STOICHIOMETRY

UNIT: 1

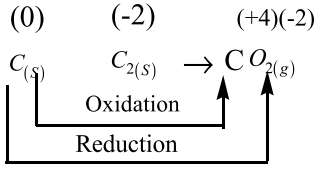
1 Laws of chemical combination, principles and examples
2 Molar mass, concept of equivalent weights with examples
3 Percentage composition of compounds and calculations of empirical and molecular formulae of compounds

VERY SHORT ANSWER QUESTIONS:

1. What is a combination reaction of redox reactions? Give example.

A. A chemical combination reaction which involves both oxidation and reduction is known as combination reaction of redox reaction.

Ex: $C + O_2 \rightarrow CO_2$



2. Chemical decomposition need not involve redox process. Answer it with one example.

A. Chemical decomposition need not involve redox process

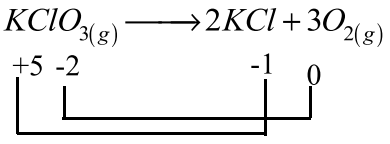
Example:

Decomposition of lime stone is not a redox change

$CaCO_3 \rightarrow CaO + CO_2$

There is no change in oxidation state of Ca, O and C. But few decomposition's involve redox process.

Example: Decomposition of potassium chlorate involved in redox process processes.



SHORT ANSWER TYPE QUESTIONS:

1. Define and explain molar mass.

A. Molar mass: The mass of one mole of any substance in grams is called its molar mass. Molar masses therefore are atomic weights, molecular weights, formula weights etc. expressed in grams.

Example: Molar mass of sulphuric acid $\left(H_2SO_4\right) = 98\,gr$

Molar mass of Hydrogen $\left(H_2\right)$ gas = 2 gm

Molar mass of oxygen $\left(O_2\right)$ gas = 32 gm

2. State and explain the Law of conservation of mass.

A. Law of conservation mass:

Law of conservation of mass was proposed by Lavoiser and verified by Landolt

Matter can neither be created nor destroyed during a chemical change

or

In a chemical total mass of the products formed during a chemical change is exactly equal to the total mass of the reactants.

Example:

$$AgNO_{3(aq)} + KCl_{(aq)} \longrightarrow AgCl_{(s)} + KNO_{3(aq)}$$

In the above reaction total mass of reactants $\left(AgNO_3 + KCl\right)$ will be equal to the total mass of products $\left(AgCl + KNO_3\right)$

All chemical equations are balanced following the law of conservation of mass

3. State and explain the Law of definite proportions.

A. **Law of definite proportions:** "A given chemical substance (compound) always contains the same elements combined in a fixed proportion by weight".

This law was proposed by "Joseph Proust"

Illustration: 'Proust' found the composition of two samples of copper carbonate, one obtained from natural sources, the other prepared in the laboratory synthetically. They are follows with the same percentage of composition.

Elements	% Composition of the sample	
	Natural	Synthetic
Cu	51.35	51.35
O	9.74	9.74
C	38.91	38.91

Irrespective of the place, method or a person, by whom a chemical compound is prepared, it contains the same elements combined in a fixed ratio by weight.

4. State and explain the Law of multiple proportions.

A. Law of multiple proportions:

It was proposed by Dalton

If two elements chemically combine to give two or more compounds, then the weights of one element, which combine, with the fixed weight of the other element in those compounds, bear a simple multiple ratios to one another.

Example:

Weights of oxygen that combine with 12g of carbon in CO and CO_2 will be in the ratio of 1: 2

5. There is no need that a given species must always possess equivalent weight always constant? Is if true? Explain.

A. **True:**

The equivalent weight of given species is depends upon the nature of chemical change of species

Ex – 1: $H_3PO_4 + NaOH \rightarrow NaHPO_4 + H_2O$

The equivalent weight of H_3PO_4 is $\frac{M}{1} = 98$

$H_3PO_4 + 3NaOH \rightarrow Na_3PO_4 + 3H_2O$

In the above reaction equivalent weight of $H_3PO_4 = \frac{M}{3} = \frac{98}{3} = 32.66$

Ex – 2:

Hypo reaction with moist chlorine

$Na_2S_2O_3 + H_2O + Cl_2 \rightarrow Na_2SO_4 + 2HCl + S$

In the above reaction equivalent weight of $Na_2S_2O_3 = M/2$

Hypo reaction with iodine

$$2Na_2S_2O_3 + I_2 \longrightarrow 2Na_2S_4O_6 + 2NaI$$

In the above reaction equivalent weight of $Na_2S_2O_3 = \frac{M}{1}$

6. The equivalent weight of sulphuric acid is given by 98. How far it is true when sulphuric acid is a di basic acid?

A. The equivalent weight of the compound is depends upon nature of chemical change

$$NaOH + H_2SO_4 \longrightarrow NaHSO_4 + H_2O$$

In the above reaction equivalent weight of

$$H_2SO_4 = \frac{\text{Molecular weight}}{\text{Number of replaceable hydrogens}} = \frac{98}{1} = 98$$

In the above reaction equivalent weight of

$$H_2SO_4 = \frac{\text{Molecular weight}}{\text{Number of replaceable hydrogens}} = \frac{98}{2} = 49$$

7. Explain mole concept.

A. A mole may be defined as the mass of a substance that contains Avogadro number of atoms or molecules or ions or any other entities.

