Atoms, Elements & Compounds

IGCSE Chemistry ▪ Topic 2

IGCSE Chemistry

What we will cover

1. Elements, compounds & mixtures
2. Inside the atom
3. Electron shells & isotopes
4. Ionic bonding
5. Covalent & giant structures
6. Metallic bonding

1 Classifying matter

Elements, compounds and mixtures

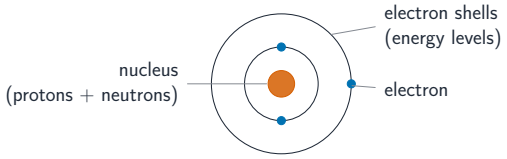
An **element** 元素 is one type of atom. A **compound** 化合物 is two or more elements chemically bonded, in a fixed ratio. A **mixture** 混合物 is not bonded – it can be separated physically.

2 The atom

Inside the atom

A tiny **nucleus** 原子核 of **protons** 质子 & **neutrons** 中子; **electrons** 电子 in **shells** 电子层 around it.

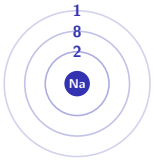
proton	**neutron**	**electron**
mass 1	mass 1	mass ≈ 0
charge $+1$	charge 0	charge -1



Two numbers, and electron shells

- **proton number** 质子数 = protons = which element
- **mass number** 质量数 = protons + neutrons
- neutrons = mass number − proton number

Shells fill from the inside: 2, then 8, then 8...



outer = 1 → Group I

3 shells → Period 3

Isotopes and relative atomic mass

Isotopes 同位素: same protons, different neutrons – same element, same chemistry.

$^{35}_{17}\mathrm{Cl}$ 18 neutrons

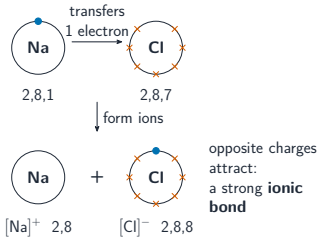
$^{37}_{17}\mathrm{Cl}$ 20 neutrons

A_r is the weighted average mass.

$$A_r = \frac{(35 \times 75) + (37 \times 25)}{100} = 35.5$$

3 Bonding

Ionic bonding



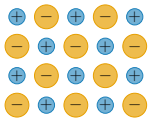
opposite charges attract: a strong **ionic bond**

A metal gives electrons to a non-metal; both reach full shells.

- metal → positive **cation** 阳离子
- non-metal → negative **anion** 阴离子

An **ionic bond** 离子键 is the pull between + and − ions.

Ionic lattices and their properties



Cl⁻ ion

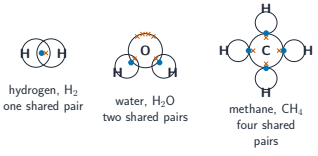
Na⁺ ion

a regular, repeating 3-D pattern of alternating + and − ions

Ions pack into a giant **lattice** 晶格 of alternating + and −.

- high melting & boiling points
- solid: does not conduct (ions fixed)
- molten / aqueous: does conduct (ions free)

Covalent bonding



hydrogen, H_2 one shared pair

water, H_2O two shared pairs

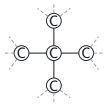
methane, CH_4 four shared pairs

Non-metals **share** 共用 pairs of electrons in a **covalent bond** 共价键.

Simple molecules (H_2O, CH_4): low melting points (weak **intermolecular forces** 分子间作用力) & poor conductors.

Giant covalent structures

diamond



each carbon bonded to **4** others: a hard 3-D network

graphite

flat layers of hexagonal rings (each C bonded to **3**); weak forces let the layers slide

Millions of atoms bonded into one network:

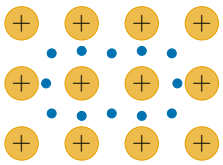
- **diamond** 金刚石 – 4 bonds each; very hard
- **graphite** 石墨 – 3 bonds, sliding **layers** 层; soft, conducts

Graphite's free electrons let it conduct.

Metallic bonding

Positive ions in a **sea of delocalised electrons** 离域电子海.

- conducts – free electrons carry charge
- **malleable** 有展性 & **ductile** 有延性 – layers slide



'sea' of **delocalised electrons**, free to move and carry charge

positive metal ions in a fixed lattice

4 Recap

Worked example – relative atomic mass

Chlorine is 75% ^{35}Cl and 25% ^{37}Cl. Find its relative atomic mass.

- Isotopes are atoms of the same element with different numbers of neutrons.
- A_r is the weighted average of the isotopes:
- $A_r = \dfrac{(75 \times 35) + (25 \times 37)}{100} = \dfrac{2625 + 925}{100}$
- $= 35.5$ – which is why the value is not a whole number.

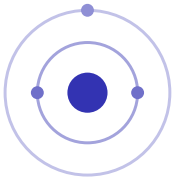
Isotopes have identical chemistry (same electrons), only different mass. Weight by abundance – never take a plain average of 35 and 37.

Topic 2 – key takeaways

1. **Atom** – nucleus of protons & neutrons; electrons in shells
2. **Isotopes** – same protons, different neutrons; A_r averages
3. **Ionic** – metal gives electrons; giant lattice
4. **Covalent & metallic** – shared pairs; ions in an electron sea

Check yourself

1. How many neutrons are in $^{35}_{17}$Cl?
2. What is the electronic configuration of sodium?
3. Why does molten NaCl conduct but solid NaCl not?
4. Why can metals be hammered into sheets?



Answers **1.** 18 $(35 - 17)$ **2.** $2, 8, 1$ **3.** molten ions are free to move **4.** layers of ions slide over each other