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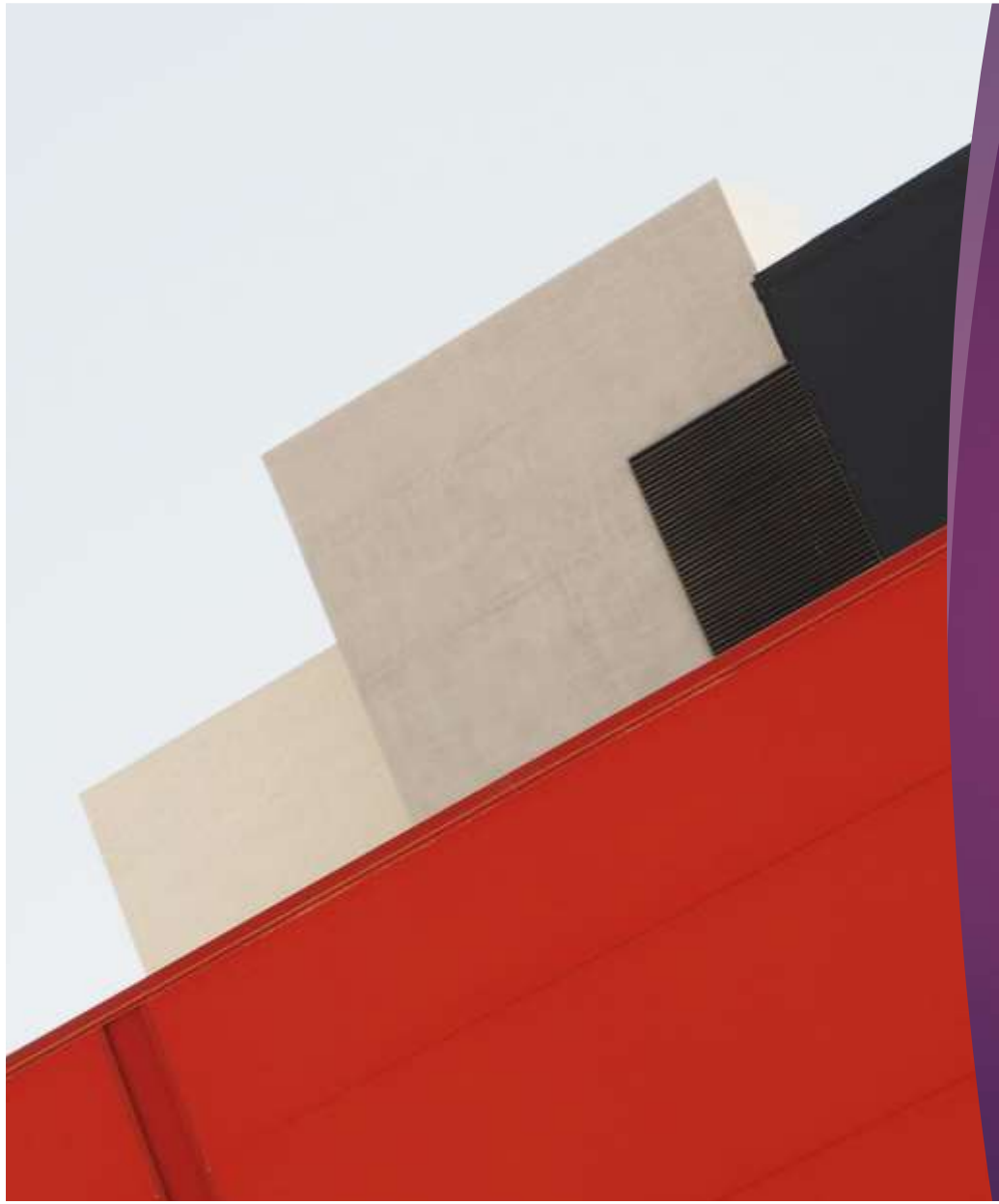

Stoichiometry and Stoichiometric Calculations

MODULE-3/5

Objectives

- To learn about stoichiometry
- To understand and learn to balance equations
- To carry out calculations based on stoichiometry
- To know about Limiting and Excess reagents

Some important definitions

Stoichiometry- Branch of chemistry which deals with the calculation of masses (sometimes volumes) or quantitative relationship of the reactants and products involved in a chemical reaction

Stoichiometric Ratio- The simplest whole number ratio of moles of reactants and products involved in the reaction

Stoichiometric Coefficients- The whole numbers representing the moles of reactants and products involved in the reaction

Chemical Equation-A symbolic brief representation of a chemical change in terms of symbols and formulae of reactants and products is called Chemical Equation

Skeleton Equation- Equations in which number of atoms of various elements in reactant and product side is not equalised in a reaction

Balanced Equation- Equations in which number of atoms of each element is equal on the reactant and product side in a reaction

Balancing of equations

Some important methods used for balancing equations which you will be dealing with in the chapter Redox reactions are-

- Hit and Trail method
- Partial equation method
- Oxidation number method
- Ion-electron method

Assignment to be done in class

Balance the following equations by Hit and trail method

1. $NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$
2. $KI + H_2SO_4 + H_2O_2 \rightarrow K_2SO_4 + I_2 + H_2O$
3. $NaOH + Cl_2 \rightarrow NaCl + NaClO_3 + H_2O$
4. $H_3PO_3 \rightarrow H_3PO_4 + PH_3$
5. $Fe(SO_4)_3 + NH_3 + H_2O \rightarrow Fe(OH)_3 + (NH_4)_2SO_4$
6. $I_2 + HNO_3 \rightarrow HIO_3 + NO_2 + H_2O$
7. $Zn + HNO_3 \rightarrow Zn(NO_3)_2 + N_2O + H_2O$
8. $Mg_3N_2 + H_2O \rightarrow Mg(OH)_2 + NH_3$
9. $Ca_2B_6O_{11} + SO_2 + H_2O \rightarrow CaSO_3 + H_3BO_3$

How to balance?

$NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$

Explain

Type-1 Mass-Mass relationship

1. Calculate the mass of Iron which will be converted into its oxide (Fe_3O_4) by the action of 18g of steam on it.

Required equation- $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$ (Fe=56, O=16, H=1)

From equation- 3 x 56 ---------- 4 x 18

Thus 72g of steam reacts with 168g of Iron

Therefore 18g of steam reacts with----------? 18 x 168/72= 42g

Thus mass of Iron required is 42g

Do Now

2. What mass of slaked lime would be required to decompose completely 4g of ammonium chloride and what would be mass of each product?

Type-2 Mass- Volume relationship

What volume of CO2 would be obtained at STP when 10g of calcium carbonate is subjected to thermal decomposition? (Ca=40, C=12, 0=16,H=1Cl=35.5)

Balanced equation required- CaCO3 + 2HCl ➔ CaCl2 + H2O + CO2

From equation 1 mole 2 moles 1 mole 1 mole 1 mole

At STP GMV of gas = 22,400 cm3

Molar mass of CaCO3= 100g≡ $1\ mole$

Thus 100g----------22400mL

10g----------? 10 x 22400/100 = 2240cm3

Do Now

The drain cleaner, Drainex contains small bits of Al which react with caustic soda to produce dihydrogen. What volume of dihydrogen at 200C and 1 bar pressure will be released when 0.15g of Al reacts?

Type-3 Volume-Volume relationship

What volume of oxygen at STP is required to affect complete combustion of 200cm3 of acetylene and what would be the volume of carbon di oxide formed?

Required equation- $2C_2H_2 + 5\ O_2 \rightarrow 4CO_2 + 2H_2O$

From equation- 2 mole 5 mole 4 mole 2 mole

Applying Gay-Lussac law 2 vol (2 x 22400cm3) --------- 5 vol (5 x 22400cm3)

Thus 200 cm3----------? 200 x 5 /2= 500 cm3 at STP

For CO_2

2 vol (2 x 22400cm3) ----------4 vol(4 x 22400cm3)

200cm3----------? 200 x 4/ 2= 400cm3 at STP

Some More Numerical based on stoichiometric calculations

How many grams of oxygen are required to completely react with 0.200g of hydrogen to yield water? Also calculate the amount of water formed. (Atomic Mass H=1 O=16)

The balanced equation for the reaction is-

$$2H_2 + O_2 \rightarrow 2H_2O$$

2 moles 1 mole 2 moles

4g 32g 36g

From equation 4g hydrogen requires 32g of oxygen

therefore 0.200g ----------?

32/4 x 0.200= 1.6g

Similarly 4g----------36g of water

Therefore 0.200g----------? 36/4 x 0.200= 1.8g

Numerical Showing all 3 types of relationship

1. What volume of oxygen at STP can be produced by 6.125g of potassium chlorate according to the reaction-

$2KClO_3 \rightarrow 2KCl + 3O_2$? (K=39, Cl=35.5, O=16)

According to equation 2 moles ---------- 2 moles + 3 moles

In terms of grams - 2 x 122.5---------- 3 x 22.4 L at STP

now 245g----------3 x 22.4

6.125g----------?

3 x 22.4/245 x 6.125

= 1.68 l at STP

Do Now

What weight of $KClO_3$ is required to produce 298 g of KCl?

What weight of Oxygen is produced when 490g of $KClO_3$ is subjected to decomposition on heating?

Higher order numerical

1.84g of Mixture of $CaCO_3$ and $MgCO_3$ is strongly heated till no furthe mass takes place. The residue weighs 0.96g. Calculate the % compositi mixture.

Solution-

Let mass of $CaCO_3$ in mixture be= X g

then mass of $MgCO_3$ will be =(1.84 – X) g

Step-1 To calculate mass of CaO residue from X g of $CaCO_3$

$CaCO_3 \rightarrow CaO + CO_2$ MM of $CaCO_3$= 100 & CaO=56

100g--------56 g

Therefore Residue of CaO from X g = 56 x X/100= 0.56X g

Step-2 Similarly $MgCO_3 \rightarrow MgO + CO_2$ MM of $MgCO_3$= 84 & MgO=

Residue of MgO from(1.84-X) g of $MgCO_3$ = 40 x (1.84-X) /84= 40 (1.84

Step-3 To calculate masses of $CaCO_3$ and $MgCO_3$ in mixture Given res weight= 0.96g

0.56 X x 84 + 40 x 1.84- 40x= 84x 0.96; 7.04 X = 7.04 or X=1

Thus mass of $CaCO_3$= 1g and mass of $MgCO_3$= 1.84-1.00= 0.84 g

% of $CaCO_3$ in mixture = 1/1.84 x 100 = 54.35%

% of $MgCO_3$ in mixture = 100- 54.35 = 45.65%

Acknowledgment

NCERT Chemistry textbook for class XI Part-1

ISC Chemistry –XI by Dr. H. C. Srivastava

Pradeep's New Course Chemistry-XI Volume-1

Comprehensive Chemistry – XI Volume-1