Avogardo number is denoted by N and its value is 6.023×10^{23}

Thus 1 mole = Mass of 6.023×10^{23} atoms = 1 g atom = 1 g at. Wt.

1 mole = Mass of 6.023×10^{23} molecules = 1 g at. Wt.

1 mole = Mass of 22.4 lts volume of any gas at NTP

1 mole = Mass of 22.4 1 volume of any gas at NTP

8. Calculate the molecular weights of the following compounds.

1) Glucose $C_6H_{12}O_6$

2) Calcium fluoride CaF_2

3) Magnesium oxide MgO

Atomic weights: C = 12. H = 1, O = 16, Ca = 40, F = 19, Mg = 24.3

A. 1) Molecular weight of $C_6H_{12}O_6$ is

$6(C)+12(H)+6(O)$

$= 6(12)+12(1)+6(16)=180$

2) Molecular weight of calcium fluoride (CaF_2) is $= 1(Ca)+2(F)$

$= 1(40.1)+2(19)=78.1$

3) Molecular weight of magnesium oxide $MgO=1(Mg)+1(O)$

$= 1(24.3)+1(16)=40.3$

9. Write down molar masses of

a) One mole of mercury **b) One mole of sulphur molecules**

c) One mole of lead

d) One mole of potassium dichromate $(K_2Cr_2O_7)$ formula units

Atomic weights: Hg = 200.6, S = 32.6, Pb = 207, K = 39, Cr = 52, O = 16 amu

A. Molar mass = The weight of Avogadro number of molecules (or) atoms (or) ions (or) the expression of molecular weight in grams is called molar mass.

1) Weight of one mole of Hg in grams = 200.6 gm

Molar mass of mercury = 200.6 gm

2) Weight of one mole of sulphur molecule (S_8)

$8(32.6)=260.8\,gm$

Molar mass of sulphur molecule $(S_8)=256\,gm$

3) Weight of one mole of lead $(Pb)=207\,gm$

molar mass of Pb = 207 gm

4) Weight of one mole of potassium dichromate $(K_2Cr_2O_7)$

$= 2(K)+2(Cr)+7(O)$

$= 2(39)+7(52)+7(16)=294\,gm$

$\therefore$ Molar mass of potassium dichromate = 294 gm

10. Calculate the molar masses of $Ca(NO_3)_2$, Al_2O_3, $C_6H_{12}O_6$

Atomic weights of Ca = 40, N = 14, Al = 27, H = 1, C = 2, O = 16 amu

a) Find out the number of moles of sodium bicarbonate present in 5.08gm of sodium bicarbonate $(NaHCO_3)$

b) Calculate the number of moles of Helium in 6.46 gm of Helium (atomic weight of Helium = 4)

c) Calculate the number of moles of zinc in 23.3 gm of zinc

d) Calculate the number of moles of sulphur in 16.3 gm of sulphur

A. Molar mass of $Ca(NO_3)_2 = 1(Ca) + 2(N) + 6(O)$

$= 1(40) + 2(14) + 6(16) = 164\,gm$

a) Number of moles of $NaHCO_3 = \dfrac{\text{weight}}{\text{Gram molecular weight}}$

$= \dfrac{5.08}{84} = 0.06\,\text{moles}$

b) Number of moles of $He = \dfrac{\text{weight}}{\text{Gram atomic weight}}$

$= \dfrac{6.46}{4} = 1.615\,mol$

c) Number of moles of $Zn = \dfrac{\text{weight}}{\text{Gram atomic weight}}$

$= \dfrac{23.3}{65.4} = 0.356\,mol$

d) Number of moles of $'S' = \dfrac{\text{weight}}{\text{Gram molecular weight}}$

$= \dfrac{16.3}{256} = 0.0637\,mol$

11. a) Your friend required you to weight 0.5 moles ammonium sulphate. How many grams do you weigh?

(Hint: formula of ammonium sulphate $(NH_4)SO_4$

(Atomic weight: N = 14, H = 1, S = 32, O = 16)

b) Calculate the weight of 0.885 mole of $Mg(NO_3)_2$

Atomic weight: Mg = 24, N = 14, O = 16

c) What is the weight of 0.590 mole of aspirine $(C_9H_8O_4)$

Atomic weight: O = 16, C = 12, H = 1

A. a) Weight of $(NH_4)_2 SO_4$

= number of moles × Gram molecular weight

= $0.5 \times 13.8 = 69\, gm$

b) Weight of $Mg(NO_3)_2$

= moles × Gram molecular weight

= $0.885 \times 148 = 130.98\, gm$

c) Weight of Aspirine

= moles × Gram molecular weight

= $0.059 \times 180 = 10.62\, gm$

PROBLEMS ON *EMPERICAL AND MOLECULAR* FORMULAE

1. The percentage composition of an organic compound is given below. Its molecular weight is 1.36. Calculate the molecular formula

