Topic EX2 : The Mole

Revised July 1995

1 Atomic Mass Unit (amu) is the weight of a proton or neutron.

THE MOLE IS THE NUMBER OF AMU'S IN 1g

1 amu weighs 1.66×10^{-24} g

$$\text{no. of amu's in 1g} = \frac{1}{1.66 \times 10^{-24}}$$

$$= 6.023 \times 10^{23}$$

$$= \underline{1 \text{ mole}}$$

1 mole of amu's weighs 1g

i.e. Weight of 1 mole of protons = weight of 1 mole of neutrons = 1g

Examples of calculations involving the mole

Example 1

Q. Write down the weight of 1 mole of Magnesium Mg

A. Weight of 1 atom of Mg = 24 amu (from tables of atomic weight)

.. .. 1 mole .. .. = 24 g

Example 2

Q. Calculate the weight of 1 mole of Chlorine Cl_2

A. 1 molecule of Cl_2 contains 2 Cl atoms

Weight of 1 molecule of Cl_2 = 2 x 35.5 = 71 amu
.. .. 1 mole .. .. = 71 g

The weight of 1 mole of molecules is called the Gram Formula Mass, usually called the **Formula Weight**.

The formula weight of Chlorine is 71 g.

Example 3

Q. Calculate the weight of 1 mole of Water H_2O

A. Weight of 1 mole of H_2O = (2 x 1) + 16 = 18 g

Example 4

Q. Calculate the weight of 2 moles of Sodium sulphate

A. Weight of 1 mole of $(Na^+)_2SO_4^{2-}$ = (2 x 23) + 32 + (4 x 16)

= 142 g

.. .. 2 .. .. .. = 284 g

Example 5

Q. Calculate the number of moles of Carbon dioxide in 11 g

A. Weight of 1 mole of CO_2 = 12 + (2 x 16) = 44 g

no. of moles of CO_2 in 11 g = $\frac{11}{44}$ = 0.25 mol

Example 6

Q. Calculate the number of moles of Aluminium nitrate in 42.6 g

A. Weight of 1 mole of $Al^{3+}(NO_3^-)_3$ = 27 + (3 x 14) + (9 x 16)

= 213 g

no. of moles in 42.6 g = $\frac{42.6}{213}$ = 0.2 mol

Example 7

Q. Calculate the weight of Calcium oxide and Carbon dioxide produced on heating 5 g of Calcium carbonate given the equation :

A.

$Ca^{2+}CO_3^{2-}$	->	$Ca^{2+}O^{2-}$	+	CO_2
5 g		? wt		? wt
1 mol		1 mol		1 mol
100 g		56 g		44 g
5 g		$\frac{56 \times 5}{100}$		$\frac{44 \times 5}{100}$
		2.8 g		2.2 g

Example 8

Q. Calculate the weight of Sodium required to produce 4 g of Hydrogen by reaction with Water.

$Na + H_2O \rightarrow Na^+OH^- + H_2$

A. First balance the equation :

$\mathbf{2}\ Na + \mathbf{2}\ H_2O \rightarrow \mathbf{2}\ Na^+OH^- + H_2$

? wt	4 g
2 mol	1 mol
46 g	2 g
<u>92 g</u>	4 g

Example 9

Q. 2.0 g Magnesium oxide contain 1.2 g Magnesium. Find the empirical (simplest) formula of the Magnesium oxide.

A. Wt. of Oxygen in the Magnesium oxide = 2.0 - 1.2

= 0.8 g

No. of moles Mg = $\frac{1.2}{24}$ = 0.05 mol

No. of moles O = $\frac{0.8}{16}$ = 0.05 mol

0.05 mol Mg are combined with 0.05 mol O

1 mol Mg is .. .. 1 mol O

Simplest formula is <u>MgO</u> (or $Mg^{2+}O^{2-}$)

Example 10

Q (a) An organic compound contains :

40.00 % Carbon
6.67 % Hydrogen
53.33 % Oxygen

Calculate its empirical formula.

(b) Its formula weight (weight of 1 mole) is 60 g. Deduce its molecular formula.

A (a) Take 100 g of the compound

Wt. of Carbon = 40.00 g
Wt. of Hydrogen = 6.67 g
Wt. of Oxygen = 53.33 g

					Ratio
No. of moles of Carbon	=	$\frac{40.00}{12}$	=	3.33 mol	1
No. of moles of Hydrogen	=	$\frac{6.67}{1}$	=	6.67 mol	2
No. of moles of Oxygen	=	$\frac{53.33}{16}$	=	3.33 mol	1

Simplest formula is CH_2O

(b) Wt. of 1 mole of CH_2O = 30 g

Molecular formula is $C_2H_4O_2$ (Wt. of 1 mole is 60 g)

Example 11

Q. Calculate the percentage, by weight, of Nitrogen in Ammonium nitrate.

A. Wt. of 1 mole $NH_4^+NO_3^-$ = 14+ (4 x 1) + 14 + (3 x 16)

= 80g

1 mole $NH_4^+NO_3^-$ contains 2 moles N

2 moles N weigh 28 g

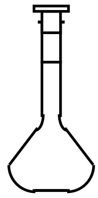
% N = $\frac{28 \times 100}{80}$ = 35 %

Molar Solutions

A solution's molarity or concentration is the number of moles of dissolved substance per 1000 cm^3 of solution e.g.

A 2M solution of Sodium chloride contains 2 moles of Sodium chloride in every 1000 cm^3 of solution.

1000 cm^3 of this solution would be prepared by first dissolving 2 moles of Sodium chloride (117 g) in a little Water and then making up the volume to 1000 cm^3 in a volumetric flask.



Example 12

Q. Calculate the number of moles of Sodium chloride in 25 cm^3 of a 5M solution.

A. No. of moles of Sodium chloride in 1000 cm^3 = 5 mol

.. .. 25 cm^3 = $\frac{5 \times 25}{1000}$

= $\underline{0.125 \text{ mol}}$

In general

$$\textbf{No. of moles} = \frac{MV}{1000}$$

Example 13

Q. Calculate the weight of Glucose present in 200 cm^3 3M solution.

A. No. of moles = $\frac{MV}{1000}$ = $\frac{3 \times 200}{1000}$ = 0.6 mol

Wt. of 1 mole $C_6H_{12}O_6$ = 180 g

.. .. 0.6 .. .. = 180 x 0.6 = $\underline{108 \text{ g}}$

Example 14

Q. 20 cm^3 2.5M Hydrochloric acid were required to neutralise 30 cm^3 Sodium hydroxide.

Calculate the molarity of the Sodium hydroxide solution.

A. $H^+Cl^- + Na^+OH^- \rightarrow Na^+Cl^- + H_2O$

$$\text{No. of moles } H^+Cl^- = \frac{MV}{1000}$$

$$= \frac{2.5 \times 20}{1000}$$

$$= 0.05 \text{ mol}$$

$$\text{No. of moles } Na^+OH^- = 0.05 \text{ mol}$$

$$\frac{MV}{1000} = 0.05$$

$$M = \frac{0.05 \times 1000}{V}$$

$$= \frac{0.05 \times 1000}{30}$$

$$= \underline{1.67 \text{ M}}$$