The required practicals are examined in the written papers: at least 15% of the marks are about experiments. For each practical, know the method in order, the variables, the apparatus and why it is used, the hazard, and what the results show.

Working scientifically – the words the questions use

Independent / dependent / control variable – the one you change; the one you measure; the ones you keep the same – and say HOW, e.g. 'the same volume of acid, measured with a measuring cylinder'

Resolution – the smallest change an instrument shows: 0.1 °C on a digital thermometer, 0.05 cm^3 when reading a burette, 0.01 g on a balance

Accurate / precise – close to the true value / repeat results close together

Repeatable / reproducible – you get similar results again with the same method / someone else, or another method, gets similar results

Uncertainty: half the range of the repeat readings. Times of 41 s, 45 s and 43 s give a mean of 43 s ± 2 s.

A mean leaves out anomalies. Titres are averaged only if they are concordant – within 0.10 cm^3 of each other.

RP1 – Making salts

Aim: make pure, dry crystals of a soluble salt – copper(II) sulfate – from an insoluble oxide and an acid.

1. Warm 40 cm^3 of dilute sulfuric acid in a beaker over a Bunsen burner; do not boil it.
2. Add copper(II) oxide a spatula at a time, stirring, until some stays undissolved. The excess makes sure all the acid has reacted.
3. Filter the mixture to remove the excess copper(II) oxide; the blue filtrate is copper(II) sulfate solution.
4. Heat the filtrate in an evaporating basin over a water bath until about half the water has gone, or until crystals start to form at the edge.
5. Leave it to cool and crystallise, then pat the crystals dry between filter papers.

$CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$. Heating to dryness would drive off the water of crystallisation and give a white powder instead of blue crystals.

Hazard: hot acid spits and copper(II) sulfate is harmful. Wear eye protection, and heat gently.

RP2 – Neutralisation by titration (chemistry only)

Aim: find the volume of acid that exactly neutralises 25.0 cm^3 of an alkali, and (higher tier) the alkali's concentration.

1. Use a pipette and pipette filler to put 25.0 cm^3 of sodium hydroxide solution into a conical flask, and add a few drops of indicator (phenolphthalein or methyl orange). Stand the flask on a white tile.
2. Fill a burette with the acid and record the starting reading at the bottom of the meniscus, at eye level.

3. Add acid while swirling the flask; near the end point add it drop by drop, until one drop changes the colour permanently. Record the final reading.

4. Do a rough titration first, then repeat until two titres are within 0.10 cm^3 of each other (concordant).

	Rough	**1**	**2**	**3**
Final reading / cm^3	23.20	22.95	23.40	22.70
Initial reading / cm^3	0.00	0.40	0.95	0.15
Titre / cm^3	23.20	22.55	22.45	22.55

All three accurate titres are concordant; the mean is $(22.55 + 22.45 + 22.55) \div 3 = 22.52$ cm^3. The rough titre is left out.

Higher tier, with 0.100 mol/dm^3 sulfuric acid: moles of $H_2SO_4 = 0.100 \times 22.52 \div 1000 = 2.252 \times 10^{-3}$. $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$, so moles of NaOH $= 4.504 \times 10^{-3}$, and its concentration $= 4.504 \times 10^{-3} \div 0.0250 = 0.180$ mol/dm^3.

Why a pipette for the alkali and a burette for the acid: the pipette measures one fixed volume accurately; the burette measures a variable volume to 0.05 cm^3.

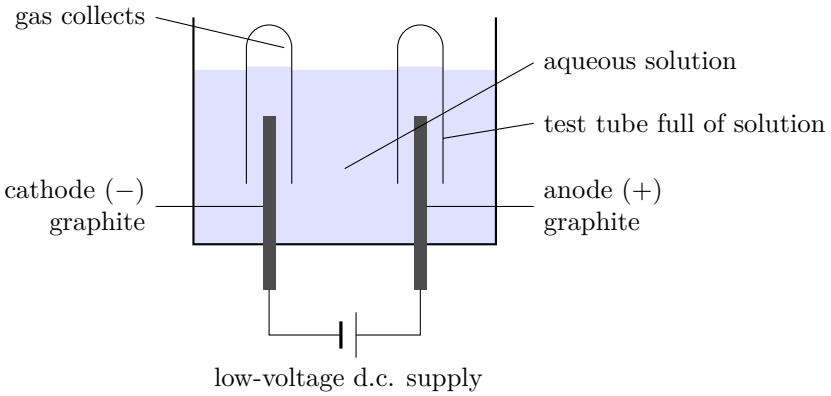
RP3 – Electrolysis

Aim: electrolyse aqueous solutions with inert (graphite) electrodes and identify the product at each electrode.