C= 70.59; H= 5. 88 O = 23. 53

A)

Element	% composition	Atomic ratio	Simple ratio
Carbon	70.59	$\frac{70.59}{12} = 5.88$	$\frac{5.88}{1.47} = 4$
Hydrogen	5.88	$\frac{5.88}{1} = 5.88$	$\frac{5.88}{1.47} = 4$
Oxygen	23.53	$\frac{23.53}{16} = 1.47$	$\frac{1.47}{1.47} = 1$

Empirical formula of the compound = C_4H_4O

Empirical formula weight $= (4 \times 12) + (4 \times 1) + (1 \times 16) = 68$

Molecular weight given = 136

$$\because n = \frac{Molecular\,Weight}{Empirical\ formula\,weight}$$

$=136/68 = 2$

$$\therefore Molecular\ formula = (C_4H_4O)_2$$

$$= C_8H_8O_2$$

2. Analysis of an organic compound gave the following results.

a) 0.100 g of the compound gave 0.2878 g of CO_2 and 0.0756 g of H_2O

b) 0.200 g of the compound at 15^0C and 760 mm pressure gave 21. 8 ml of N_2.

The molecular weight of compound is 107.

Calculate its molecular formula

A. From (a) % of carbon $= \frac{12}{44} \times \frac{weight\ of\ CO_2}{weight\ of\ organic\ compound} \times 100$

$$= \frac{12}{44} \times \frac{0.2878}{0.1} \times 100$$

$$= 78.49\%$$

% of Hydrogen $= \frac{2}{18} \times \frac{weight\ of\ H_2O}{weight\ of\ organic\ compound} \times 100$

$$= \frac{2}{18} \times \frac{0.0756}{0.1} \times 100 = 8.4\%$$

From the data of (b): Calculating volume N_2 at STP

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Given conditions	STP conditions
$P_1 = 760mm$	$P_2 = 760\,mm$
$V_1 = 21.8\,ml$	$V_2 = ?$
$T_1 = 15^0C$	$T_2 = 0^0C$
$= 15 + 273 = 288K$	=273 K

$$\therefore V_2 = \frac{P_1V_1}{T_1} \times \frac{T_2}{P_2}$$

$$= \frac{760 \times 21.8}{288} \times \frac{273}{760} = 20.66ml$$

$$\% \text{ of Nitrogen} = \frac{28}{22400} \times \frac{Volume\,of\ N_2\ at\ STP(ml)}{Height\,of\ organic\,Compound} \times 100$$

$$= \frac{28}{22400} \times \frac{20.66}{0.2} \times 100 = 12.91\%$$

Sol.

Element	**% composition**	**Atomic ratio**	**Simple ratio**
Carbon	78.49	$\frac{70.49}{12} = 6.54$	$\frac{6.54}{0.92} = 7.10$
Hydrogen	8.4	$\frac{8.4}{1} = 8.4$	$\frac{8.4}{0.92} = 9.13$
Oxygen	12.91	$\frac{12.91}{14} = 0.92$	$\frac{0.92}{0.92} = 1$

Empirical formula of the compound = C_7H_9N

Empiricial formula weight = 7 (12) + 9 (1) + 1 (14)

Given Molecular weight = 107

$$n = \frac{molecular\,weight}{Empirical\ formula\,weight} = \frac{107}{107} = 1$$

$$Molecular\ formula = (C_7H_9N)_1$$

$$= C_7H_9N$$

3. An organic compound on analysis was found to contain 16.27% carbon. 0.67% H_2, 7.2.2% chlorine. The V.D. of the compound is equal to 73. 75. Calculate the empirical formula and molecular formulae of the compound.

A.

Element	**% composition**	$\frac{atomic\ ratio\%\,weight}{At.weight}$	**Simple ratio**
Carbon	16.27	$\frac{16.27}{12} = 1.35$	$\frac{1.35}{0.67} = 2.02$

Hydrogen	0.67	$\frac{0.67}{1}0.67$	$\frac{0.67}{0.67}=1$
Chlorine	72.2	$\frac{72.2}{35.5}=2.03$	$\frac{2.03}{0.67}=3.02$
Oxygen	10.86	$\frac{10.86}{16}=0.678$	$\frac{0.678}{0.67}=1$

Empirical formula of the compound = C_2HCl_3O

Empirical formula weight $=(2\times12)+(1\times1)+(3\times35.5)+(1\times16)=147.5$

Molecular weight = 2 x V. D

= 2 x 73. 75 = 147 . 50

$$n=\frac{Molecular\,Weight}{Empiricial\ formula\,weight}$$

$$=\frac{147.50}{147.50}=1$$

$$\therefore Molecular\ formula=C_2HCl_3O$$

4. Combustion of 0.277g of an organic compound gave 0.66g carbon dioxide and 0.337g water. Vapour density of the compound is equal to 37. Calculate its molecular formula.

