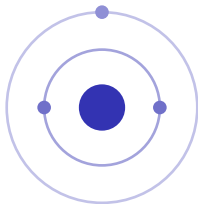


Atoms, Elements & Compounds

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



Elements, compounds and mixtures

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

Element, compound, mixture

the building blocks

all substances are made from about 100 elements

an element

only one type of **atom** – and it cannot be broken into anything simpler by a chemical reaction

a compound

two or more elements **chemically joined**, in a fixed ratio, with new properties

a mixture

substances **just mixed**, not joined – the parts keep their own properties and can be separated physically

the atomic number

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.



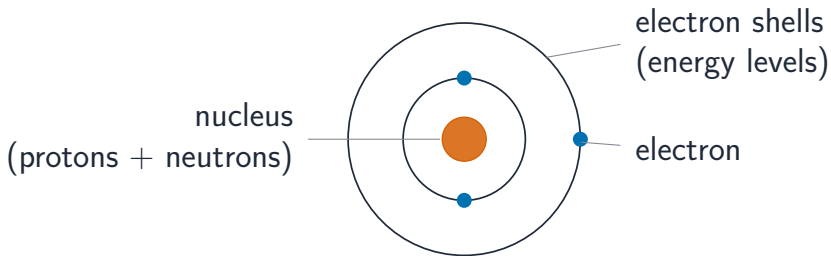
Inside the atom

A tiny **nucleus** of **protons** & **neutrons** ; **electrons** in **shells** around it.

proton
mass 1
charge +1

neutron
mass 1
charge 0

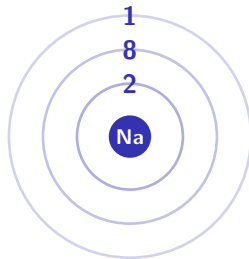
electron
mass ≈ 0
charge -1



Two numbers, and electron shells

- **proton number** = protons = which element
- **mass number** = protons + neutrons
- **neutrons** = mass number – proton number

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



outer = 1 → Group 1

3 shells → Period 3

The particles, and the two numbers

Relative mass and charge

Proton: **relative charge** +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** : protons plus neutrons.

The noble gases

The **noble gases** 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 : same protons, different neutrons – same element, same chemistry.



18 neutrons



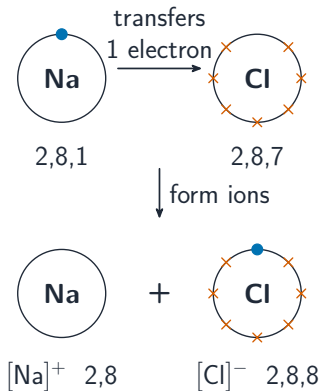
20 neutrons

A_r is the weighted average mass.

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



Ionic bonding



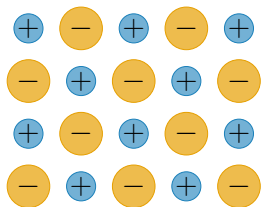
opposite charges
attract:
a strong **ionic
bond**

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

- metal → positive **cation**
- non-metal → negative **anion**

An **ionic bond** 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** 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

the strong force between oppositely charged ions – so ionic compounds have high melting points

electrical conductivity

an **ionic compound** conducts only when molten or dissolved, because the ions must be **free to move**

metals

delocalised electrons give conductivity, **ductility**, and malleability

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

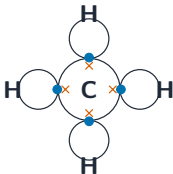
Covalent bonding



hydrogen, H_2
one shared pair



water, H_2O
two shared pairs



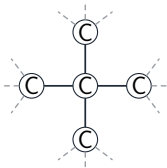
methane, CH_4
four shared
pairs

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

Simple molecules (H_2O , CH_4): **low** melting points (weak **intermolecular forces**) & poor conductors.

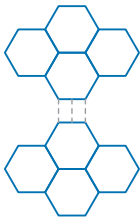
Giant covalent structures

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** – 4 bonds each; very **hard**
- **graphite** – 3 bonds, sliding **layers** ; soft, conducts

Graphite's 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**, 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**; weak forces let the layers slide, which makes it a **lubricant**.

Silicon(IV) oxide

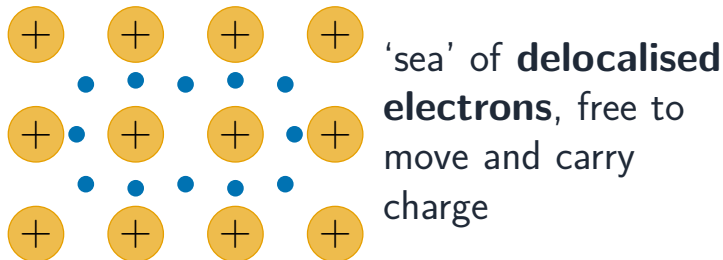
Silicon(IV) oxide (SiO_2) has a giant covalent structure like diamond – very hard, very high melting point.

