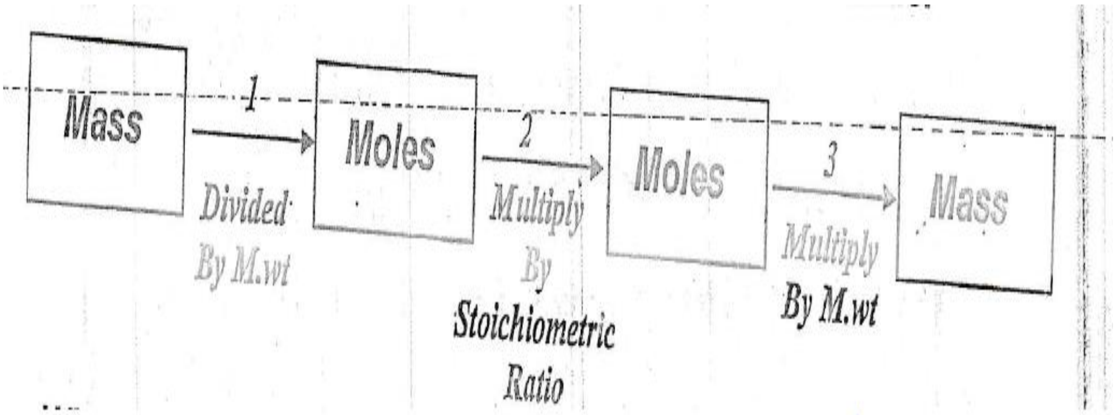
Chemical Stoichiometry :

The Stoichiometry of reaction is the quantitative relationship among the number of moles of reactants and products as shown by a balanced equation .

Flow diagram for making Stoichiometric Calculations



When the mass of reactant or product is given , the mass is first converted to the number of moles using molecular weight .

The stoichiometry ratio given by chemical equation for the reaction is then used to find the number of mole of another reactant. Finally ,the mass of the other reactant or the product is computed by multiply by molecular weight .

Example 8 : what mass of $AgNO_3$ is needed to convert 2.33 gm of Na_2CO_3 to Ag_2CO_3? What mass of Ag_2CO_3 will be formed ?

Solution: The chemical reaction eq. is:

$$Na_2CO_3 + 2\,AgNO_3 \rightarrow Ag_2CO_3 + 2\,NaNO_3$$

Mwt. $(Na_2CO_3) = 106\ \frac{g}{mol}$, Mwt. $(AgNO_3) = 169.9\ \frac{gm}{mol}$, Mwt. $(Ag_2CO_3) = 275.7\ \frac{g}{mol}$

$$\text{no. moles of } Na_2CO_3 = \frac{wt.}{Mwt.} = \frac{2.33\ gm}{106\ \frac{g}{mol}} = 0.02198\ mol$$

$$\therefore \text{no. mol } AgNO_3 = 0.02198 * \frac{2\ mol\ AgNO_3}{1\ mol\ Na_2CO_3} = 0.04396\ mol$$

mass of $AgNO_3$ = mole * Mwt. = 0.04396 * 169.9 = **7.47 g** $AgNO_3$

no. moles of Ag_2CO_3 = no. moles of Na_2CO_3 = 0.02198 mol

$\therefore$ mass of Ag_2CO_3 = 0.02198 * 275.7 = **6.06 gm** Ag_2CO_3

Example 2: Calcium carbide, CaC_2 reacts with water to form acetylene.

(a) How many grams of CaC_2 required to produce 23.6 gm acetylene.

(b) If 55.3 grams of $Ca(OH)_2$ are formed, how many grams of water reacted.

