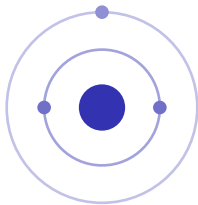


Atoms, Elements & Compounds

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

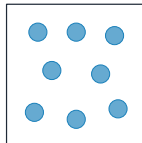
Classifying matter

Elements, compounds and mixtures

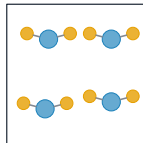
element 元素 one type of atom

compound 化合物 elements **chemically bonded** in a **fixed ratio**

mixture 混合物 **not bonded** – it can be separated physically



element
only one
type of atom



compound
different
atoms bonded
in a fixed ratio



mixture
not bonded,
easy to separate

Element, compound, mixture

the building blocks	all substances are made from about 100 elements
an element 元素	only one type of atom 原子 – and it cannot be broken into anything simpler by a chemical reaction
a compound 化合物	two or more elements chemically joined, in a fixed ratio, with new properties
a mixture 混合物	substances just mixed, not joined – the parts keep their own properties and can be separated physically
the atomic number 原子序数	the number of protons – it is what makes an atom that element
telling them apart	a compound has a fixed formula and a sharp melting point; a mixture has neither

Air is a mixture, water is a compound, and both are colourless liquids or gases. The distinction is about bonding, not appearance.

2

The atom

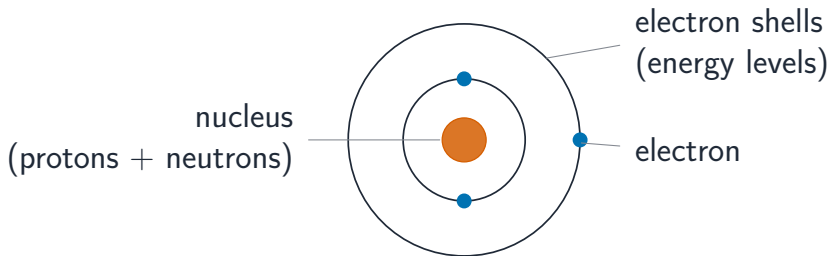
Inside the atom

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

proton
mass 1
charge +1

neutron
mass 1
charge 0

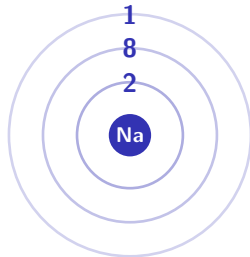
electron
mass ≈ 0
charge -1



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

The particles, and the two numbers

Relative mass and charge

Proton: **relative charge** 相对电荷 +1, relative mass 1. Neutron: 0 and 1. Electron: -1 and almost nothing.

Proton number

The number of protons – it fixes which element the atom is.

Nucleon number

The mass number, also called the **nucleon number** 核子数: protons plus neutrons.

The noble gases

The **noble gases** 稀有气体 in Group VIII have a full outer shell, which is why they are so unreactive – and why every other atom bonds to reach one.

Electrons decide the chemistry; the nucleus decides the identity and the mass.

Isotopes and relative atomic mass

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



18 neutrons



20 neutrons

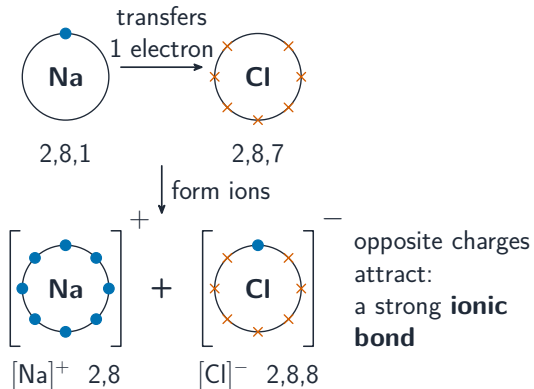
A_r is the weighted average mass.

