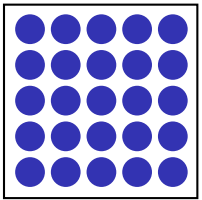
Topic 1: Principles of chemistry

Edexcel International GCSE Chemistry 4CH1 · Section 1 · statements 1.1–1.60C · sheets 1.1–1.3

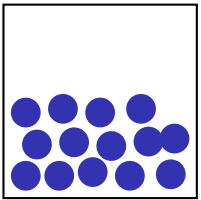
One language for the whole course

Sheet	**What you learn**
1.1	states of matter, solutions, separation, atoms and the Periodic Table
1.2	formulae, balanced equations, moles, reacting masses, empirical formulae
1.3	ionic, covalent and (C) metallic bonding; (C) **electrolysis**

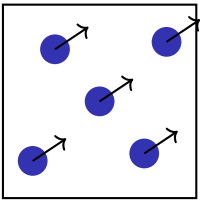
Three states and their changes



solid



liquid

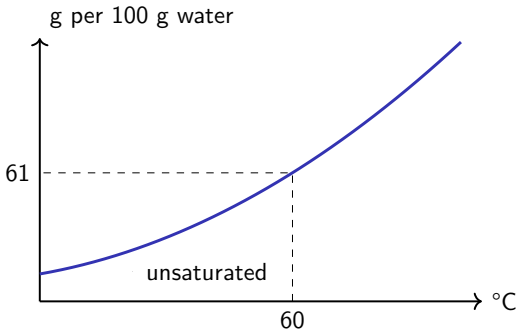


gas

Solid: vibrate in fixed rows. Liquid: touch but move past each other. Gas: far apart, fast, random.

- Energy separates particles; bonding again releases it.
- **Sublimation** goes straight from solid to gas.

Solutions and solubility curves



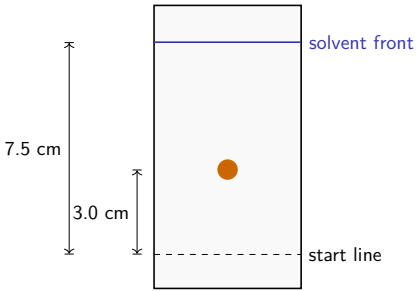
> On the curve, saturated; below it, unsaturated. Most solids dissolve more when hotter.

- **Solvent** dissolves **solute** to make a **solution**.
- (C) Solubility is grams per 100 g of solvent.

Elements, compounds and mixtures

Technique	Separates
filtration	an insoluble solid from a liquid
crystallisation	a dissolved solid, by evaporating to leave crystals
simple distillation	a liquid from a dissolved solid
fractional distillation	liquids with close boiling points
paper chromatography	solutes that dissolve differently in a solvent

Worked example: Rf values



Spot 3.0 cm, **solvent** front 7.5 cm: Rf $= 3.0 \div 7.5 = 0.40$.

- Rf = spot distance ÷ solvent distance.
- Same substance, same solvent, same Rf.

Inside the atom

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

Use the evidence

17 protons and 20 neutrons: **mass number** 37; the neutral atom has 17 electrons.

Relative atomic mass and the Periodic Table

1. **Known** Chlorine: 75% Cl-35, 25% Cl-37.
2. **Weighted mean** $A_r = (75 \times 35 + 25 \times 37)/100 = 35.5$.
3. **Shells** Electrons fill 2, 8, 8, 2: sodium is 2.8.1, one outer electron, **Group** 1.
4. **Group 0** Noble gases have full outer shells and do not readily react.

Moles and reacting masses

$$n = \frac{m}{M_r}$$

n in mol, m in g

1. **Equation** $2\mathrm{Mg}(s) + \mathrm{O_2}(g) \rightarrow 2\mathrm{MgO}(s)$; find the mass of MgO from 6.0 g Mg.
2. **Moles of Mg** $n = 6.0\ \mathrm{g} / 24\ \mathrm{g/mol} = 0.25$ mol.
3. **Ratio** 2 Mg : 2 MgO, so $n(\mathrm{MgO}) = 0.25$ mol.
4. **Mass** $m = n \times M_r = 0.25 \times 40 = 10$ g.