Solution: The chemical eq. reaction is:

$$CaC_2 + 2\,H_2O \rightarrow C_2H_2 + Ca(OH)_2$$

Mwt. CaC_2 = 64 g/mol, Mwt. C_2H_2 = 26 g/mol, Mwt. $Ca(OH)_2$ = 74

$$n\ C_2H_2 \text{ formed} = \frac{23.6\ g}{26\ \frac{g}{mol}} = 0.908\ mol$$

$n\ CaC_2$ reacted = $n\ C_2H_2$ produced = 0.908 mol

$\therefore$ mass of $CaC_2 = n * Mwt = 0.908 * 64 = \underline{\underline{58.1\ gm}}$

$$n_{Ca(OH)_2}\ \text{formed} = \frac{55.3\ gr}{74\ g/mol} = 0.747\ mol$$

$\therefore$ n_{H_2O} reacted $= 2 * n_{Ca(OH)_2} = 2 * 0.747 = 1.494$ mol

$\therefore$ mass of H_2O req. $= n * Mwt = 1.494 * 18 = \underline{\underline{26.89\ gm}}$

Example 3: An impure sample of $CaCl_2$ is dissolved and titrated with a solution of $AgNO_3$. The reaction is:

$$CaCl_2 + 2\,AgNO_3 \rightarrow Ca(NO_3)_2 + 2\,AgCl$$

It is found that 46.35 ml, 0.1034 M $AgNO_3$ titrates a 0.2843 gm sample of $CaCl_2$. Compute the percentage of $CaCl_2$ in the sample?

Solution:

$$\text{mmoles of } AgNO_3 = 46.35\ ml * 0.1034\ \frac{mmol}{ml} = 4.793\ mmol$$

The equation shows that 2 moles $AgNO_3$ reacts with 1 mole $CaCl_2$

$$\therefore\ \text{mmoles } CaCl_2 = 4.793 * \frac{1\ \text{mole } CaCl_2}{2\ \text{mole } AgNO_3} = 2.397\ mmol$$

$$\text{wt. } CaCl_2 = 2.397 * \underset{Mwt_{CaCl_2}}{111} = 266.1\ mg$$

$$\%\ CaCl_2 = \frac{266.1\ mg}{284.3\ mg} * 100 = 93.6\ \%$$

Calculation based on Molarity:

$$aA + bB \longrightarrow \text{product}$$

where: $R = \frac{b}{a}$

mmole of $A = M_A * V_A$

mmole of $B =$ mmole of $A * R \Rightarrow$ mmole of $B = M_A * V_A * R$ [$* Mwt_B$]

$\therefore$ | wt of B in mg = mmole of $A * R * Mwt_B$ |

Example: Exactly 50 ml of HCl required 29.71 ml of 0.01963 M of $Ba(OH)_2$ to reach end point as afollowing eq.:

$$2HCl + Ba(OH)_2 \rightarrow BaCl_2 + 2H_2O$$

What is the molarity of HCl?

Solution:

mmole of $Ba(OH)_2 = 0.01963 * 29.71 = 0.5832$ mmole.

mmole of $HCl = 2 *$ mmole of $Ba(OH)_2 = 2 * 0.5832 = 1.1664$ mmole.

$\therefore M_{HCl} = \frac{1.1664}{50} = \underline{\underline{0.0233}}$ mmole/ml.

Calculation based on Normality:

The basis of all computations dealing with normalities of solutions is the simple relation that the number of equivalents of one reactant is equal to the number for the other reactant.

If A reacts with B

$$eq._A = eq._B$$

$$meq._A = meq._B$$

$$N = \frac{wt.}{eq.wt} * \frac{1}{L} \Rightarrow \frac{wt}{eq.} = N * L$$

$$\therefore \quad \boxed{\frac{mg}{meq.} = N * V}$$

Example: 25 ml of HCl sol. is required to react with 0.1854 gm of pure Na_2CO_3. What is the normality of acid? if 32.16 ml of acid reacts with 29.65 ml of NaOH. What is the normality of NaOH sol.?

Solution:

$$meq._{HCl} = meq._{Na_2CO_3}$$

$$N_{acid} * 25\ ml = \frac{0.1854\ gm * \frac{1000\ mg}{1\ gm}}{\frac{106}{2}\ mg/meq.} \Rightarrow N_{acid} = \underline{0.1394}\ meq./ml$$

$$N_{acid} * V_{acid} = N_{base(NaOH)} * V_{base(NaOH)}$$

$$0.1394 * 32.16 = N_{NaOH} * 29.65 \Rightarrow N_{NaOH} = \underline{0.1515}\ meq/ml.$$