A). % of Carbon $=\frac{12}{44}\times\frac{0.66}{0.277}\times100=64.98$

% of Hydrogen $=\frac{2}{18}\times\frac{0.337}{0.277}\times100=13.51$

% of Oxygen = 100 – (64. 98 + 13.51) =21. 51

Element	**% composition**	$\frac{atomic\ ratio\,\%\,weight}{At.weight}$	**Simple ratio**
Carbon	64. 98	$\frac{64.98}{12}=5.415$	$\frac{5.415}{1.344}=4$
Hydrogen	13.51	$\frac{13.51}{1}=13.51$	$\frac{13.51}{1.344}=10$
Oxygen	21.51	$\frac{21.51}{16}=1.344$	$\frac{1.344}{1.344}=1$

Empirical formula of the compound = $C_4H_{10}O$

Empirical formula weight = $(4\times12)+(10\times1)+(1\times16)=74$

$$n=\frac{Molecular\,Weight}{Empirical\ formula\,weight}$$

$$=\frac{2\times37}{74}=1$$

$\therefore$ Molecular formula = (Empirical formula) x n

$$=(C_4H_{10}O)_1$$

$$=C_4H_{10}O$$

STOICHIOMETRY

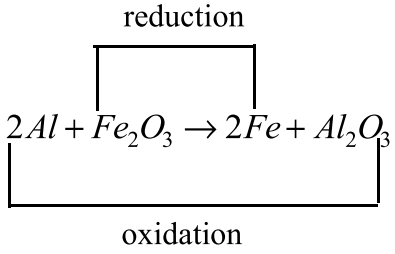
UNIT: 2

1 Chemical reactions and equations
2 Oxidation number Concept
3 Balancing of Redox reactions by ion electron method and oxidation number method

VERY SHORT ANSWER QUESTIONS

1. Alimunothermit process is an example for which type of redox change ? Which substance is the reducing agent here?

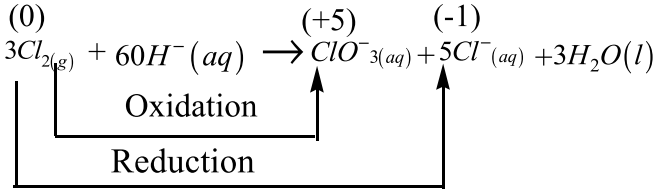
A. Aluminothermit process is an example for metal displacement redox reaction. In this process 'Al' acts as reducing agent.



2. What are disproportionation reactions? Give an example.

A. Chemical reactions in which the same element undergoes both oxidation and reduction simultaneously are known as disproportionation reactions.

Ex:



3. What are comproportionation reactions? Give example.

A. Comproportionation reactions:

The inverse of disproportionation is comproportionation

In comproportionation reactions, two species with the same element in two different oxidation states form a single product in which the element is in an intermediate oxidation state.

Ex: $Ag^{2+}(aq) + Ag(s) \rightarrow 2Ag^{+}(aq)$

4. Now a days it is thought that oxidation is simply decrease in electron density and reduction is increase in electron density. How would you justify this?

A. The decrease in electron density means loss of electrons. The loss of electrons is called oxidation.

The increase in electron density means a gain of electrons. . The gain of electrons is called reduction.

SHORT ANSWER TYPE QUESTIONS:

1. Balance the following equations and write down the stoichiometric proportions.

a) $C + O_2 \rightarrow CO_2$ **b)** $H_2 + Cl_2 \rightarrow HCl$

c) $N_2 + H_2 \rightarrow NH_3$ **d)** $Fe + O_2 \rightarrow Fe_2O_3$

e) $CaCO_3 + HCl \rightarrow CaCl_2 + H_2O + CO_2$

f) $MnO_2 + HCl \rightarrow MnCl_2 + H_2O + Cl_2$

g) $Mg(OH)_2 + HCl \rightarrow MnCl_2 + H_2O + Cl_2$

h) $KI + H_2SO_4 \rightarrow KHSO_4 + I_2 + SO_2$

A. a) Given equation: $C + O_2 \rightarrow CO_2$

Balanced equation: $C + O_2 \rightarrow CO_2$

Stoichiometric ratio's = 1: 1: 1

b) Given equation: $H_2 + Cl_2 \rightarrow HCl$

Balanced equation: $H_2 + Cl_2 \rightarrow 2HCl$ (or) $\frac{1}{2}H_2 + \frac{1}{2}Cl_2 \rightarrow HCl$

Stoichiometric ratios = 1: 1: 2 (or) $\frac{1}{2}:\frac{1}{2}:1$

c) Given equation: $N_2 + H_2 \rightarrow NH_3$

Balanced equation: $N_2 + 3H_2 \rightarrow 2NH_3$

Stoichiometric ratios = 1: 3: 2

d) Given equation: $Fe + O_2 \rightarrow Fe_2O_3$

Balanced equation: $4Fe + 3O_2 \rightarrow 2Fe_2O_3$

Stoichiometric ratios = 4: 3: 2

e) Given equation: $CaCO_3 + HCl \rightarrow CaCl_2 + H_2O + CO_2$

Balanced equation:

