

Principles of chemistry

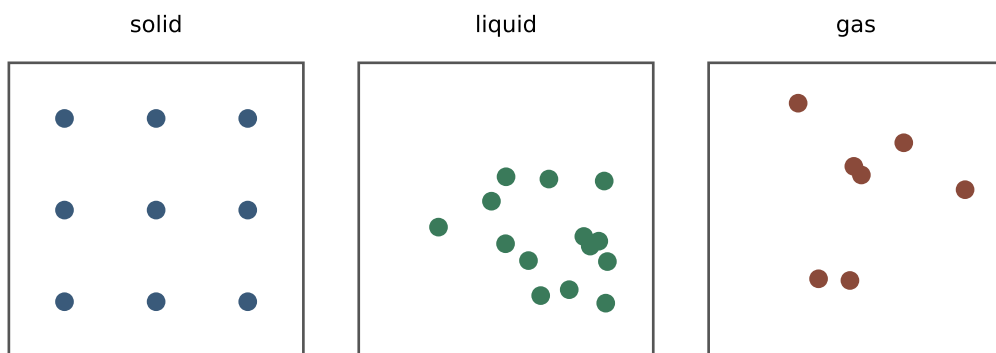
Pearson Edexcel · International GCSE · Chemistry

The language of chemistry

Everything in this course is written in one language: particles, formulae and equations. Section 1 teaches it – how particles arrange themselves in solids, liquids and gases; how atoms are built and lined up in the Periodic Table; how to turn a sentence about a reaction into a balanced equation and a mass calculation; and how the three kinds of bonding give every substance its properties.

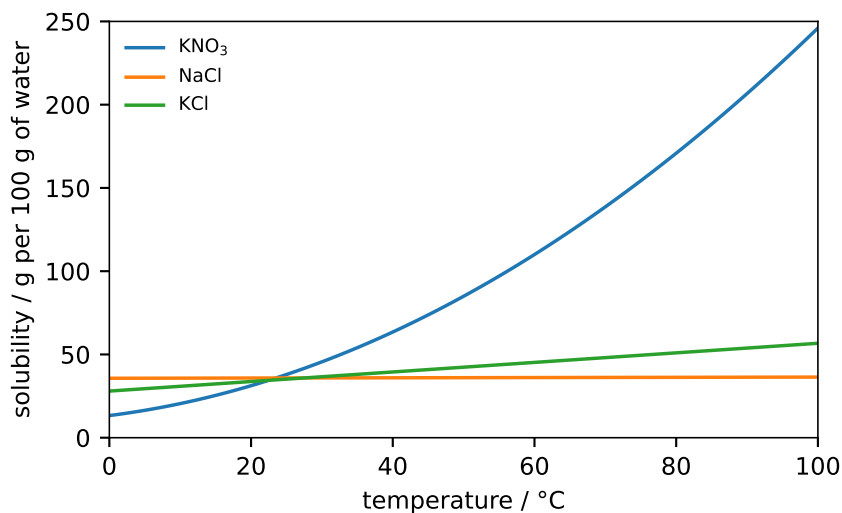
Edexcel International GCSE Chemistry 4CH1, Section 1 (statements 1.1–1.60C) is the largest section and the foundation for the other three. C-suffixed statements are the separate-science (Chemistry-only) extension.

States of matter and solutions



Solid: particles vibrate about fixed positions in a regular pattern. **Liquid:** particles touch but move past each other at random. **Gas:** particles far apart, fast, random. Interconversions: **melting** / **freezing**, **boiling** / **condensation**, **evaporation** (surface only, below boiling), **sublimation** (solid → gas directly). Energy is absorbed to separate particles and released as they bond again.

A **solvent** dissolves the **solute** to make a **solution**; a **saturated solution** holds all the solute it can at that temperature. (C) **Solubility** is the mass dissolved per 100 g of solvent at a stated temperature, read from a **solubility curve** – points on the line are saturated; below it, unsaturated.

