow 2B_2H_6 + 3LiCl_{(s)} + 3AlCl_{3(s)}$**

**Ans :**

a) $\overset{+3}{Fe_2}O_3 + 3\overset{+2}{C}O \longrightarrow 2\overset{O}{Fe} + 3\overset{+4}{C}O_2$

Here oxidation number of Fe decreases from +3 to zero while oxidation number of C increases from +2 to +4. Therefore, $Fe_2O_3$ is reduced while CO is oxidised. Thus, this is a redox reaction.

b) $4\,\overset{+3\,-1}{B}Cl_3 + \overset{+1\,+3}{Li}Al\,H_4 \longrightarrow 2\,\overset{-3\,+1}{B_2}H_6 + 3\,\overset{+1\,-1}{Li}Cl + 3\,\overset{+3\,-1}{Al}Cl_3$

Here, oxidation number of B decreases from +4 to -3 while oxidation number of H increases from -1 to +1. Therefore, $BCl_3$ is reduced while $LiAlH_4$ is oxidised. Thus, this is a redox reaction.

**5. List the substances where carbon can exhibit oxidation number from - 4 to +4.**

| | Substance | Oxidation Number of carbon |
|---|---|---|
| 1. | $CH_4$ | – 4 |
| 2. | $CH_3^- CH_3$ | – 3 |
| 3. | $CH_3Cl$ | – 2 |
| 4. | $C_2H_2$ | – 1 |
| 5. | $C_6H_{12}O_6$ | 0 |
| 6. | $C_6Cl_6$ | + 1 |
| 7. | $CHCl_3$ | + 2 |
| 8. | $H_2C_2O_4$ | + 3 |
| 9. | $CO_2$ | + 4 |

**6. Identify substance act as oxidising agent and reducing agent for each of the following reaction.**

**a)** $2\overset{+1}{Ag}\overset{-1}{Br}_{(s)} + \overset{-1/3}{C_6}\overset{+6}{H_6}\overset{-4}{O_2} \longrightarrow 2\overset{0}{Ag}_{(s)} + 2HBr_{(aq)}$

**b)** $\overset{0}{Pb}_{(S)} + \overset{+4}{Pb}\overset{-4}{O_2}_{(S)} + 2H_2SO_{4(aq)} \longrightarrow \overset{+2}{Pb}SO_4(S) + 2H_2O_{(l)} + \overset{0}{C_6}\overset{+4}{H_4}\overset{-4}{O_2}_{(aq)}$

| Reaction | Oxidising agent | Reducing agent |
|---|---|---|
| a. | AgBr | $C_6H_6O_2$ |
| b. | $PbO_2$ | Pb |

**7. Give the empirical formula for the following compounds.**

**a) Acetic acid ($C_2H_4O_2$)**

**b) Hydrogen Peroxide ($H_2O_2$)**

**c) Benzene ($C_6H_6$)**

**Solution :**

| Compound | Empirical formula |
|---|---|
| a. Acetic acid ($C_2H_4O_2$) | $CH_2O$ |
| b. Hydrogen Peroxide ($H_2O_2$) | HO |
| c. Benzene ($C_6H_6$) | CH |

**8. Define :**

**i) Excess Agent**

**ii) Oxidising agents**

**iii) Reducing agents**

**Excess Agent :**

The reactant other than the limiting reagent which are in excess are called the excess agents.

**Oxidising agents :**

The reagent which facilitate oxidation by gaining electrons and get reduced.

**Reducing agents :**

The reagent which facilitate reduction by releasing electrons and get oxidised.