$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

Stoichiometric ratios = 1: 2: 1: 1: 1

f) Given equation: $MnO_2 + HCl \rightarrow MnCl_2 + H_2O + Cl_2$

Balanced equation: $MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2$

Stoichiometric ratios = 1: 4: 1: 2: 1

g) Given equation: $Mg(OH)_2 + HCl \rightarrow MgCl_2 + H_2O$

Balanced equation: $Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + H_2O$

Stoichiometric ratios = 1: 2: 1: 2

h) Given equation: $KI + H_2SO_4 \rightarrow KHSO_4 + I_2 + SO_2$

Balanced equation: $2KI + 3H_2SO_4 \rightarrow 2KHSO_4 + I_2 + SO_2 + 2H_2O$

Stoichiometric ratios = 2: 3: 2: 1: 1: 2

2. What is the oxidation number of manganese in $KMnO_4$?

A. K Mn O_4

$\downarrow \downarrow \downarrow$

+1 x -2

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

$\boxed{x=+7}$

3. Calculate the oxidation number of Sulphur in SO_4^{2-} ?

A. S O_4^{2-}

$\downarrow \downarrow$

x -2

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

$\boxed{x=+6}$

4. What is the oxidation number of manganese in $MnSO_4$?

A. $Mn\,(SO_4)$

$\downarrow \quad \downarrow$

$x \quad -2$

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

$x=+2$

5. Calculate the oxidation numbers of hydrogen to different states making use of following formulae.

H, HCl, H_2O_2, NaH

A. Oxidation state of 'H' in uncombined state is '0'

$\therefore$ Oxidation state of H is '0'

Hydrogen common oxidation state (with non metals) = '+1'

In HCl, ‘H’ oxidation state = ‘+1’

In H_2O_2, ‘H’ oxidation state = ‘+1’

Hydrogen exhibit ‘-1’ oxidation state with metals

In NaH, ‘H’ oxidation state is ‘-1’

6. Calculate the oxidation number of oxygen in the following.

$O_2, KO_2, H_2O_2, MgO, Cl_2O, OF_2$

A. Oxidation number of oxygen is -2, in its compounds. In peroxides it is ‘-1’ and ‘+1’ and ‘+2’ in oxygen fluorides O_2F_2 and OF_2 respectively. In super oxides like KO_2 it is ‘$-1/2$’

Oxidation state of oxygen in $O_2 = '0'$

Oxidation state of oxygen in potassium superoxide $\left(KO_2\right)$ is = $-1/2$

Oxidation state of oxygen in Hydrogen peroxide $\left(H_2O_2\right)$ = ‘-1’

In Mg O

$\downarrow \quad \downarrow$

+2 x

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

$\boxed{x=-2}$

In oxygen fluoride OF_2

$O \quad F_2$

$\downarrow \quad \downarrow$

x -1

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

$\boxed{x=+2}$

7. Calculate the oxidation numbers of hydrogen in different states making use of following formulae.

a) $C_6H_{12}O_6$ **b)** $C_{12}H_{22}O_{11}$

A. a) $C_6H_{12}O_6$

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

$$\boxed{x=0}$$

b) $C_{12}H_{22}O_{11}$

$$\downarrow\ \downarrow\ \downarrow$$

$$x\ \ +1\ \ +2$$

$$12(x)+22(+1)+11(-2)=0$$

$$\boxed{x=0}$$

8. Calculate the oxidation number of iron in Fe_3O_4 ?

A. Fe_3O_4

$$\downarrow\ \downarrow$$

$$x\ \ -2$$

$$3(x)+4(-2)=0$$

$$\boxed{x=+8/3}$$

9. Calculate the oxidation number of sulphur in $H_2S_2O_8$?

(Hint: Two of the oxygen form peroxide bond)

A. $H_2S_2O_8 : H_2S_2O_6(O_2)$

$$\downarrow\ \downarrow\ \downarrow\ \downarrow$$

$$+1\ \ x\ \ -2\ \ -1$$

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

$$\boxed{x=+6}$$

10. What is the common oxidation number of halogens, when they are in combined state with metals?

A. The common oxidation state of halogens when they combine with metals is '-1'

BALANCING EQUATIONS

1. Balance the following half reaction by ion electron method.

$NO_2^- \rightarrow \underset{(g)}{NO}(acidic\ solution)$

A) Sep-1 Write down the oxidation number of each atom $\overset{+3}{N}O_2^- \rightarrow \overset{+2}{N}O$

Step 2:

a) Balance the atoms other than oxygen and hydrogen

$NO_2^- \rightarrow NO$ (N is already balanced)

b) Balance oxygen atoms by adding H_2O molecules to the suitable side

$NO_2^- \rightarrow NO + H_2O$ (O is balanced)

c) Balance hydrogen by adding H^+ ions to the suitable side

$NO_2^- + 2H^+ \rightarrow NO + H_2O$

d) Balance charges by adding electrons to the suitable side

$NO_2^- + 2H^+ + e^- \rightarrow NO + H_2O$

(Charges balanced)