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

Metallic bonding

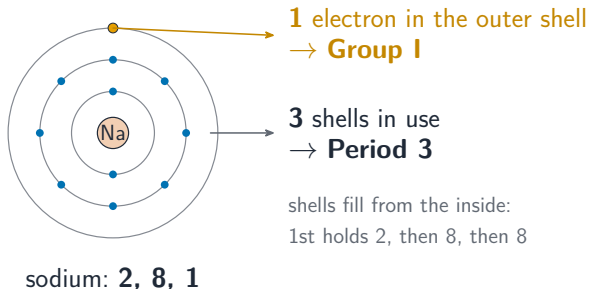
Positive ions in a **sea of delocalised electrons** .

- **conducts** – free electrons carry charge
- **malleable & ductile** – layers slide



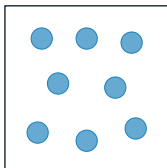
positive metal ions in a fixed lattice

Electronic configuration

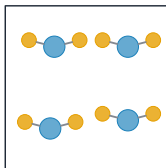


Sodium's configuration 2,8,1 links to the Periodic Table: one outer electron means Group 1, three shells means Period 3

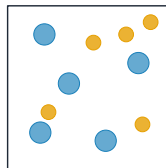
Elements, compounds and mixtures, continued



element
only one
type of atom



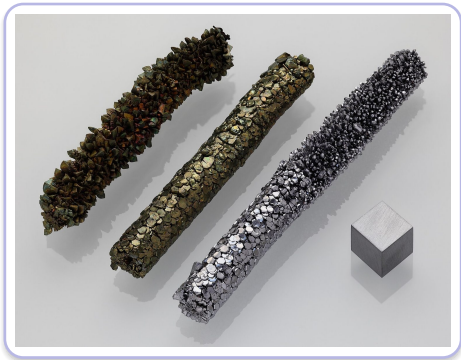
compound
different
atoms bonded
in a fixed ratio



mixture
not bonded,
easy to separate

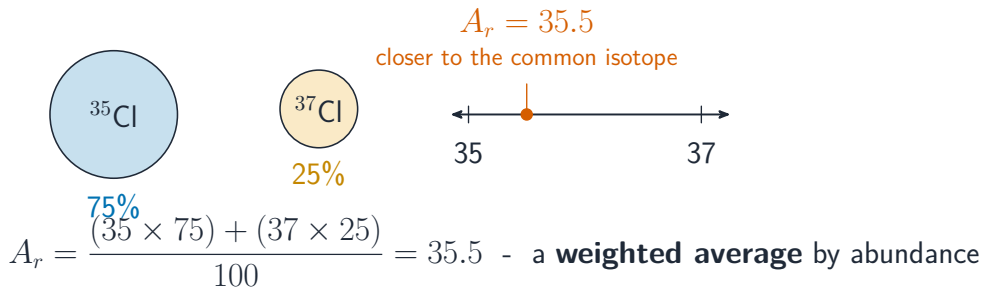
An element has one type of atom; a compound has different atoms bonded in a fixed ratio; a mixture is not bonded

Elements, compounds and mixtures, continued (2)



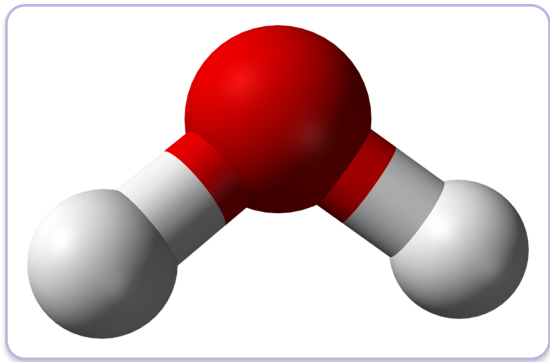
A pure element (vanadium): elements are the simplest substances.

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:

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



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

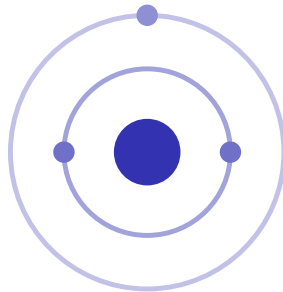
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Covalent & metallic

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