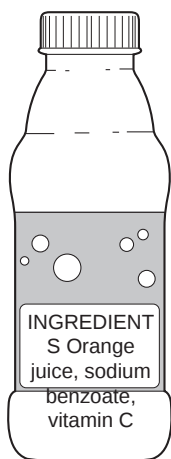


EMPIRICAL AND MOLECULAR FORMULA

Empirical formula of a compound: It is the simplest whole number ratio of the different atoms or ions in a compound

Molecular formula of a compound : It is the number and type of different atoms in one molecule



WORKED EXAMPLE:

Across the world, food safety agencies are investigating the presence of minute traces of the toxic hydrocarbon, benzene, in soft drinks. It is formed by the reduction of sodium benzoate by vitamin C.

Benzene contains 92.3% of carbon and its relative molecular mass is 78.

(i) What is the percentage of hydrogen in benzene?

$$\begin{aligned} \text{(i) \% of hydrogen in benzene} \\ &= 100 - 92.3 \\ &= 7.7\% \end{aligned}$$

[1]

(ii) Calculate the ratio of moles of C atoms: moles of H atoms in benzene.

$$\begin{aligned} \text{(ii) Moles of Carbon} &= \frac{\text{Mass of Carbon}}{\text{MR of Carbon}} \\ &= \frac{92.3}{12} = 7.69 = 7.7 \end{aligned}$$

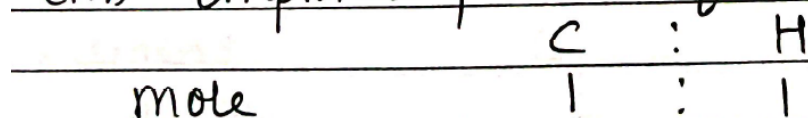
$$\begin{aligned} \text{Moles of hydrogen} &= \frac{\text{Mass of hydrogen}}{\text{MR of hydrogen}} \\ &= \frac{7.7}{1} = 7.7 \end{aligned}$$

$$\begin{aligned} \therefore \text{Moles of C-atoms} &: \text{Moles of H-atoms} \\ 7.7 &: 7.7 \\ 1 &: 1 \end{aligned}$$

[2]

(iii) Calculate its empirical formula and **then** its molecular formula.

ciii) Empirical formula of benzene :



$\therefore$ Empirical formula $\Rightarrow$ CH

The empirical formula of benzene is

Also, Empirical formula mass $\Rightarrow$ 13

Given: Relative molecular mass of benzene = 78

$$\therefore 78 \div 13 = 6$$

$\therefore$ The molecular formula of benzene = $6 \times \text{CH}$
 $= \text{C}_6\text{H}_6$

The molecular formula of benzene is

[2]

4.8.5

[2]

Maleic acid is an unsaturated acid. 5.8 g of this acid contained 2.4 g of carbon, 0.2 g of hydrogen and 3.2 g of oxygen.

(i) How do you know that the acid contained only carbon, hydrogen and oxygen?

(i) We know that the acid only contained carbon, hydrogen and oxygen because:

$2.4 \text{ g (C)} + 0.2 \text{ g (H)} + 3.2 \text{ g (O)} = 5.8 \text{ g}$ and 5.8 g of the maleic acid were taken.

[1]

(ii) Calculate the empirical formula of maleic acid.

Number of moles of carbon atoms :
= $\frac{\text{Mass of C-atoms}}{\text{Mr of C-atoms}}$

$$= \frac{2.4}{12} = 0.2 \text{ mol}$$

Number of moles of carbon atoms =

Number of moles of carbon atoms :
= $\frac{\text{Mass of C-atoms}}{\text{Mr of C-atoms}}$

$$= \frac{2.4}{12} = 0.2 \text{ mol}$$

Number of moles of hydrogen atoms =

Number of moles of hydrogen atoms :
= $\frac{\text{Mass of H-atoms}}{\text{Mr of H-atoms}}$

$$= \frac{0.2}{1} = 0.2$$

Number of moles of oxygen atoms =

The empirical formula is [3]

Element	C	H	O
No. of moles	0.2	0.2	0.2
Moles [lowest ratio]	0.2	0.2	0.2
	0.2	0.2	0.2
	= 1	= 1	= 1
∴ Empirical formula = $C_1H_1O_1$			
= CHO			

(iii) The mass of one mole of maleic acid is 116g. What is its molecular formula?

..... [2]

(iii) Mr (Maleic acid) = 116g → Given
Molecular formula = ?

Empirical formula = CHO

Empirical formula mass = $A_r(C) + A_r(H) + A_r(O)$

$$= 12 + 1 + 16$$

$$= 29$$

Molecular formula mass of Maleic acid

Empirical formula mass of maleic acid

$$= \frac{116}{29} = 4$$

∴ Molecular formula of maleic acid = $4 \times CHO$
= $C_4H_4O_4$