Hence, the balanced half-reaction is

$NO_2^- + 2H^+ + e^- \rightarrow NO + H_2O$

2. Balance the following half reaction by ion-electron method

$\underset{(aq)}{CN^-} \rightarrow \underset{(aq)}{CNO^-}$ **(Basic medium)**

A. Step – 1 Write the oxidation numbers of each atom

+2 – 3 + 4 -3 -2

C $N^{(-)} \rightarrow$ C $NO^{(-)}$

Step 2: a) Balance the atoms other than oxygen and hydrogen

$CN^{(-)\rightarrow}CNO^{(-)}$ (bothC, N are already balanced)

b) Balance oxygen atoms by adding H_2O molecule to the suitable side

$CN^{(-)} + H_2O \rightarrow CNO^{(-)}\left(O\,is\,balanced\right)$

c) Balance hydrogen atoms by adding H_2O at deficent side of hydrogen and add same number of OH^- ions in opposite side.

$CN^{(-)} + H_2O + 2OH^{(-)} \rightarrow CNO^- 2H_2O$

(H is balanced in basic medium)

d) Balanced charges by adding electrons to the suitable side

$CN^- + H_2O + 2OH^- \rightarrow CNO^- 2H_2O + 2e^-$

Hence the balanced half- reaction is

$CN^- = 2OH^- \rightarrow CNO^- H_2O + 2e^-$

3. Balance of the following redox-reaction by ion electron method.

$\underset{(g)}{C_2H_2} + \underset{(aq)}{MnO_4^-} \rightarrow \underset{(aq)}{Mn^{+2}} + \underset{(g)}{CO_2}$ **(Acidic sol)**

A Step 1: Write the oxidation number of each atom

-1 + 1 + 7 - 2 + 2 + 4 -2

$C_2H_2 + MnO_4^{(-)\rightarrow}Mn^{+2} + CO_2$

Step -2: Divide the reaction into two half- reactions.

Oxidation half – reaction	**Reduction half reaction**
$C_2H_2 \rightarrow CO_2$ a) **Balance atoms otherthan oxygen and hydrogen** $C_2H_2 \rightarrow 2CO_2$ (C is balanced)	$MnO_4^- \rightarrow Mn^{+2}$ $MnO_4^- \rightarrow Mn^{+2}$ (Mn is already balanced)

b) **Balance oxygen atoms** $C_2H_2 + 4H_2O \rightarrow 2CO_2$ (O is balanced)	$MnO_4^- \rightarrow Mn^{+2} + 4H_2O$ (O is balanced)
c) **Balanced hydrogen** $C_2H_2 + 4H_2O \rightarrow 2CO_2 + 10H^+$ (H is balanced in acidic medium)	$MnO_4^- + 8H^- \rightarrow Mn^{+2} + 4H_2O$ (H is balanced in acidic medium)
d) **Balance charges** $C_2H_2 + 4H_2O \rightarrow \ 2CO_2 + 10H^+ + 10e^-)$	$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{+2} + 4H_2O$
e) **Balance electrons** $1\left(C_2H_2 + 4H_2O \rightarrow 2CO_2 + 10H^+ + 10e^-\right)$	$2\left(MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{+2} + 4H_2O\right)$

Step – 3 Add both the half- reaction and cancel the electrons and other similar species on both sides.

$$C_2H_2 + 4H_2O \rightarrow 2CO_2 + 10H^+ + 10e^-$$

$$2MnO_4^- + 16H^+ + 10e^- \rightarrow 2Mn^{+2} + 8H_2O$$

$$\boxed{C_2H_2 + 2MnO_4^- + 6H^+ \rightarrow 2Mn^{+2} + 2CO_2 + 4H_2O}$$

Hence, the balanced redox –reaction is

$$C_2H_2 + 2MnO_4^- + 6H^+ \rightarrow 2Mn^{+2} + 2CO_2 + 4H_2O$$

4. Balance the following redox –reaction by ion electron method.

$$Br_2 \rightarrow \underset{(aq)}{BrO_3^-} + \underset{(aq)}{Br^-}$$ **(Basic medium)**

A) Step 1: Write the oxidation numbers of each atom

0 +5 – 2 -1

$Br_2 \rightarrow \quad BrO_3^- + Br^-$ (basic medium)

Step 2: Divide the reaction into two half-reactions.

Oxidation half-reaction	**Reduction half reaction**

$\frac{1}{2}Br_2 \rightarrow BrO_3^-$	$\frac{1}{2}Br_2 \rightarrow Br^-$
a) **Balance atoms otherthan oxygen and hydrogen**	
$\frac{1}{2}Br_2 \rightarrow BrO_3^-$	$\frac{1}{2}Br_2 \rightarrow Br^-$
(Br is already balance)	(Br is already balanced)
b) **Balanced oxygen atoms**	
$\frac{1}{2}Br_2 + 3H_2O \rightarrow BrO_3^-$	$\frac{1}{2}Br_2 \rightarrow Br^{(-)}$
c) **Balance hydrogen**	
$\frac{1}{2}Br_2 + 3H_2O + 6OH^- \rightarrow$ $BrO_3^- + 6H_2O$	$\frac{1}{2}Br_2 \rightarrow Br^{(-)}$
(hydrogen balanced in basic medium)	
d) balance charges	
$\frac{1}{2}Br_2 + 3H_2O + 6OH^- \rightarrow$ $BrO_3^- + 6H_2O + 5e^-$	
e) **Balance electrons both sides**	
$\frac{1}{2}Br_2 3H_2O + 6OH^- \rightarrow$ $BrO_3^- + 6H_2O + 5e^-$	$\frac{1}{2}Br_2 + e^- \rightarrow Br^-$ $5\left(\frac{1}{2}Br_2 + e^- \rightarrow Br^-\right)$

