

Chapter 3 F4 : The Mole Concept, Chemical Formula & Equations

1. Relative Atomic Mass (RAM) & Relative Molecular Mass (RMM)

Relative atomic mass (RAM)	Relative molecular mass (RMM)	Relative formula mass (RFM)
Average mass of an atom of the element compared to 1/12 of the mass of one carbon-12 atom.	Average mass of the molecule compared to 1/12 of the mass of one carbon-12 atom.	Relative mass of an ionic substance. Uses concept of relative mass in ionic substances.
Formula : $\text{RAM} = \frac{\text{Average mass of one atom of element}}{1/12 \times \text{Mass of 1 Carbon-12 atom}}$	Formula : $\text{RMM} = \frac{\text{Average mass of one molecule}}{1/12 \times \text{Mass of 1 Carbon-12 atom}}$ Can be calculated by adding up all RAM of all atoms in molecule.	To calculate : Sum up all RAM of all atoms in the formula of the ionic substance.

Why Carbon-12 is used as standard atom?

- Solid at room temperature
- Easy to handle
- Combines easily with other elements, found in most substances.
- Major isotopes with 99% of abundance, makes it exactly 12.0

2. The Mole Concept.

What is mole?

- Symbol : mol ; SI unit of amount of substance.
- 1 mole of substance = 6.0221×10^{23} entities of substance.
- This **fixed** value is known as Avogadro constant or Avogadro Number, N_A which are expressed in mol^{-1} .
- **Avogadro number, $N_A = 6.02 \times 10^{23}$ particles**

2. The Mole Concept [CONT.]

NUMBER OF MOLES & MASS OF SUBSTANCES		
NUMBER OF PARTICLES	MASS OF SUBSTANCES	VOLUME OF GASES
<ul style="list-style-type: none"> • Number or moles, $n = \frac{\text{Number or particles}}{N_A}$ 	<ul style="list-style-type: none"> • Molar mass : mass of 1 mole of substance • Value of molar mass = relative mass of the substance. • Eg : RMM of H_2O is 18, the molar mass = 18. 	<ul style="list-style-type: none"> • Molar volume : Volume occupied by 1 mol of a gas. • Depends on condition : <ul style="list-style-type: none"> – At STP : $22.4 \text{ dm}^3 \text{ mol}^{-1}$ – At room : 24 dm^3
<p>Number of particles</p> <p>Number of moles, n N_A, Avogadro number</p>	<p>Mass (g)</p> <p>Number of moles, n Molar mass (g mol^{-1})</p>	<p>Volume of gas</p> <p>Number of moles, n Molar volume</p>

3. Chemical Formula

Definition : representation of chemical substance using alphabet to represent **atom** & subscript number to show the **number of each type of atoms** found in the substance.

Elements

10
Ne
20.1797

- Substance : **Neon**
- Chemical formula : **Ne**
- CF shows that neon consist of neon atoms only.

Compounds

- Substance : **Carbon dioxide**
- Chemical formula : **CO_2**
- CF shows that carbon dioxide consist of **1 carbon atom & 2 oxygen atoms.**

4. Empirical Formula & Molecular Formula

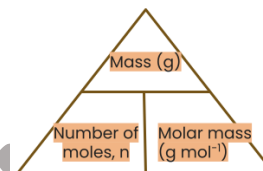
EMPIRICAL FORMULA	MOLECULAR FORMULA
Chemical formula that shows the simplest ratio of the number of atoms of each element in a compound.	Chemical formula that shows actual number of atoms of each element found in a molecule of a compound.

EMPIRICAL FORMULA	MOLECULAR FORMULA
NO_2	N_2O_4
The ratio of nitrogen to oxygen atoms is 1:2.	There are 2 nitrogen atoms and 4 oxygen atoms.

Determining Empirical Formula : Determine the **simplest whole number ratio of atoms**

Elements	A	B
Mass (g)		
Number of moles of atoms		
Mole ratio		
Simplest mole ratio of atom		

– To find number of moles, use :



– For **mole ratio**, divide the number with the **smallest number**

Determining Molecular Formula :

The molecular formula is **multiplied empirical formula**

- **Molecular formula = (Empirical formula) n**
- Value of n is a positive integer

To calculate molecular formula :

- Know empirical formula
- Relative mass or molar mass

5. Chemical Formula :

- **Cations : Positively-charged ions**
- **Anions : Negatively-charged ions**

Cation	Formula of cation	Anion	Formula of anion
Sodium ion	Na^+	Oxide ion	O^{2-}
Potassium ion	K^+	Chloride ion	Cl^-
Aluminium ion	Al^{3+}	Bromide ion	Br^-
Zinc ion	Zn^{2+}	Iodide ion	I^-
Magnesium ion	Mg^{2+}	Hydroxide ion	OH^-
Iron(II) ion	Fe^{2+}	Carbonate ion	CO_3^{2-}
Iron(III) ion	Fe^{3+}	Nitrate ion	NO_3^-
Copper(II) ion	Cu^{2+}	Sulphate ion	SO_4^{2-}
Calcium ion	Ca^{2+}	Phosphate ion	PO_4^{3-}
Silver ion	Ag^+	Manganate(VII) ion	MnO_4^-
Lead(II) ion	Pb^{2+}	Thiosulphate ion	$S_2O_3^{2-}$
Ammonium ion	NH_4^+	Dichromate(VI) ion	$Cr_2O_7^{2-}$

- Students need to memorise the formulae of cations and anions to construct chemical formulae correctly.