## IV. ADDITIONAL PROBLEMS

**1. Calculate the mass of (i) an atom of silver, (ii) a molecule of $CO_2$.**

**Solution :**

i) Atomic of an atom = 108

$$\text{Mass of an atom} = \frac{\text{Atomic mass of the atom}}{\text{Avogadro number}}$$

$$\text{One atom of silver} = \frac{108}{6.022\times10^{23}} = 1.793\times10^{-22}\text{ g}$$

ii) Molar mass of $CO_2 = 12 + (2 \times 16) = 44\text{g mol}^{-1}$

$$\text{Mass of a molecule} = \frac{\text{Molar mass of the molecule}}{\text{Avogadro number}} = \frac{44}{6.022\times10^{23}} = 7.307\times10^{-23}\text{ g}$$

**2. How many atoms and molecules of sulphur are present in 64g of sulphur ($S_8$)?**

**Solution :**

Molecular mass of $S_8$ = 8 x 32 = 256 u

256 g of sulphur contains $6.022 \times 10^{23}$ molecules

∴ 64 g of sulphur will contain

$$= \frac{6.023 \times 10^{23} \times 64}{256}$$

$= 1.506 \times 10^{23}$ molecules

1 molecule of sulphur ($S_8$) contains 8 atoms of sulphur

∴ $1.506 \times 10^{23}$ molecules of sulphur will contain $8 \times 1.506 \times 10^{23} = 1.2048 \times 10^{24}$ atoms

**3. Calculate the number of atoms of the constituent elements in 53g of $Na_2CO_3$.**

**Solution :**

$$\text{No of moles of } Na_2CO_3 = \frac{\text{given mass}}{\text{molar mass}}$$

$$= \frac{53g}{106g\ mol^{-1}}$$

Number of moles of $Na_2CO_3$ = 0.5 mole

One mole of $Na_2CO_3$ contains 2 moles of Na+ (or) $2 \times 6.022 \times 10^{23}$ $Na^+$ ions

$\therefore$ 0.5 mole of $Na_2CO_3$ will contain

$= 2 \times 6.022 \times 10^{23} \times 0.5$

$= 6.022 \times 10^{23}$ $Na^+$ ions

Similarly, one mole of $Na_2CO_3$ will contain one mole of C - atoms (or)

$6.022 \times 10^{23}$ carbon atoms

$\therefore$ 0.5 mole of $Na_2CO_3$ will contain

$0.5 \times 6.022 \times 10^{23} = 3.11 \times 10^{23}$ C atoms

Further, one mole of $Na_2CO_3$ contains 3 mole of oxygen atoms (or) $3 \times 6.022 \times 10^{23}$ O - atoms

$\therefore$ 0.5 mole of $Na_2CO_3$ contain

$= 3 \times 6.022 \times 10^{23} \times 0.5$

$= 9.033 \times 10^{23}$ O - atoms

**4. Calculate the number of moles in**
**(i) 392 g of $H_2SO_4$**
**(ii) 44.8 litres of $CO_2$**
**(iii) $3.011 \times 10^{23}$ oxygen molecules**
**(iv) 9g of Al**

**Solution :**

i) $$\text{No. of moles} = \frac{\text{given mass}}{\text{molar mass}}$$

$$\text{No. of moles of } H_2SO_4 = \frac{392}{(2+32+4\times16)}$$

$$= \frac{392}{98}$$

= 4 moles of $H_2SO_4$

ii) No. of moles for gaseous substance

$$= \frac{\text{Given volume of gas}}{\text{Molar volume (SATP)}}$$

$$\text{No. of moles of } CO_2 = \frac{44.8}{22.4} = 2 \text{ moles of } CO_2$$

iii) No. of moles of molecules

$$= \frac{\text{Given number of molecules}}{\text{Avogadro number}}$$

No. of moles for oxygen molecules

$$= \frac{3.011\times10^{23}}{6.022\times10^{23}}$$

= 0.5 mole of oxygen molecules

iv) No. of moles of atoms

$$= \frac{\text{Given mass of atom}}{\text{atomic mass}}$$

$$\text{No. of moles of Al} = \frac{9}{27}$$

= 0.33 mole Aluminium

**5. An organic compound having C,H,N and O was found to contain C=41.37%, H=5.75% N = 16.09% and rest oxygen. Calculate the molecular formula if vapour density is 43.3**