Step -3: Add both the half reactions and cancel the electrons and other similar species on both sides.

$$\frac{1}{2}Br_2 + 3H_{2d}O + 6OH^- \rightarrow BrO_3^- + 6H_2O + 5e^-$$

$$\frac{5}{2}Br_2 + 5e^- \rightarrow 5Br^-$$

$$3Br_2 + 6OH^- \rightarrow BrO_3^- + 5Br^- + 3H_2O$$

Hence, the balanced redox- reaction is

$$3Br_2 + 6OH^- \rightarrow BrO_3^- + 5Br^- + 3H_2O$$

5. Balance the following equations by oxidation number method.

$$HNO_{(aq)} + C_{(s)} \rightarrow NO_{2(g)} + H_2O_{(l)} + CO_{2(g)}$$

A. **Step – 1** Skeleton equation is

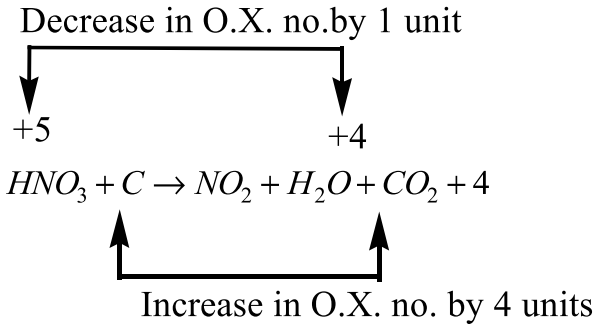
$$HNO_3 + C \rightarrow NO_2 + H_2O + CO_2$$

Step -2: Assign oxidation numbers of the elements particularly in the reaction

$+1+5-2 \quad 0+4-2+1-2+4-2$

H N O_3 + C $\rightarrow$ NO_2 + H_2O + CO_2

Step – 3: Identify atoms whose oxidation states have changed



Step 4: Balance the no. of electrons lost and gained by adjusting the co-efficients of the molecules containing the atoms that undergo changes in oxidation number.

$$4HNO_3 + C \rightarrow NO_2 + H_2O + CO_2$$

Step 5: Supply proper coefficient for the rest of the reaction

$$4HNO_3 + C \rightarrow 4NO_2 + 2H_2O + CO_2$$

STOICHIOMETRY

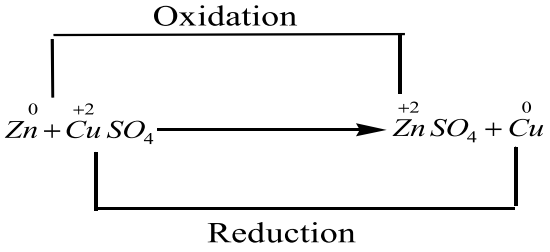
UNIT: 3

1. Types of Redox reactions
2. Applications of redox reactions in titrimetric quantitative analysis and redox reactions in electrode process
3. Numerical calculations based on equation

VERY SHORT ANSWER QUESTIONS:

1. What is redox concept? Give an example.

A. Chemical change in which both the oxidation and reduction are takes place simultaneously is called redox reaction.



2. What is the role of salt bridge in a Daniel cell?

A. In a Daniel cell, salt bridge provides an electric contact between the two solutions by preventing accumulation of charges at the respective electrodes.

3. $I_{2(aq)} + 2S_2O_3^{2-} \longrightarrow 2I_{(aq)} + S_4O_{6(aq)}^{2-}$ **for the above trimetric reactions how is the end point determined.**

A. $I_{2(aq)} + 2S_2O_3^{2-} \longrightarrow 2I_{(aq)} + S_4O_{6(aq)}^{2-}$

In this titrimetric reaction, the end point can be detected by a colour change from blue to colourless state.

SHORT ANSWER TYPE QUESTIONS:

1. How are MnO_4^- and $Cr_2O_7^{2-}$ titrations with other substances carried out to detect the end point.

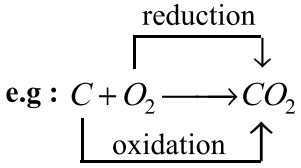
A. 1) In $Cr_2O_7^{2-}$ titrations, diphenyl amine is used as reagent and at the end point it produces intense blue colour due to the oxidation by $Cr_2O_7^{2-}$

2) In MnO_4^- (i.e.,) permangametric titrations, there is no need of external indicator because $KMnO_4$ acts as self indicator. At the **end point, light pink colour** is produced.

