Atoms and Time of Flight Map

AQA A-level Chemistry · 3.1.1 Atomic structure: atoms and mass spectrometry

1 Models of the atom

3.1.1.1 i

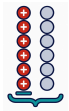
- Dalton: solid spheres; Thomson: the electron
- **Alpha scattering**: a tiny, dense, positive **nucleus**
- Bohr: electrons in **fixed energy levels**
- Chadwick: the neutron
- Models change when **new evidence** needs it



2 Fundamental particles

3.1.1.1 ii–iii

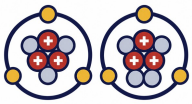
- **Proton**: mass 1, charge +1
- **Neutron**: mass 1, charge 0
- **Electron**: mass 1/1840, charge −1
- Protons and neutrons in the nucleus
- Electrons around it

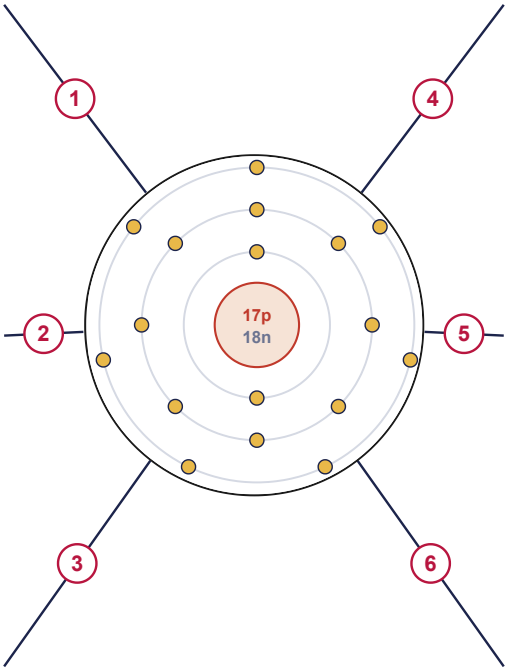


3 Numbers and isotopes

3.1.1.2 i–iii

- **Z**: protons; **A**: protons + neutrons
- Neutrons = A − Z; ions: electrons = Z − charge
- **Isotopes**: same Z, different neutrons
- Same electrons: **same chemistry**
- Mass-dependent properties differ





4 Ionisation

3.1.1.2 iv

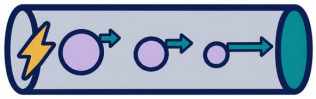
- **Electron impact**: $X(g) + e^- \rightarrow X^+(g) + 2e^-$
- High-energy electrons from an electron gun
- **Electrospray**: $X(g) + H^+ \rightarrow XH^+(g)$
- Electrospray for large molecules
- Every ion is 1+



5 Accelerate, drift, detect

3.1.1.2 iv

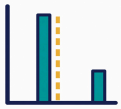
- Electric field: **same kinetic energy**
- KE = ½mv²: lighter ions faster
- **Drift**: no field, constant speed
- Detector: ions gain e^-, a **current**
- Current ∝ abundance; time → m/z



6 Relative atomic mass

3.1.1.2 v–vi

- One peak per isotope; height = abundance
- A_r = Σ(m/z × abundance) ÷ total
- Weighted mean relative to 1/12 of ^{12}C
- Backwards: x and 100 − x
- A_r identifies the element



Time-of-flight calculations

$N_A = 6.022 \times 10^{23}$ mol^{-1}; same KE for every ion

Step	Equation	Example: $^{63}Cu^+$, KE 1.00×10^{-13} J, 1.50 m
Mass of one ion	$m = (A_r \div 1000) \div N_A$	1.046×10^{-25} kg
Speed	$v = \sqrt{(2KE \div m)}$	1.383×10^6 m s^{-1}
Time of flight	$t = d \div v$	1.08×10^{-6} s
Kinetic energy	$KE = \frac{1}{2}mv^2$	the same for every ion
Two ions, same KE	$t \propto \sqrt{m}$	m/z 64 takes twice as long as m/z 16

Reading a mass spectrum

Isotopes of an element

- One peak per isotope
- m/z = mass number (1+ ions)
- Heights give the abundances

Order of arrival

- Lightest ion arrives first
- Flight time grows with √m
- Vacuum: no collisions

Relative atomic mass

- Multiply, add, divide by the total
- Total may not be 100
- Limited to mononuclear ions

Next in 3.1.1: electrons in shells and sub-shells, and the ionisation energies that give the evidence.

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