**Solution:**

We recall that 1 mole of any substance contains the Avogadro's number of particles and has a mass equal to the molar mass of the substance.

(a) 1 mole of Magnesium has a mass of $^{24}$ g.

$$\therefore\ 6.02 \times 10^{23} \text{atoms of Mg} = 24\text{g}$$

$$\therefore\ 1 \text{ atom of Mg} = \frac{24}{6.02 \times 10^{23}}\ \text{g} = 4.0 \times 10^{-23}\ \text{g}$$

$$\therefore\ 1 \text{ atom of Mg has a mass of } 4.0 \times 10^{-23}\ \text{g}.$$

(b) 1 mole of Iron has a mass of

$$\therefore\ 6.02 \times 10^{23} \text{ atoms of Fe} = 56\ \text{g}$$

$$\therefore\ 1 \text{ atom of Fe} = \frac{56}{6.02 \times 10^{23}}\ \text{g} = 9.33 \times 10^{-23}\ \text{g}$$

$$\therefore\ 1 \text{ atom of Fe has a mass of } 9.33 \times 10^{-23}\ \text{g}.$$

## PERCENT COMPOSITION AND FORMULAS OF COMPOUNDS

If the formula of a compound is known, its chemical composition can be expressed in terms of the percentage by mass of each element in the formula. Usually, the mass contributed by each element in the formula (from the relative atomic mass, and the number of times the element occurs) is taken as a fraction of the molar mass of the compound and expressed as a percentage.



$$\%\ \text{Composition of element} = \frac{\text{mass contributed by element}}{\text{molar mass of compound}} \times 100$$

Let us now study some examples on percent composition.

**Example 6: Percent Composition of a Compound.**

Calculate the percent composition by mass of sodium hydroxide (NaOH).

$(\text{H} = 1,\ \text{O} = 16,\ \text{and},\ \text{Na} = 23)$

**Solution:**

NaOH contains 1 atom of Na, 1 atom of O, and 1 atom of H.

Analysis of a pure sample of a compound reveals that it contains $50.1\ \%$ sulphur, and $49.9\ \%$ Oxygen by mass. What is the empirical formula of the compound?
$(\mathrm{O}=16, \mathrm{S}=32)$

**Solution:**
We are interested in expressing the simplest ratio of atoms of the elements in the compound. Since the number of atoms is directly proportional, to the number of moles of atoms (i.e $N = nN_A$), the ratio of atoms of the elements in the compound is given by the ratio of the number of moles of atoms of the elements.
The solution is set in tabular form below.

| Element | Relative mass | Relative moles of atoms | Division by smaller number | Simplest whole number ratio of atoms |
|---|---|---|---|---|
| S | 50.1 | $\frac{50.1}{32} = 1.57$ | $\frac{1.57}{1.57} = 1$ | 1 |
| O | 49.9 | $\frac{49.9}{16} = 3.12$ | $\frac{3.12}{1.57} = 2.0$ | 2 |



The simplest whole-number ratio of sulphur atoms to Oxygen atoms is 1:2, hence the simplest formula of the compound is $\mathrm{SO}_2$.

**Example 9: Molecular Formula from Percent Composition.**
An alcohol is $64.8\ \%$Carbon, $13.6\ \%$Hydrogen, and $21.6\ \%$Oxygen by mass. Another experiment shows that its molar mass is approximately 74. Determine the molecular formula of the alcohol.
$[\mathrm{H}=1, \mathrm{C}=12, \mathrm{O}=16]$

**Solution:**
We use the tabular format introduced in example 8 above.

By simple proportion,

$$25 \text{ g of } CaCO_3 = \frac{48}{100} \times 25 \text{ g of Oxygen.}$$
$$= 12 \text{ g of Oxygen.}$$

**Example 12: Composition of Compounds.**
What mass of Calcium oxide $(CaO)$ would contain $= 40.0$ g of Oxygen?
$[O = 16, Ca = 40]$

**Solution:**
Molar mass of $CaO = (40 + 16) = 56$
1 mole of Oxygen atoms is contained in 1 mole of $CaO$.
Thus, $16$ g of Oxygen is contained in $56$ g of $CaO$.
By simple proportion, $40$ g of Oxygen $= \frac{56}{16} \times 40$ g of $CaO$.
$= 140$ g of $CaO$.

**Example 13: Percent Purity.**
A sample of Sodium hydroxide, NaOH is $98.2$ % pure. Calculate the mass of Sodium hydroxide and impurities in $48.5$ g of the sample.



**Solution:**
The given mass of the sample = 48.5 g
Since the sample is only 98.2% pure,
the mass of pure NaOH in the sample = $98.2$ % of $48.5$ g
$\therefore$ mass of NaOH in the sample $= \frac{92.8}{100} \times 48.5 = 47.6$ g
Mass of impurities = mass of sample − mass of pure NaOH
$\therefore$ Mass of impurities $= (48.5 - 47.6) = 0.9$ g

**Example 14: Percent Purity; Chemical Composition.**
A sample of marble, $CaCO_3$ is only $82.75$ % pure. What mass of the sample would contain $32.72$ g of Calcium?
$[C = 12, O = 16, Ca = 40]$

**Solution:**
Molar mass of $CaCO_3$ $40 + 12 + (16 \times 3) = 100$
$40$ g of Ca is contained in $100$ g of $CaCO_3$.
By simple proportion,