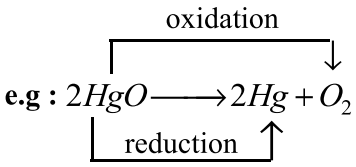
2. Explain any two types of redox reactions with examples.

A. Redox reactions – Types:

a) Chemical combination reactions: One species combine with another species to form product. In this conversion one species undergo oxidation and other species undergo reduction.



ii) Decomposition reactions: Chemical compounds chemically split into two or more simpler substances during decomposition reactions.



3. Write the electrode reactions in a Daniel cell.

A. In Daniel cell a zinc rod is kept in copper sulphate solution the redox reaction takes place and heat is also evolved.

at anode: $Zn \rightarrow Zn^{+2} + 2e^-_{(\text{Oxidation})}$

at cathode: $Cu^{2+} + 2e^- \longrightarrow Cu_{(\text{Reduction})}$

Cell reaction: $Zn + Cu^{+2} \longrightarrow Zn^{+2} + Cu$

4. For two redox couples A^{2+}/A and B^{2+}/B the reduction potential values are -1.28V and +0.34V which is strong reducing agent? Can both of them displace H_2 from dilute Hydrochloric acid? Why?

A. The low S.R.P element acts as strong reducing agent and the high S.R.P element acts as strong oxidising agent. High S.R.P element can replaceable by low S.R.P element from their salts.

A is strong reducing agent

A is only displace H_2 from dilute Hydrochloric acid due to its low reduction potential value.

$$H_2SO_4 = \frac{\text{Molecular weight}}{\text{Number of replaceable hydrogens}} = \frac{98}{2} = 49$$

5. How are the end points of titrations detected in the following reaction.

(a) MnO_4^- oxidizes Fe^{2+}

(b) $Cr_2O_7^{2-}$ oxidizes Fe^{2+}

(c) Cu^{+2} oxidizes I^-

A. a) In the titration which involves oxidation of Fe^{+2} by MnO_4^- the end point can be detected by a sharp colour change from pale pink to colourless.

b) In the titration which involves oxidation of Fe^{+2} by $Cr_2O_7^{-2}$ the end point can be detected by the formation of intense blue colour.

c) In the titration which involves oxidation of I^- by Cu^{+2} the end point can be detected by the formation of a deep blue colour with starch solution.

CALCULATIONS BASED ON WEIGHT RELATIONSHIP:

1. Calculate the amount of oxygen formed, when 122.6 g of $KClO_3$ was heated?

A. $2KClO_{3(g)} \xrightarrow{\Delta} KCl_{(s)} + 3O_{2(g)}$

$2\times122.6\,g \qquad 2\times32\,g$

$2\times122.6\,g$ of $KClO_3$ liberates $3\times32\,g\,O_2$

122.6 g of $KClO_3$ liberates $\frac{122.6}{2\times122.6}\times3\times32=48\,g$

2. What is the weight of limestone required to get 11.2g of lime?

A. $CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$

100g 56g

56g of lime is formed from 100g of limestone

11.2g of lime is formed from, $\frac{11.2}{56}\times100=20\,g$ of limestone

CALCULATIONS BASED ON WEIGHT – VOLUME RELATIONSHIPS:

1. What volume of oxygen is required for the complete combustion of 4 g of CH_4?

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

1 mole 2 mole

16 g 2 x 22. 4 lit

16 g of CH_4 required 2x 22.4 lit of oxygen for the combustion.

$\therefore$ 4 g of CH_4 requires $=\frac{4}{16}\times2\times22.4$ lit of oxygen =11.2 lit

2. What is the amount of calcium carbonate for the preparation of 250cc of CO_2 at 27^oC and 750 mm of Hg by the action of dil HCl

A. Step I: Conversion of the volume CO_2 from experimental condition to STP conditions .

Experimental condition to STP conditions .

$P_1 = 750$ mm of Hg P_2=760 mm of Hg

$V_1 = 250$ c.c $V_2 = ?$

$T_1 = 300K$ $T_2 = 273K$

Applying formula

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$$\frac{750\times 250}{300}=\frac{760\times V_2}{273}$$

$V_2 = 224.5$ C.C

Step II The given reaction is,

$$CaCO_{3(s)} + 2HCl_{(l)} \rightarrow CaCl_{2(s)} + CO_{2(g)} + H_2O_{(l)}$$

100g 22,400 C.C

100g of $CaCO_3$ is required to produce 22,400 C.C of CO_2

The weight of $CaCO_3$ required to produce 224.5 C.C. of CO_2

is $\frac{224.5}{22,400}\times 100 = 1.002g$.

CALCULATIONS BASEDON VOLUME – VOLUME RELATIONSHIPS:

1. What volume of oxygen is required for the complete combustion of 4 lit of CO at NTP.

Sol. $$CO_{(g)} + \frac{1}{2}O_{2(g)} \rightarrow CO_{2(g)}$$

1 mole $1/2$ mole

22.4 lit 11.2 lit

22.4 lit of CO requires 11.2 lit of oxygen

4 lit g CO requires $\frac{4}{22.4}\times 11.2\,lit = 2\,lit$