Relative Atomic Mass Revision Notes | CIE | A-Level Chemistry

Defining Atomic Mass

To compare the masses of different atoms, chemists use a standard scale. All atomic masses are measured relative to a standard atom, which is an isotope of carbon, **carbon-12**.

Unified Atomic Mass Unit (u)
The unified atomic mass unit is the standard unit for atomic masses. It is defined as exactly one-twelfth of the mass of a single, unbound neutral atom of carbon-12 in its ground state.

- **1 u** is approximately equal to **1.66×10^{-27} kg**.

Relative Isotopic Mass
This refers to the mass of an atom of a specific isotope of an element, measured on the unified atomic mass unit scale. For example, the relative isotopic mass of chlorine-37 is approximately 37.

Relative Atomic Mass (A_r)
Most elements exist naturally as a mixture of isotopes. The relative atomic mass is the weighted average mass of the atoms of an element compared to one-twelfth the mass of a carbon-12 atom.

- The formula is:
  A_r = (weighted average mass of atoms of an element) / (1/12 × mass of one carbon-12 atom)
- Because A_r is a ratio of masses, it has **no units**.
- The weighted average accounts for the different masses and the relative abundances of the isotopes. This is why the relative atomic mass of chlorine is 35.5, not a whole number.

Relative Molecular and Formula Mass (M_r)
For molecules and ionic compounds, we use relative molecular mass or relative formula mass.

- It is calculated by **summing the relative atomic masses** of all the atoms present in the chemical formula.
- For example, the M_r of methane (CH_4) is calculated as:
  $(1 \times A_r \text{ of C}) + (4 \times A_r \text{ of H}) = (1 \times 12.0) + (4 \times 1.0) = 16.0$

Determining Relative Atomic Mass

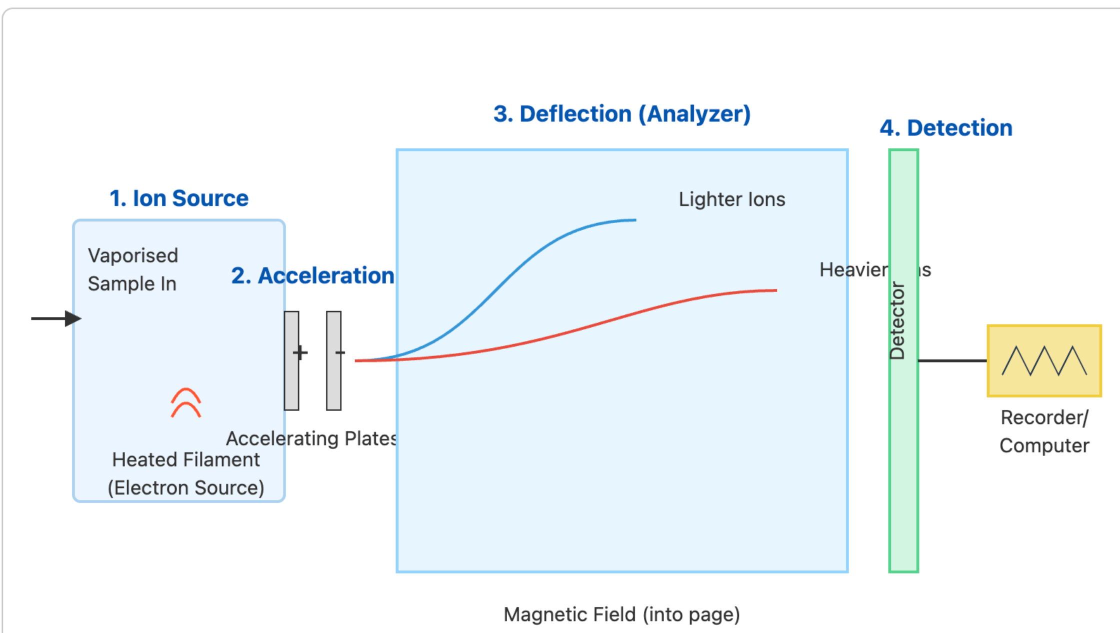
The most accurate way to determine relative atomic masses is by using a mass spectrometer.

Mass Spectrometry

A mass spectrometer is an instrument that measures the mass and relative abundance of different isotopes within a sample of an element.

The process involves vaporising the sample, ionising the atoms, accelerating them, deflecting them with a magnetic field, and then detecting them. Heavier isotopes are deflected less than lighter ones.

Simplified Diagram of a Mass Spectrometer



The Mass Spectrum

The output from a mass spectrometer is a mass spectrum. This is a graph that plots the mass-to-charge (m/e) ratio against the relative abundance of the ions.

- For singly charged positive ions, the m/e ratio is equivalent to the mass number of the isotope.
- The height of each peak indicates the relative abundance of that isotope, often as a percentage.

Calculating Relative Atomic Mass from a Mass Spectrum

To calculate the relative atomic mass of an element from its mass spectrum, you follow a three-step process:

1. Multiply the mass-to-charge ratio of each isotope by its percentage abundance.
2. Add these values together.
3. Divide the total by 100.

Example Calculation (for Neon):
A sample of neon has three isotopes with the following abundances:

- ^{20}Ne: 90.9%
- ^{21}Ne: 0.3%
- ^{22}Ne: 8.8%

A_r of Neon = [(20 × 90.9) + (21 × 0.3) + (22 × 8.8)] / 100 = **20.2**

This calculation demonstrates how the presence and abundance of different isotopes result in a non-integer value for the relative atomic mass of an element.