UNIT – I – BASIC CONCEPTS OF CHEMISTRY & CHEMICAL CALCULATIONS

| Mr. S.JOHNSON., M.Sc., M.Sc., B.Ed.,

UNIT – 1 – BASIC CONCEPTS OF CHEMISTRY & CHEMICAL CALCULATIONS

II. WRITE BRIEF ANSWER TO THE FOLLOWING QUESTIONS.

26. Define relative atomic mass. ***[FMT-18]***

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

$$\text{Relative atomic mass (Ar)} = \frac{Mass\ of\ one\ atom\ of\ the\ element}{Mass\ of \frac{1}{12th} mass\ of\ one\ atom\ of\ Carbon-12}$$

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

27. What do you understand by the term mole. ***[JUN-19, CRT-22]***

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

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

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

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

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

30. Distinguish between oxidation and reduction. ***[HY-19, SEP-21]***

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

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]**

(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}

UNIT – I – BASIC CONCEPTS OF CHEMISTRY & CHEMICAL CALCULATIONS

| Mr. S.JOHNSON., M.Sc., M.Sc., B.Ed.,

(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.

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

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

= 44.01 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

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

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

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

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

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

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

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

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

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

Isotopes of Mg

Atomic mass = Mg^{24} = 23 99 x $\frac{78.99}{100}$ = 18.95

Atomic mass = Mg^{25} = 24 99 x $\frac{10}{100}$ = 2.499

Atomic mass = Mg^{26} = 25 98 x $\frac{11.01}{100}$ = 2.860

Average atomic mass = 24.309

Average atomic mass of Mg = 24.309

UNIT – I – BASIC CONCEPTS OF CHEMISTRY & CHEMICAL CALCULATIONS

| Mr. S.JOHNSON., M.Sc., M.Sc., B.Ed.,

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) 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

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 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.

Given : mass of one atom = 6.645×10^{-23} g

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

$\therefore$ number of moles of element in 0.320 kg $= \frac{1\ mole}{40g} \times 0.320kg$

$= \frac{1\ mol \times 320g}{40g}$ = **8 mol.**

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

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

UNIT – I – BASIC CONCEPTS OF CHEMISTRY & CHEMICAL CALCULATIONS

| Mr. S.JOHNSON., M.Sc., M.Sc., B.Ed.,

38. What is the empirical formula of the following ? *[FMT-18, QY-18, SEP-21]*

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]*

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 3273K 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? *[GMQP-2018]*

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 $\frac{102}{54}$ x 324 = 612g of Al_2O_3

ii) 54g of Al required 160g of Fe2O3 for welding reaction

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

$\therefore$ Excess Fe_2O_3 – unreacted Fe_2O_3 = 1120 – 960 = 160g.

40. How many moles of ethane is required to produce 44 g of CO_2(g) after combustion. *[FMT-18, QY-19]*

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 $= \frac{2\ mol\ ethane}{4\ mol\ CO_2}$ x 1 mol CO_2

$= \frac{1}{2}$ 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.

H_2O_2 – Oxidising agent

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

Ferrous ion is oxidized by H_2O_2 to Ferric ion. The balanced eq. is $Fe^{2+} \longrightarrow Fe^{3+} + e^- \times 2$

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

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

UNIT – I – BASIC CONCEPTS OF CHEMISTRY & CHEMICAL CALCULATIONS

| Mr. S.JOHNSON., M.Sc., M.Sc., B.Ed.,

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

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

42. Calculate the empirical and molecular formula of a compound containing 76.6% carbon, 6.38 % hydrogen and rest oxygen its vapour density is 47. ***[MAR-19, SEP-20, AUG-21]***

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

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

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

since Molar mass = 2 x Vapour density

molecular formula n × n empirical formula

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

43. A Compound on analysis gave Na = 14.31% S = 9.97% H = 6.22% and O = 69.5% calculate the molecular formula of the compound, if all the hydrogen in the compound is present in combination with O_2 as H_2O of crystallization. (molecular mass of the compound is 322).