Formula of ionic compound :

- Cation then followed by anion

To write :

1. Write the **cation & anion**
2. Determine the number of cation & anion by **balancing the +ve & -ve charges**
3. Write the number of cations and anions as **subscript number**.

Name: **Zinc chloride**

Cation: Zinc ion Anion: Chloride ion

Zn^{2+}	Cl^-
Zn^{2+}	Cl^-

The number of ion:

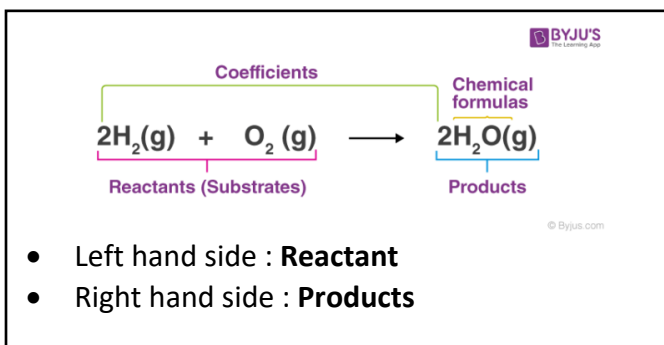
1	2
---	---

Check: Positive charge : $1 \times (+2) = +2$
 Negative charge : $2 \times (-1) = -2$
 Total charge : 0

Formula: **$ZnCl_2$**

6. Chemical Equation

- Precise description of a chemical equation.
- Chemical equation **must be balanced** because, according to law of conservation of mass, *a matter can neither be destroyed, created nor divided further.*



Step for writing chemical equation:

Step	Example		
1. Identify reactant, products & their formulae .	Reactants: Iron, Fe & Copper (II) chloride, CuCl_2 Products: Iron(III) chloride, FeCl_3 & copper, Cu		
2. Write the main part of the equation (without coefficient)	$\text{Fe} + \text{CuCl}_2 \rightarrow \text{FeCl}_3 + \text{Cu}$		
3. Check the number of atom on LHS & RHS to see if it's balanced.	<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; vertical-align: top;"> Left hand side : Atom Fe : 1 Atom Cu : 1 Atom Cl : <u>2</u> </td> <td style="width: 50%; vertical-align: top;"> Right hand side : Atom Fe : 1 Atom Cu : 1 Atom Cl : <u>3</u> </td> </tr> </table> <p>The number of atoms are not balanced.</p>	Left hand side : Atom Fe : 1 Atom Cu : 1 Atom Cl : <u>2</u>	Right hand side : Atom Fe : 1 Atom Cu : 1 Atom Cl : <u>3</u>
Left hand side : Atom Fe : 1 Atom Cu : 1 Atom Cl : <u>2</u>	Right hand side : Atom Fe : 1 Atom Cu : 1 Atom Cl : <u>3</u>		
4. Balance the equation by adjusting the coefficient .	<ul style="list-style-type: none"> Balance the atoms that are not the same first by trying to find it's lowest common multiply (LCM). Eg : For chlorine atom (Cl), their LCM is 6. Meaning, we can multiply LHS by 3 and RHS by 2. $\text{Fe} + \mathbf{3} \text{CuCl}_2 \rightarrow \mathbf{2} \text{FeCl}_3 + \text{Cu}$ Then, since there are 2 atoms of Fe on the RHS, multiply the LHS by 2 to make it balanced. $\mathbf{2} \text{Fe} + 3 \text{CuCl}_2 \rightarrow 2 \text{FeCl}_3 + \text{Cu}$ Finally, balance copper atom, Cu by multiplying the RHS with 3 to make it balanced. $2 \text{Fe} + 3 \text{CuCl}_2 \rightarrow 2 \text{FeCl}_3 + \mathbf{3} \text{Cu}$ 		
5. Check the number of atom on LHS & RHS to see if it's balanced, again.	LHS & RHS : Atom Fe : 2 Atom Cu : 3 Atom Cl : 6		
6. Write the state symbol of each substance.	$2 \text{Fe} (\text{s}) + 3 \text{CuCl}_2 (\text{aq}) \rightarrow 2 \text{FeCl}_3 (\text{aq}) + 3 \text{Cu} (\text{s})$		