Cambridge (CIE) A Level Chemistry

Your notes

Relative Masses of Atoms & Molecules

Contents

Relative Masses

Atomic Mass Unit

- The mass of a single atom is so small that it is impossible to weigh it directly
- Atomic masses are therefore defined in terms of a **standard** atom which is called the **unified atomic mass unit**
- This unified atomic mass is defined as **one-twelfth** of the mass of a carbon-12 isotope
- The symbol for the unified atomic mass is ***u*** (often *Da*, Dalton, is used as well)
- 1 u = 1.66×10^{-27} kg

Relative atomic mass, A_r

- The **relative atomic mass** (A_r) of an element is the **ratio** of the average mass of the atoms of an element to the **unified atomic mass unit**
- The relative atomic mass is determined by using the **average** mass of the **isotopes** of a particular element
- The A_r has **no units** as it is a ratio and the units cancel each other out

$$\text{Relative atomic mass of } \mathbf{X} = \frac{\text{average mass of one atom of } \mathbf{X}}{\text{one twelfth of the mass of one carbon} - 12 \text{ atom}}$$

Relative isotopic mass

- The **relative isotopic mass** is the mass of a particular atom of an **isotope** compared to the value of the **unified atomic mass unit**
- Atoms of the same element with a different number of neutrons are called **isotopes**
- **Isotopes** are represented by writing the **mass number** as ^{20}Ne, or neon-20 or Ne-20
  - To calculate the average atomic mass of an element the **percentage abundance** is taken into account
  - Multiply the atomic mass by the percentage abundance for each isotope and add them all together
  - Divide by 100 to get average relative atomic mass
  - This is known as the **weighted average** of the masses of the isotopes

$$\text{Relative atomic mass} = \frac{\Sigma(\text{isotope percentage abundance} \times \text{isotope mass number})}{100}$$

Relative molecular mass, M_r

- The **relative molecular mass** (M_r) is the **ratio** of weighted average mass of a molecule of a molecular compound to the **unified atomic mass unit**
- The M_r has **no units**

$$M_r = \frac{\text{weighted average mass of molecules in a given sample of a molecular compound}}{\text{unified atomic mass unit}}$$

- The M_r can be found by adding up the **relative atomic masses** of all atoms present in one molecule
- When calculating the M_r the **simplest formula** for the compound is used, also known as the **formula unit**
    - Eg. silicon dioxide has a giant covalent structure, however the simplest formula (the **formula unit**) is SiO_2

Example M$_r$ calculations

Substance	Atoms present	M_r
Hydrogen (H_2)	2 x H	(2 x 1.0) = 2.0
Water (H_2O)	(2 x H) + (1 x O)	(2 x 1.0) + (1 x 16.0) = 18.0
Potassium carbonate (K_2CO_3)	(2 x K) + (1 x C) + (3 x O)	(2 x 39.1) + (1 x 12.0) + (3 x 16.0) = 138.2
Calcium hydroxide ($Ca(OH)_2$)	(1 x Ca) + (2 x O) + (2 x H)	(1 x 40.1) + (2 x 16.0) + (2 x 1.0) = 74.1
Ammonium sulfate ($(NH_4)_2SO_4$)	(2 x N) + (8 x H) + (1 x S) + (4 x O)	(2 x 14.0) + (8 x 1.0) + (1 x 32.1) + (4 x 16.0) = 132.1

Relative formula mass, M$_r$

- The **relative formula mass** (M_r) is used for compounds containing **ions**
- It has the same units and is calculated in the same way as the **relative molecular mass**
- In the table above, the M_r for potassium carbonate, calcium hydroxide and ammonium sulfates are relative formula masses

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