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

∴ Empirical formula is = $Na_2SO_4.10H_2O$

Empirical formula mass = $(23 \times 2) + (32 \times 1) + (16 + 4) + (10 \times 18)$

$= 46 + 32 + 64 + 180 = 322$

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

Molecular formula = $Na_2SO_4.10H_2O$

44. Balance the following equations by oxidation number method

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

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

UNIT – I – BASIC CONCEPTS OF CHEMISTRY & CHEMICAL CALCULATIONS

| Mr. S.JOHNSON., M.Sc., M.Sc., B.Ed.,

iii) $Cu + HNO_3 \rightarrow Cu(NO_3)_2 + NO_2 + H_2O$ *[QY-19]*

iv) $KMnO_4 + H_2C_2O_4 + H_2SO_4 \rightarrow K_2SO_4 + MnSO_4 + CO_2 + H_2O$ *[FMT-18]*

i) $\overset{+6}{K_2Cr_2O_7} + K\overset{-1}{I} + H_2SO_4 \rightarrow K_2SO_4 + \overset{+3}{Cr_2}(SO_4)_3 + \overset{0}{I_2} + H_2O$

$2 \times 3e^-$ $1e^-$

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

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

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

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

$3e^-$ $2e^-$

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

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

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

iii) $\overset{0}{C}u + H\overset{+5}{N}O_3 \longrightarrow \overset{+2}{C}u(NO_3)_2 + \overset{+4}{N}o_2 + H_2O$

$2e^-$ $1e^-$

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

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

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

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

$5e^-$ $1e^- \times 2$

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

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

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

45. Balance the following equations by ion electron method.

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

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

UNIT – I – BASIC CONCEPTS OF CHEMISTRY & CHEMICAL CALCULATIONS

| Mr. S.JOHNSON., M.Sc., M.Sc., B.Ed.,

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

iv) $Zn + NO_3^- \rightarrow Zn^{2+} + NO$ (in acid medium) *[FMT-18]*

(i) Half reaction are

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

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

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

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

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

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

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

(ii)

$\overset{+3}{C}_2O_4^{2-} \longrightarrow \overset{+4}{C}O_2$ ..... (1)

$\overset{+6}{Cr}_2O_7^{2-} \longrightarrow Cr^{3+}$ ..... (2)

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

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

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

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

$Cr_2O_7^{2-} + 3\,C_2O_4^{2-} + 14\,H^+ \longrightarrow 2\,Cr^{3+} + 6\,CO_2 + 7\,H_2O$

(iii)

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

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

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

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

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

(iv) Half reactions are

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

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

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

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

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

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

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

UNIT – I – BASIC CONCEPTS OF CHEMISTRY & CHEMICAL CALCULATIONS

| Mr. S.JOHNSON., M.Sc., M.Sc., B.Ed.,

EVALUATE YOURSELF

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

Sugar, Sea water, Distilled water, Carbon dioxide, Copper wire, Table salt, Silver plate, Naphthalene balls

(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 [$C_{12}H_{22}O_{11}$]

(i) C_2H_5OH = (2 x 12) + (5 x 1) + (1 x 16) + (1 x 1) = **46g**

(ii) $KMnO_4$ = (1 x 39) + (1 x 55) + (4 x 16) = **158g**

(iii) $K_2Cr_2O_7$ = (2 x 39) + (2 x 52) + (7 x 16) = **294g**

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

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 224ml at 272K and 3atm pressure.

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

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

b) At 273K 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 224ml at 273K and 3atm pressure

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

1 mole of oxygen contains 6.022 x 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, $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

a) Mass of the metal = W_1 = 0.456g

Mass of the metal chloride = W_2 = 0.606g

∴ Mass of chlorine = $W_2 - W_1$ = 0.606 – 0.456 = **0.15g**

0.15g of chlorine combine with 0.456g of metal

∴ 35.5g of chlorine will combine with $\frac{0.456}{0.15}$ x 35.5 = **107.92g eq^{-1}**

b) Equivalent mass of a oxidising agent = $\frac{Molar\ mass}{No.of\ moles\ of\ electrons\ gained\ by\ one\ mole\ of\ the\ reducing\ agent}$

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

UNIT – I – BASIC CONCEPTS OF CHEMISTRY & CHEMICAL CALCULATIONS

| Mr. S.JOHNSON., M.Sc., M.Sc., B.Ed.,

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.