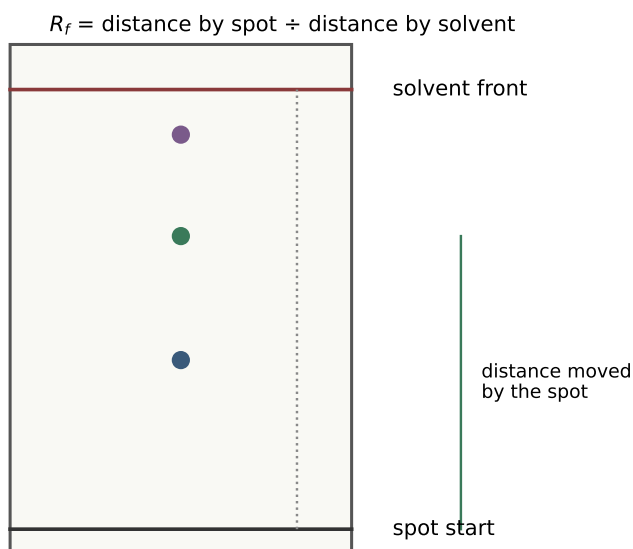


Dilution of coloured solutions and gas diffusion (bromine spreading through air) both show particles moving from where they are many to where they are few.

Elements, compounds, mixtures and separation

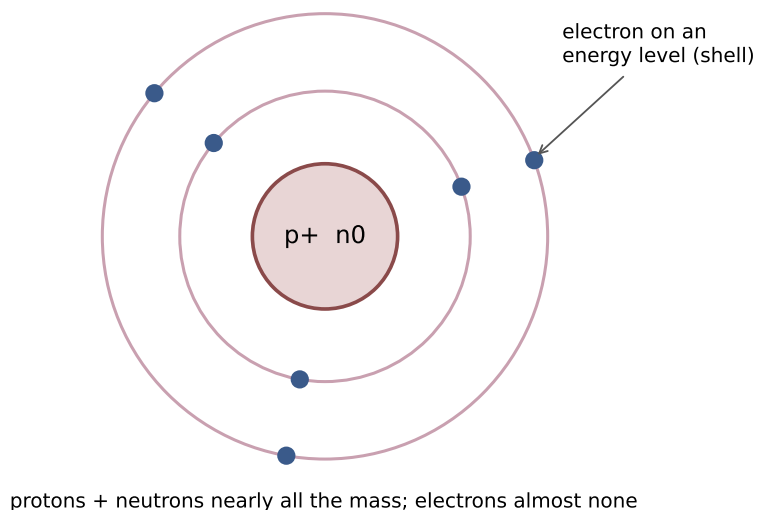
An **element** contains one type of atom; a **compound** holds different atoms chemically joined; a **mixture** is not chemically joined. A **pure substance** has a sharp melting/boiling point; mixtures melt and boil over a range – the test for purity.

Separation techniques, matched to the job: **filtration** (insoluble solid from liquid); **crystallisation** (evaporate a solution to leave crystals); **simple distillation** (liquid from dissolved solid – evaporate then condense); **fractional distillation** (liquids with close boiling points, using a fractionating column); **paper chromatography** (solutes that dissolve differently in a solvent).



R_f = distance moved by the spot ÷ distance moved by the solvent. The same substance always has the same R_f in the same solvent – comparing with known values identifies the components of the mixture.

Atoms and the Periodic Table



Particle	Relative mass	Relative charge
proton	1	+1
neutron	1	0
electron	1/1835 (≈ 0)	-1

Atomic number = protons; **mass number** = protons + neutrons.

Isotopes have the same protons but different neutrons. **Relative atomic mass** (A_r) is the weighted mean over the isotopes.

Worked check. Chlorine: 75 % Cl-35, 25 % Cl-37 $\rightarrow A_r = (75 \times 35 + 25 \times 37)/100 = 35.5$.

The Periodic Table lists elements by atomic number into **groups** (columns, same outer electrons) and **periods** (rows). The first 20 electronic configurations follow 2,8,8,2 shells (e.g. sodium 2.8.1). Metals sit left/centre: their oxides are basic and they conduct; non-metal oxides are acidic. Group members behave alike because they have the same number of outer electrons; Group 0 noble gases have full outer shells and do not readily react.