1. Pour the solution into a beaker and put in two graphite rods, not touching, held by a lid or clamp.

2. Connect them to a low-voltage d.c. supply (about 4 V) and switch on.

3. Collect any gas in a test tube filled with the solution and inverted over the electrode, then test it. Look for a metal coating on the cathode.



An electrolysis cell: the rods come up through the base so a test tube can sit over each. Each tube starts full of solution; the gas pushes the liquid down. Lift the tube out with a thumb over the end and test the gas.

At the cathode (−) – the metal forms if it is LESS reactive than hydrogen (copper, silver); otherwise hydrogen forms

At the anode (+) – a halogen forms if the solution contains chloride, bromide or iodide ions; otherwise oxygen forms

Gas tests – hydrogen – a lighted splint gives a squeaky pop; oxygen – relights a glowing splint; chlorine – bleaches damp blue litmus paper (it may turn red first)

Example: copper(II) chloride solution gives copper on the cathode and chlorine at the anode. Sodium chloride solution gives hydrogen and chlorine – sodium is more reactive than hydrogen. Copper(II) sulfate gives copper and oxygen.

Hazard: chlorine is toxic. Use dilute solutions, a low voltage, a short run time and a well-ventilated room.

RP4 – Temperature changes

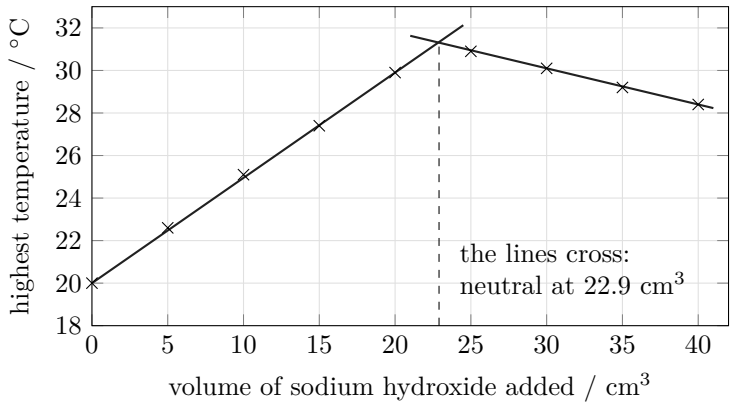
Aim: find how the volume of sodium hydroxide added to hydrochloric acid affects the temperature change, and so the volume that neutralises it.

1. Measure 30 cm^3 of dilute hydrochloric acid into a polystyrene cup standing in a beaker (for stability); record its temperature.

2. Add 5 cm^3 of sodium hydroxide solution, put on the lid, stir, and record the highest temperature reached.

3. Keep adding 5 cm^3 portions, up to 40 cm^3, recording the highest temperature after each.

4. Plot highest temperature against volume of alkali, and draw two straight lines of best fit.



Typical results. The temperature rises while acid is left to react, then falls as cooler alkali is added to a mixture with nothing left to react.

The highest reading, 30.9 °C at 25 cm^3, is below the point where the lines cross (about 31.3 °C at 22.9 cm^3): the true maximum fell between two readings. That is why the crossing of the lines, not the highest reading, locates the neutralisation point.

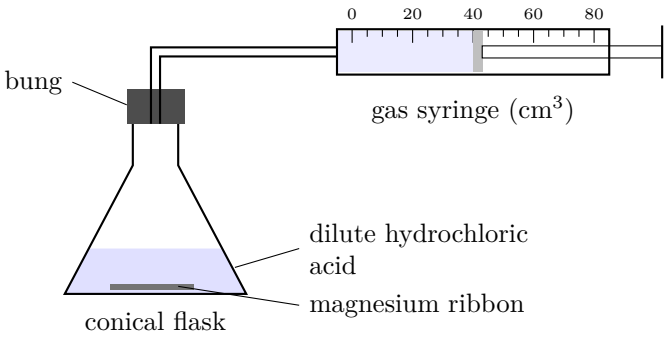
The polystyrene cup and lid reduce energy transfer to the surroundings. Heat still lost makes every temperature rise slightly too small.

RP5 – Rates of reaction

Aim: find how the concentration of a reactant affects the rate, (a) by a change in colour or cloudiness and (b) by the volume of gas produced.