Element	Percentage	Atomic mass	Relative no. of atoms = $\frac{Percentage}{Atomic\ mass}$	Simple ratio	Ratio (whole Nos)
C	54.55%	12	54.55 / 12 = 4.55	4.55 / 2.27 = 2	2
H	9.09%	1	9.09 / 1 = 9.09	9.09 / 2.27 = 4	4
O	36.36%	16	36.36 / 16 = 2.27	2.27 / 2.27 = 1	1

∴ Empirical formula = $\mathbf{C_2H_4O}$

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 400g) 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.

Element	Percentage	Relative no. of atoms = $\frac{Percentage}{Atomic\ mass}$	Atomic mass = $\frac{Percentage}{Relative\ no.of\ mass}$	Simple ratio	Ratio (whole Nos)
X	32%	2	32 / 2 = 16	4	4
Y	24%	1	24 / 1 = 24	2	2
Z	44%	0.5	44 / 0.5 = 88	1	1

∴ Empirical formula = $\mathbf{X_4Y_2Z}$

Calculate empirical formula mass = (16 x 4) + (24 x 2) + (88 x 1)
= 64 + 48 + 88 = 200

$n = \frac{molar\ mass}{calculated\ empirical\ formula\ mass} = \frac{400}{200} = 2$

∴ Molecular formula $(X_4Y_2Z)_2 = \mathbf{X_8Y_4Z_2}$

7. The balanced equation for a reaction is given below $2x + 2y \rightarrow 4l + m$
When 8 moles of x react with 15 moles of y, then i) Which is the limiting reagent? ii) Calculate the amount of products formed. iii) Calculate the amount of excess reagent left at the end of the reaction.

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

Limiting reagent = *x*

Product formed = 16 moles of *l* & 4 moles of *m*

Amount of excess reactant = 3 moles of *y*

UNIT – I – BASIC CONCEPTS OF CHEMISTRY & CHEMICAL CALCULATIONS

| Mr. S.JOHNSON., M.Sc., M.Sc., B.Ed.,

8. Balance the following equation using oxidation number method

$$\mathbf{As_2S_3 + HNO_3 \longrightarrow H_3AsO_4 + H_2SO_4 + NO}$$

$$\overset{+3\ \ -2}{As_2S_3} + \overset{+5}{HNO_3} \longrightarrow \overset{+5}{H_3AsO_4} + \overset{+6}{H_2SO_4} + \overset{+2}{NO}$$

$3e^-$

$2 \times 2e^- \quad 3 \times 8e^-$

$4e^- + 24e^-$

$28e^-$

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

$$3As_2S_3 + 28HNO_3 \longrightarrow H_3AsO_4 + H_2SO_4 + NO$$

Based on reactant side, balance the products

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

Product side: 36 hydrogen atoms & 88 oxygen atoms

Reactant side: 28 hydrogen atoms & 84 oxygen atoms

Difference is 8 hydrogen atoms & 4 oxygen atoms

$\therefore$ Add 4 H_2O molecule on the reactant side.

Balanced equation,

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

UNIT – I – BASIC CONCEPTS OF CHEMISTRY & CHEMICAL CALCULATIONS

| Mr. S.JOHNSON., M.Sc., M.Sc., B.Ed.,

GOVERNMENT QUESTIONS AND ANSWERS

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

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

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

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

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

Ans. $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$

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

To produce 10 moles of ammonia

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

$= 15$ moles of hydrogen are required.

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

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

4. 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)

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

Ans. $CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)}$

As per the stoichiometric equation,

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

UNIT – I – BASIC CONCEPTS OF CHEMISTRY & CHEMICAL CALCULATIONS

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CH_4

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

H_2O

$(2 \times 1) + (1 \times 16) = 18\ g\ mol^{-1}$

Combustion of 32 g CH_4 produces

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

1.