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

3

Bonding

Ionic bonding

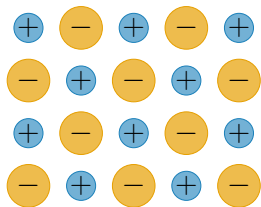


A metal **gives** electrons to a non-metal; both reach full shells.

- 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)

Dot-and-cross diagrams, and what the bonding explains

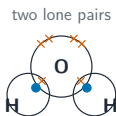
a dot-and-cross diagram	draw each atom's outer-shell electrons – dots for one element, crosses for the other – and show where they end up
ionic	electrons are transferred ; show the ion charges and use square brackets
covalent	electrons are shared ; show the overlapping outer shells
electrostatic attraction 静电引力	the strong force between oppositely charged ions – so ionic compounds have high melting points
electrical conductivity 导电性	an ionic compound 离子化合物 conducts only when molten or dissolved, because the ions must be free to move
metals	delocalised electrons give conductivity, ductility 延展性, and malleability

Draw **only the outer shell** unless asked otherwise, and label which atom the dots came from. Both are marked.

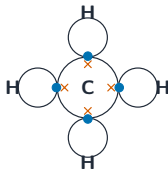
Covalent bonding



hydrogen, H_2
one shared pair



water, H_2O
two shared pairs



methane, CH_4
four shared pairs
● electron from hydrogen
× electron from the other atom

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

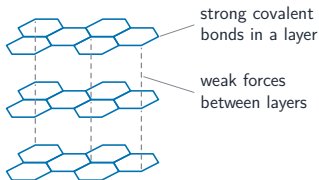
Millions of atoms bonded into one network:

diamond



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

graphite



flat layers of hexagonal rings, each
carbon bonded to **3**; the layers slide

diamond 金刚石: 4 bonds each, very **hard**. **graphite** 石墨: 3 bonds, sliding **layers** 层, soft; its free electrons let it **conduct**.

Three giant covalent structures

Diamond

Every carbon bonded to four others in a rigid 3D network: extremely hard, so it is used in **cutting tools** 切削工具, and it does not conduct.

Graphite

Flat layers, three bonds each. The fourth outer electron is delocalised, so graphite conducts and is used as an **electrode** 电极; weak forces let the layers slide, which makes it a **lubricant** 润滑剂.

Silicon(IV) oxide

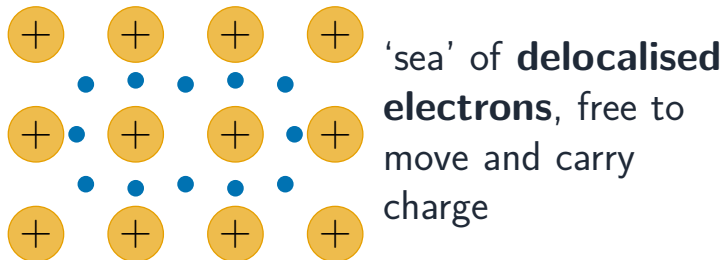
Silicon(IV) oxide 二氧化硅 (SiO_2) has a giant covalent structure like diamond – very hard, very high melting point.

Same element, opposite properties: diamond and graphite differ only in how the bonds are arranged.

Metallic bonding

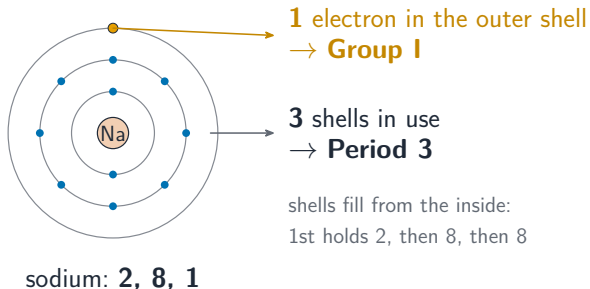
Positive ions in a **sea of delocalised electrons** 离域电子海.