Formulae, equations and calculations

Balance equations with **state symbols** : (s), (l), (g), (aq). M_r sums the A_r values. The **mole** is the amount of substance: $n = m/M_r$ (mass in grams).

Worked check (reacting masses). What mass of magnesium oxide forms from 6.0 g of magnesium? $2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$: $n(\text{Mg}) = 6.0/24 = 0.25 \text{ mol} \rightarrow n(\text{MgO}) = 0.25 \text{ mol} \rightarrow \text{mass} = 0.25 \times 40 = 10 \text{ g}$.

Percentage yield = actual $\div$ theoretical $\times 100$ %. **Empirical formula** is the simplest whole-number ratio (divide each mass by its A_r , scale to integers); the **molecular formula** is the true count ($M_r \div$ empirical mass gives the multiplier).

Worked check. A hydrocarbon is 85.7 % C, 14.3 % H: C $85.7/12 = 7.14$, H $14.3/1 = 14.3 \rightarrow$ ratio 1:2 $\rightarrow$ empirical CH_2 . With $M_r = 56$: $56/14 = 4 \rightarrow$ molecular C_4H_8 .

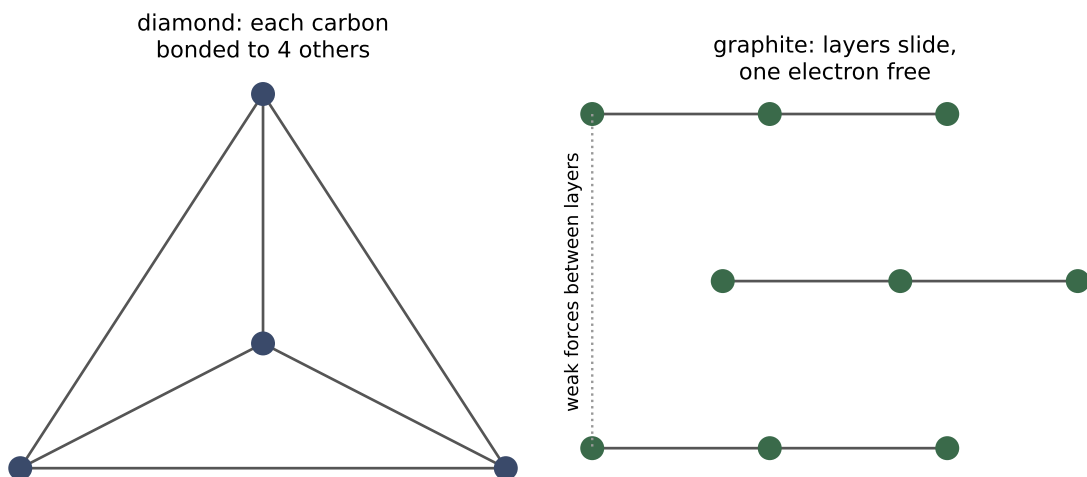
(C) **Solutions:** $n = c \times V$ with c in mol/dm^3 and V in dm^3 ($\text{cm}^3 \div 1000$). **Gases:** molar volume 24 dm^3 at rtp, so $n = V/24$. (C-practical) A metal oxide's formula comes from combustion (weigh magnesium, burn, weigh the oxide) or reduction (weigh copper(II) oxide, reduce with hydrogen, weigh the copper).

Bonding

Ionic bonding : metals lose electrons to non-metals; the charged ions attract electrostatically in a **giant lattice** – dot-and-cross diagrams show the transfer (Groups 1–3 with 5–7). High melting points (strong attractions); conduct only when **molten or dissolved** (ions free to move). Learn the charges: Groups 1/2/3 $\rightarrow 1+/2+/3+$; Groups 5/6/7 $\rightarrow 3-/2-/1-$; Ag^+ , Cu^{2+} , Fe^{2+} , Fe^{3+} , Pb^{2+} , Zn^{2+} ; OH^- , NH_4^+ , CO_3^{2-} , NO_3^- , SO_4^{2-} . Formulae balance the charges: calcium nitrate