**Solution :**

| Element | % | Atomic mass | Relative no of moles | Simplest ratio |
|---|---|---|---|---|
| C | **41.37** | **12** | $\frac{41.37}{12} = 3.45$ | $\frac{3.45}{1.15} = 3$ |

| | | | | |
|---|---|---|---|---|
| **H** | **5.75** | **1** | $\frac{5.75}{1} = 5.75$ | $\frac{5.75}{1.15} = 5$ |
| **N** | **16.09** | **14** | $\frac{16.09}{14} = 1.15$ | $\frac{1.15}{1.15} = 1$ |
| **O** | **(100 – 63.21) = 36.79** | **16** | $\frac{36.79}{16} = 2.30$ | $\frac{2.30}{1.15} = 2$ |

Hence, the empirical formula $C_3H_5NO_2$

Empirical formula mass = (3 x 12) + (5 x 1) + (1x14) + (2 x 16)

= 36 + 5 +14 + 32 = 87

$$\text{Whole number (n)} = \frac{\text{Molar mass of the compound (or) } 2 \times \text{V.D}}{\text{Calculated empirical formula mass}}$$

$$n = \frac{2 \times 43.3}{87} = \frac{86.6}{87} = n = 0.9954 \cong 1$$

Molecular formula = (Empirical formula) n = $(C_3H_5NO_2)_1$

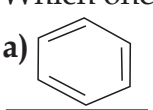
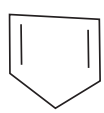
Molecular formula = $C_3H_5NO_2$

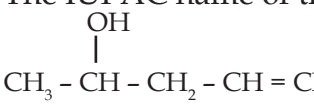
## GOVT. EXAM - MARCH 2023

Time Allowed : 3.00 Hours Maximum Marks : 70

### PART - I

**Note : i) Answer All the questions.**
**ii) Choose the most appropriate answer from the given four alternatives and write the option code and the corresponding answer.** **15 x 1 = 15**

1. – I effect is shown by :
   a) – Cl b) – Br **c) both (a) and (b)** d) – $CH_3$
2. Which of the following compound has percentage of Carbon same as that in Ethylene ($C_2H_4$)?
   a) Benzene **b) Propene** c) Ethane d) Ethyne
3. Solubility of carbon-di-oxide gas in cold water can be increased by
   a) decrease in pressure b) increase in volume
   **c) increase in pressure** d) none of these
4. The pH of Normal rain water is :
   **a) 5.6** b) 6.5 c) 4.6 d) 7.5
5. The boiling point of heavy water ($D_2O$) is _____
   a) 375.4 K b) 373.4 K c) 376.2 K **d) 374.4 K**
6. **Assertion :** Oxygen molecule is Paramagnetic
   **Reason :** It has two unpaired electrons in its bonding molecular orbital.
   **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.
7. Chloroform reacts with Nitric acid to produce :
   **a) Chloropicrin** b) Nitro toluene c) Chloropicric acid d) Nitro glycerine
8. Which one of the following is aromatic?
   **a)**  b)  c)  d) both (a) and (b)
9. An unknown gas diffuses at a rate of 0.5 times that of Nitrogen at the same temperature and pressure. The molar mass of the unkown gas is _____
   a) 114 g $mol^{-1}$ **b) 112 g $mol^{-1}$** c) 120 g $mol^{-1}$ d) 110 g $mol^{-1}$
10. Osmotic pressure ($\pi$) of a solution is given by the equation:
    **a) $\pi v = nRT$** b) $\pi RT = n$ c) $\pi = nRT$ d) none of these
11. Sodium is stored in
    **a) Kerosene** b) Alcohol c) Ether d) Water
12. Which of the following is not a thermodynamic function?
    a) entropy b) internal energy **c) frictional energy** d) enthalpy
13. The IUPAC name of the compound