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



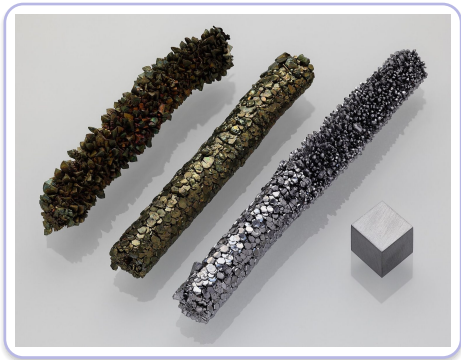
positive metal ions in a fixed lattice

Electronic configuration



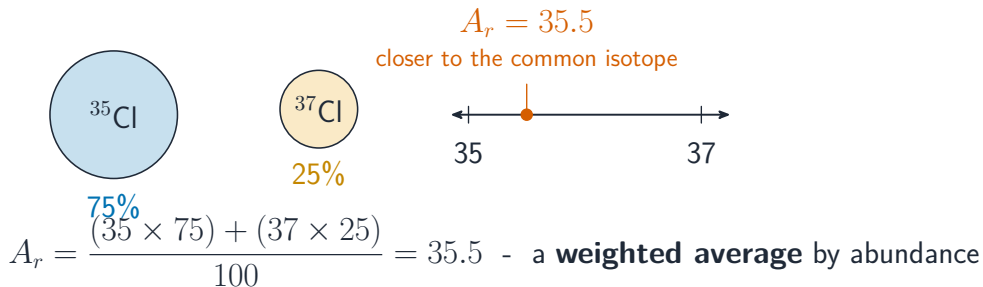
Sodium's configuration 2,8,1 links to the Periodic Table: one outer electron means Group 1, three shells means Period 3

Elements, compounds and mixtures, continued (2)



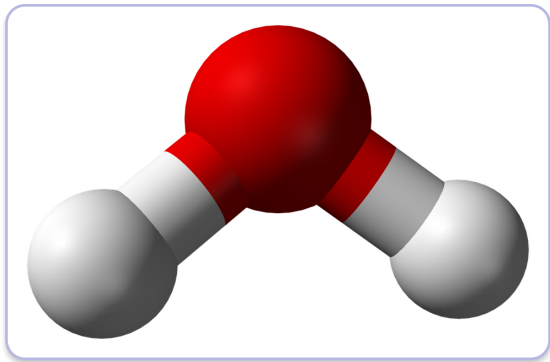
A pure element (vanadium): elements are the simplest substances.

Calculating relative atomic mass



Relative atomic mass is a weighted average: chlorine is 75 percent Cl-35 and 25 percent Cl-37, so A_r is 35.5

Simple molecules and covalent bonds



A model of a water molecule: atoms share electrons in covalent bonds.

Exam tips

- Number of neutrons = mass number — proton number. The **proton number** is what decides which element an atom is.
- **Isotopes** have the same chemical properties because reactions involve only electrons, and isotopes share the same electron configuration; only the mass differs.
- Match structure to properties: **ionic** = giant lattice (high melting point; conducts only when molten or aqueous); **simple molecular** = weak forces *between* molecules (low melting point; no conduction); **giant covalent** = very hard, very high melting point.
- **Graphite** conducts and is slippery (one free electron per carbon; layers slide); **diamond** does neither (all four electrons bonded, so hard and non-conducting). Metals conduct and bend thanks to the sea of **delocalised electrons**.
- For relative atomic mass, take the weighted average:

$$A_r = \frac{\sum(\text{isotope mass} \times \text{abundance})}{100}.$$

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:
- $$A_r = \frac{(75 \times 35) + (25 \times 37)}{100} = \frac{2625 + 925}{100}$$
- $= 35.5$ – 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

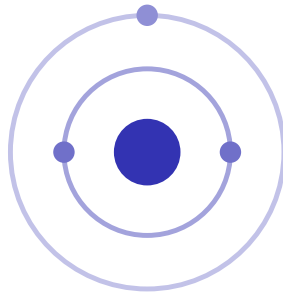
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Covalent & metallic

shared pairs; ions in an electron
sea

Check yourself

- 1 How many neutrons are in $^{35}_{17}\text{Cl}$?
- 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