

3 THE MOLE CONCEPT CHEMICAL FORMULA AND EQUATION



RELATIVE ATOMIC MASS AND RELATIVE MOLECULAR MASS

RELATIVE ATOMIC MASS

average mass of an atom of the element compared to $1/12$ of the mass of one carbon-12 atom.

$$\text{Relative atomic mass of an element} = \frac{\text{Average mass of one atom of the element}}{\frac{1}{12} \times \text{Mass of one carbon-12 atom}}$$

DEFINISI JISIM MOLEKUL RELATIF

average mass of the molecule compared to $1/12$ of the mass of one carbon-12 atom.

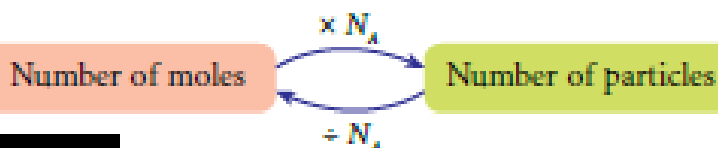
$$\text{Relative molecular mass of a substance} = \frac{\text{Average mass of one molecule}}{\frac{1}{12} \times \text{Mass of one carbon-12 atom}}$$



NUMBER OF MOLES & NUMBER OF PARTICLES

$$\text{Number of moles, } n = \frac{\text{Number of particles}}{N_A}$$

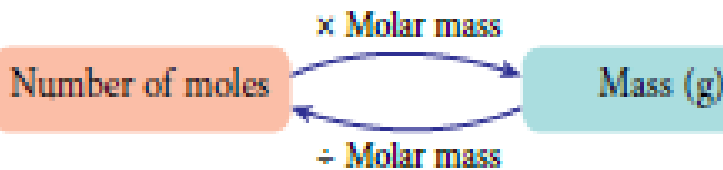
Diagrammatically, the relationship between the number of mole and the number of particles by using Avogadro constant as the conversion factor is shown below:



NUMBER OF MOLES & MASS OF SUBSTANCES



$$\text{Number of moles, } n = \frac{\text{Mass (g)}}{\text{Molar mass (g mol}^{-1}\text{)}}$$



NUMBER OF MOLES & VOLUME OF GASES



$$\text{Number of moles, } n = \frac{\text{Volume of gas}}{\text{Molar volume}}$$

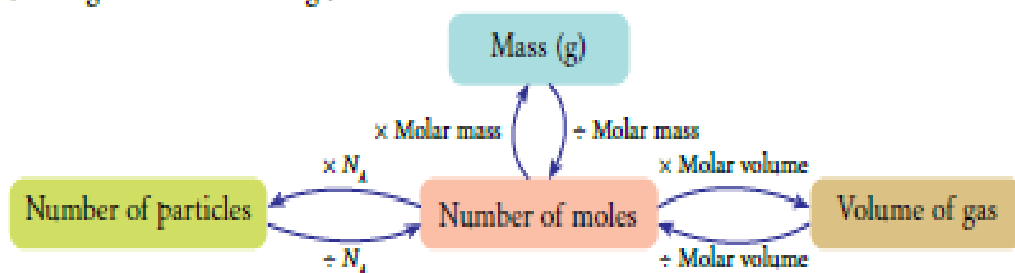
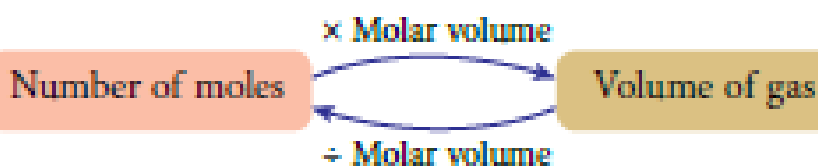


Figure 3.9 Relationship between the number of moles, number of particles, mass and volume of gases

CHEMICAL FORMULA

MOLECULAR FORMULA

formula that shows the actual number of atoms of each element found in a molecule of a compound.



EMPIRICAL FORMULA

formula that shows the simplest ratio of the number of atoms of each element in a compound



FORMULAE OF IONIC

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 ₂ O ₃ ²⁻
Ammonium ion	NH ₄ ⁺	Dichromate(VI) ion	Cr ₂ O ₇ ²⁻

Name: **Zinc chloride**

Cation: Zinc ion Anion: Chloride ion

Zn²⁺

Cl⁻

1. Based on the name of the compound, determine the cation and anion.

Zn²⁺

Cl⁻

2. Cross-change the cation charge and anion charge to determine the number of cations and anions.

The number of ion:

1

2

Check: Positive charge : 1 × (+2) = +2

Negative charge : 2 × (-1) = -2

Total charge : 0

Formula: **ZnCl₂**



Further example on cross-change method

<http://bit.ly/32DGbUu>

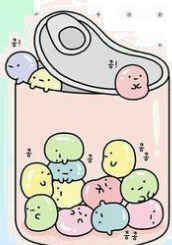
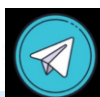


The basic concept of constructing a chemical formula of an ionic compound

<http://bit.ly/35WMLmm>



Figure 3.16 Constructing the chemical formula of zinc chloride via cross-change method



CHEMICAL EQUATION



Reactants			Product	
Hydrogen	+ Oxygen	→	Water	
H_2	+ O_2	→	H_2O	
H_2 (2 H atoms)	+ O_2 (2 O atoms)	→	H_2O (2 H atoms, 1 O atom)	
Equation is not balanced				
$2H_2$ (4 H atoms)	+ O_2 (2 O atoms)	→	$2H_2O$ (4 H atoms, 2 O atoms)	
$2H_2(g)$	+ $O_2(g)$	→	$2H_2O(l)$	

1. Write the equation in words.

2. Write down the chemical formula of each reactant and product.

3. Check whether the equation is balanced.

4. Balance the equation by adjusting the coefficient in front of the chemical formula.

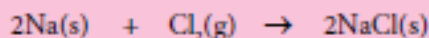
5. Write the physical state of each reactant and product.

Figure 3.17 Writing the chemical equation for the reaction between hydrogen and oxygen



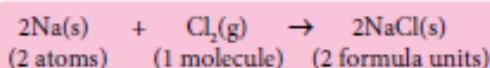
USING CHEMICAL EQUATIONS

- From the quantitative aspect, we can study the stoichiometry of chemical equations.
- Stoichiometry is the quantitative study of the composition of substances involved in a chemical reaction.
- Coefficients in chemical equations show the ratio of substances involved, either as the ratio of elementary entities of substance or the mole ratio



Reactants: Sodium metal and chlorine gas

Product: Solid sodium chloride



or

or

or

(2 mol)

(1 mol)

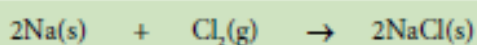
(2 mol)

Ratio of basic entities (particles):
Two sodium atoms react with one molecule of chlorine to produce two NaCl units.

Mole ratio:
2 mol of sodium react with 1 mol of chlorine gas to produce 2 mol of sodium chloride.



- Based on the mole ratio of substances from a balanced chemical equation, we can solve various numerical problems by calculating the number of moles of substances required in the right ratio.
- The number of moles determined can be converted to mass, number of particles or volume of gas using the molar mass, Avogadro constant or molar volume like all the relationships you have learned before



(2 mol) (1 mol) (2 mol) ← Initial mole ratio from the stoichiometry

(1 mol) (0.5 mol) (1 mol) ← All values are divided by 2

⋮ ⋮ ⋮ ← Calculated in the right ratio for other values