    :
    a) hex - 2 - en - 4 - ol **b) hex - 4 - en - 2 - ol** c) hex - 2 - en - 4 - al d) hex - 4 - en - 2 - al

14. What would be the IUPAC name for an element with atomic number 222?
a) didibium b) bibibiium **c) bibibium** d) bididium

15. The total number of orbitals associated with the Principal Quantum Number n = 3 is:
a) 5 **b) 9** c) 7 d) 8

## PART - II

**Answer any six questions. Question No. 24 is Compulsory.** **6 x 2 = 12**

16. Distinguish between oxidation and reduction. Unit 1
17. State: Heisenberg's Uncertainty principle. Unit 2
18. Mention the uses of Plaster of Paris. Unit 5
19. State. Le - Chartelier principle. Unit 8
20. Define Osmotic Pressure. Unit 9
21. Draw the Lewis structure for Unit 10
i) $H_2O$ ii) $HNO_3$
22. Write short notes on Friedel Craft's Reaction. Unit 13
23. What are Particular Pollutants? Give example. Unit 15
24. Calculate the entropy change during the melting of one mole of ice into water at $0^oC$ and 1 atm pressure. Enthalpy of Fusion of ice is 6008 J $mol^{-1}$. Unit 7

## PART - III

**Answer any six questions. Question No. 33 is Compulsory.** **6x3=18**

25. Balance the following equations by oxidation Number Method. Unit 1
i) $KMnO_4 + Na_2SO_3 \rightarrow MnO_2 + Na_2SO_4 + KOH$
ii) $Cu + HNO_3 \rightarrow Cu(NO_3)_2 + NO_2 + H_2O$
26. Write short notes on Principal Quantum Number. Unit 2
27. Explain the Diagonal Relationship. Unit 3
28. How do you convert Para hydrogen into Ortho hydrogen? Unit 4
29. Derive ideal Gas equation. Unit 6
30. What are State and Path Functions? Give two examples. Unit 7
31. An organic compound (A) with molecular formula $C_2H_5Cl$ reacts with aqueous KOH and gives compound (B) and with alcoholic KOH gives compound (C). Identify (A), (B) and (C). Unit 14
32. Explain inductive effect with suitable example. Unit 12
33. Write the structural formula for the following compounds. Unit 11
i) m-dinitro benzene
ii) p-dichloro benzene
iii) 1,3,5 trimethyl benzene

## PART - IV

**Answer all the questions.** **5 x 5 = 25**

34. a) A compound on analysis gave Na = 14.31 %, S = 9.97 %, H = 6.22 %, O = 69.5 %. Calculate the molecular formula of the compound, if all the Hydrogen in the compound is present in combination with Oxygen as Water of Crystallisation. (molecular mass of the compound is 322) **Unit 1**

**(OR)**

b) i) State Pauli Exclusion Principle. **Unit 2**

ii) State Modern Periodic Law. **Unit 3**

35. a) i) What are Isotopes? Write the names of Isotopes of Hydrogen. **Unit 4**

ii) Give the uses of Calcium. **Unit 5**

**(OR)**

b) Derive the values of Critical Constants in terms of Vander Waals constants. **Unit 6**

36. a) State the various statements of Second law of Thermodynamics. **Unit 7**

**(OR)**

b) i) State law of Mass Action. **Unit 8**

ii) What are the limitations of Henry's Law? **Unit 9**

37. a) Explain the salient features of Moelcular Orbital theory. **Unit 10**

**(OR)**

b) i) Give any three characteristics of Organic compounds. **Unit 11**

ii) Find the functional group of the following compounds. **Unit 11**

A) Acetaldehyde

B) Oxalic acid

C) Dimethyl ether

D) Methylamine

38. a) Explain the structure of Benzene. **Unit 13**

**(OR)**

b) i) Starting from $CH_3MgI$, how will you prepare the following? **Unit 14**

A) Ethylalcohol

B) Acetaldehyde

C) Ethyl methyl ether

ii) What is Eutrophication? **Unit 15**

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