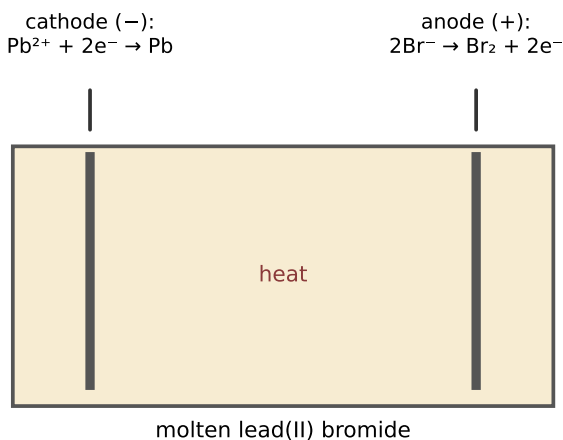
$\text{Ca}(\text{NO}_3)_2$, ammonium sulfate $(\text{NH}_4)_2\text{SO}_4$.

Covalent bonding : shared pairs of electrons (dot-and-cross for H_2 , O_2 , N_2 , halogens, HCl , H_2O , NH_3 , CO_2 and small organics). **Simple molecular** substances have weak intermolecular forces – low melting points, rising with M_r ; they do not conduct (no ions, no free electrons). **Giant covalent**: diamond (each C bonded to 4 – very hard, non-conductor), graphite (3 bonds + one free electron per C, layers with weak forces – soft, conducts, slippery), C_{60} fullerene (simple molecular cage).



(C) **Metallic**: a lattice of positive ions in a sea of delocalised electrons – electrostatic attraction; the free electrons conduct electricity, and layers slide (malleable).

Electrolysis (C)



Electrolysis uses electricity to split **molten or dissolved ionic compounds**: the **cathode** (negative) attracts **cations** ; the **anode** (positive) attracts **anions** . Molten PbBr_2 gives Pb at the cathode ($\text{Pb}^{2+} + 2\text{e}^- \rightarrow \text{Pb}$) and Br_2 at the anode ($2\text{Br}^- \rightarrow \text{Br}_2 + 2\text{e}^-$). In aqueous solution, **hydrogen forms at the cathode if the metal is more reactive than hydrogen**; at the anode, halide ions give the halogen, otherwise oxygen ($4\text{OH}^- \rightarrow \text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^-$). Loss of electrons is **oxidation** , gain is **reduction** .

Check yourself

1. Describe the particle arrangement and movement in a liquid.
2. Define saturated solution, and state the units of solubility.
3. Which technique separates two miscible liquids with close boiling points?
4. An isotope has 17 protons and 20 neutrons. Give its mass number and the numbers of each particle.
5. Calculate A_r of an element with 80 % of mass 20 and 20 % of mass 22.
6. Balance with state symbols: magnesium + oxygen $\rightarrow$ magnesium oxide.
7. 8.4 g of the oxide of calcium forms from 6.0 g of calcium. Show the empirical formula of the oxide.
8. Write the formula of ammonium carbonate.
9. Explain why graphite conducts but diamond does not.
10. (C) What forms at each electrode in the electrolysis of molten potassium chloride?

Answers: 1 particles touch but are disordered, moving randomly past each other; 2 a solution containing the maximum mass of dissolved solute at that temperature; g per 100 g of solvent; 3 fractional distillation; 4 mass number 37; 17 protons, 20 neutrons, 17 electrons; 5 $(80 \times 20 + 20 \times 22)/100 = 20.4$; 6 $2\text{Mg(s)} + \text{O}_2\text{(g)} \rightarrow 2\text{MgO(s)}$; 7 Ca $6.0/40 = 0.15$ mol; O mass $8.4 - 6.0 = 2.4$ g $\rightarrow 2.4/16 = 0.15$ mol; ratio 1:1 $\rightarrow$ empirical formula CaO; 8 $(\text{NH}_4)_2\text{CO}_3$; 9 graphite uses three bonds per carbon, leaving one delocalised electron per carbon free to move between layers – diamond uses all four in fixed bonds; 10 (C) potassium at the cathode ($\text{K}^+ + \text{e}^- \rightarrow \text{K}$) and chlorine at the anode ($2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$).