Empirical and molecular formulae

1. **Known** Hydrocarbon: 85.7% C, 14.3% H; $M_r = 56$.
2. **Moles** C: $85.7/12 = 7.14$; H: $14.3/1 = 14.3$.
3. **Ratio** $7.14 : 14.3 = 1 : 2$, so the **empirical formula** is CH_2 (mass 14).
4. **Molecular** $56/14 = 4$, so the molecular formula is C_4H_8.

Decision

Percentage yield = actual mass ÷ theoretical mass × 100%.

(C) Solutions and gases

$$n = c \times V \qquad n = \frac{V_{\text{gas}}}{24}$$

c in mol/dm^3, V in dm^3; gas volume in dm^3 at rtp

1. **Solution** 25.0 cm^3 of 0.200 mol/dm^3: $n = 0.200 \times 0.0250 = 0.00500$ mol.
2. **Gas** 0.25 mol of CO_2 at rtp: $V = 0.25 \times 24 = 6.0$ dm^3.
3. **Practical** Formula of an oxide: weigh Mg, burn it, weigh the oxide; or reduce CuO with hydrogen and weigh the Cu.

Ionic bonding and ionic formulae

Ion	Charge	Example formula
Groups 1, 2, 3	$1+$, $2+$, $3+$	Na^{+}, Mg^{2+}, Al^{3+}
Groups 5, 6, 7	$3-$, $2-$, $1-$	N^{3-}, O^{2-}, Cl^{-}
nitrate, sulfate	$1-$, $2-$	calcium nitrate $Ca(NO_3)_2$
ammonium, carbonate	$1+$, $2-$	ammonium sulfate $(NH_4)_2SO_4$

Use the evidence

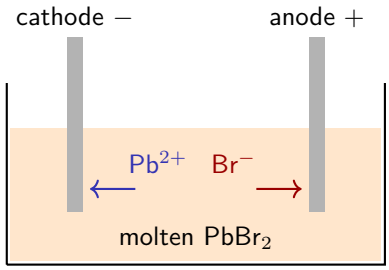
Giant ionic lattice: high **melting** point; conducts only when molten or dissolved, when ions can move.

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Covalent structures and carbon

Structure	Bonding	Properties
simple molecular	strong covalent bonds, weak forces between molecules	low **melting** point; no conduction
diamond	each C bonded to 4 others	very hard; does not conduct
graphite	each C bonded to 3; layers; one free electron per C	soft, slippery; conducts
(C) metals	positive ions in a sea of delocalised electrons	conduct; malleable

(C) Electrolysis of molten lead(II) bromide



Cathode: $\mathrm{Pb}^{2+} + 2e^- \rightarrow \mathrm{Pb}$. **Anode**: $2\mathrm{Br}^- \rightarrow \mathrm{Br}_2 + 2e^-$.

- Cations go to the cathode; anions to the anode.
- **Oxidation** is loss of electrons; reduction is gain.

(C) Electrolysis of solutions

Electrolyte	**Cathode**	**Anode**
molten KCl	potassium	chlorine
aqueous NaCl	hydrogen	chlorine
aqueous $CuSO_4$	copper	oxygen

Use the evidence

Oxygen at the **anode**: $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$.

Check yourself

Your turn

Answer without notes, then check.

A. Calculate A_r of an element with 80% of mass 20 and 20% of mass 22.

B. Balance with state symbols magnesium + oxygen $\rightarrow$ magnesium oxide.

C. 6.0 g of calcium forms 8.4 g of oxide. Find the empirical formula.

D. Explain why graphite conducts but diamond does not.

E. (C) What forms at each electrode with molten potassium chloride?