Let us take one more example. What is the percentage of carbon, hydrogen and oxygen in ethanol?

Molecular formula of ethanol is : C_2H_5OH

Molar mass of ethanol is : $(2\times12.01 + 6\times1.008 + 16.00)$ g

$= 46.068$ g

Mass per cent of carbon

$$= \frac{24.02\,g}{46.068\,g} \times 100 = 52.14\%$$

Mass per cent of hydrogen

$$= \frac{6.048\,g}{46.068\,g} \times 100 = 13.13\%$$

Mass per cent of oxygen

$$= \frac{16.00\,g}{46.068\,g} \times 100 = 34.73\%$$

After understanding the calculation of per cent of mass, let us now see what information can be obtained from the per cent composition data.

Problem 1.6

A solution is prepared by adding 2 g of a substance A to 18 g of water. Calculate the mass per cent of the solute.

Solution

$$\text{Mass per cent of A} = \frac{\text{Mass of A}}{\text{Mass of solution}} \times 100$$

$$= \frac{2\,\text{g}}{2\,\text{g of A} + 18\,\text{g of water}} \times 100$$

$$= \frac{2\,\text{g}}{20\,\text{g}} \times 100$$

$$= 10\ \%$$

Problem 1.7

Calculate the molarity of NaOH in the solution prepared by dissolving its 4 g in enough water to form 250 mL of the solution.

Solution

Since molarity (M)

$$= \frac{\text{No. of moles of solute}}{\text{Volume of solution in litres}}$$

$$= \frac{\text{Mass of NaOH/Molar mass of NaOH}}{0.250\ \text{L}}$$

$$= \frac{4\ \text{g} / 40\ \text{g}}{0.250\text{L}} = \frac{0.1\ \text{mol}}{0.250\ \text{L}}$$

$= 0.4\ \text{mol L}^{-1}$

$= 0.4\ \text{M}$

Note that molarity of a solution depends upon temperature because volume of a solution is temperature dependent.

Problem 1.8

The density of 3 M solution of NaCl is 1.25 g mL^{-1}. Calculate molality of the solution.

Solution

M = 3 mol L^{-1}

Mass of NaCl
in 1 L solution = $3 \times 58.5 = 175.5$ g

Mass of
1L solution = $1000 \times 1.25 = 1250$ g
(since density = 1.25 g mL^{-1})

Mass of
water in solution = 1250 – 175.5
= 1074.5 g

$$\text{Molality} = \frac{\text{No. of moles of solute}}{\text{Mass of solvent in kg}}$$

$$= \frac{3 \text{ mol}}{1.0745 \text{ kg}}$$

$$= 2.79 \ m$$

Often in a chemistry laboratory, a solution of a desired concentration is prepared by diluting a solution of known higher concentration. The solution of higher concentration is also known as stock solution. Note that molality of a solution does not change with temperature since mass remains unaffected with temperature.

EXERCISES

1.1 Calculate the molecular mass of the following :

(i) H_2O (ii) CO_2 (iii) CH_4

1.2 Calculate the mass per cent of different elements present in sodium sulphate (Na_2SO_4).

1.3 Determine the empirical formula of an oxide of iron which has 69.9% iron and 30.1% dioxygen by mass.

1.4 Calculate the amount of carbon dioxide that could be produced when

(i) 1 mole of carbon is burnt in air.

(ii) 1 mole of carbon is burnt in 16 g of dioxygen.

(iii) 2 moles of carbon are burnt in 16 g of dioxygen.

1.5 Calculate the mass of sodium acetate (CH_3COONa) required to make 500 mL of 0.375 molar aqueous solution. Molar mass of sodium acetate is 82.0245 g mol

1.6 Calculate the concentration of nitric acid in moles per litre in a sample which has a density, 1.41 g mL^{-1} and the mass per cent of nitric acid in it being 69%

1.7 How much copper can be obtained from 100 g of copper sulphate ($CuSO_4$) ?

1.8 Determine the molecular formula of an oxide of iron in which the mass per cent of iron and oxygen are 69.9 and 30.1 respectively.

1.9 Calculate the atomic mass (average) of chlorine using the following data :

	% Natural Abundance	Molar Mass
^{35}Cl	75.77	34.9689
^{37}Cl	24.23	36.9659