(a) Disappearing cross – sodium thiosulfate and hydrochloric acid make a cloudy precipitate of sulfur. Put the flask on a cross drawn on paper, add the acid, start the clock, and stop it when the cross can no longer be seen from above. Repeat with different thiosulfate concentrations, keeping the total volume the same

(b) Gas volume – magnesium ribbon with hydrochloric acid in a conical flask connected to a gas syringe (or an upturned measuring cylinder in water). Record the volume every 10 s until it stops changing



Method (b). Put the bung in as soon as the magnesium is added, and start the clock at the same moment.

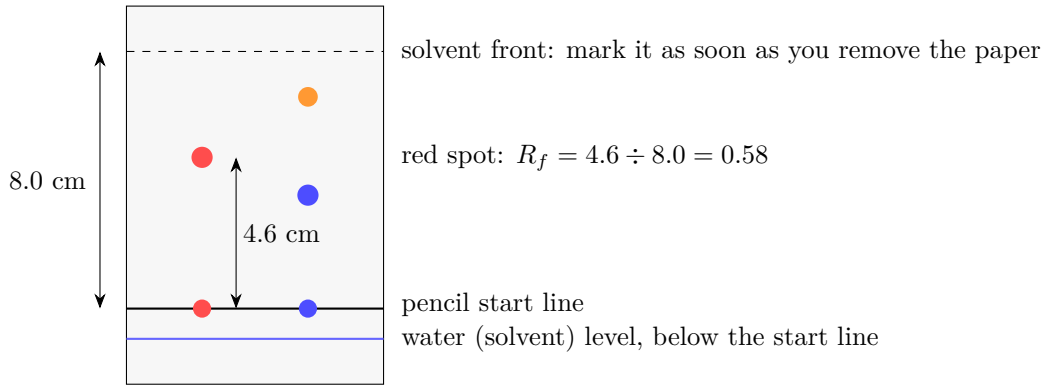
Rate = 1 ÷ time for (a). For (b), the gradient of the volume–time graph is the rate; the curve is steepest at the start, where the concentration is highest, and levels off when a reactant is used up.

The 'cross' end point is judged by eye, and different people judge it differently. Use the same person and the same cross, or a light sensor and data logger in its place.

Control: the same temperature, the same total volume, and the same length (and so surface area) of magnesium. Hazard: sulfur dioxide is formed in (a) – ventilate the room, and asthmatics should take care.

RP6 – Chromatography

Aim: separate the coloured substances in inks or food colourings and identify them using R_f values.



R_f = distance moved by the substance ÷ distance moved by the solvent, both measured from the start line to the CENTRE of the spot. Each R_f is between 0 and 1.

1. Draw the start line in PENCIL about 2 cm from the bottom; ink would itself separate and run.

2. Put small spots of each ink on the line, with known food colourings alongside for comparison.

3. Stand the paper in a beaker with water below the start line, so the spots do not dissolve into the solvent. Put on a lid to stop the solvent evaporating.

4. Remove the paper before the solvent reaches the top, mark the solvent front and let it dry.

A pure substance gives ONE spot in every solvent. A mixture gives more than one. Two spots with the same R_f in the same solvent are probably the same substance.

A spot that stays on the start line is insoluble in this solvent – try another one.

RP7 – Identifying ions (chemistry only)

Flame tests (metal ions) – lithium crimson; sodium yellow; potassium lilac; calcium orange-red; copper green. Clean the wire loop in acid first, and remember a mixture can hide a colour

Sodium hydroxide solution (metal ions) – copper(II) blue precipitate; iron(II) green; iron(III) brown; aluminium, calcium and magnesium white – aluminium's precipitate DISSOLVES in excess sodium hydroxide

Carbonate – add dilute acid: it fizzes, and the gas turns limewater milky (carbon dioxide)

Halides – add dilute nitric acid then silver nitrate solution: chloride a white precipitate, bromide cream, iodide yellow

Sulfate – add dilute hydrochloric acid then barium chloride solution: a white precipitate

The acid in the halide and sulfate tests removes carbonate ions first, which would also give a precipitate. Nitric acid, not hydrochloric, for halides – hydrochloric acid would add chloride ions.

RP8 – Water purification

Aim: analyse samples of water – pH and dissolved solids – and purify salty water by distillation.

1. Test the pH of each sample with universal indicator paper or a pH meter.

2. Weigh an empty evaporating basin, add a measured volume of the sample, evaporate the water gently, and reweigh. The gain in mass is the dissolved solids.

3. Distil salty water: heat it in a flask with a thermometer at the side arm; the steam condenses in a water-cooled condenser and pure water collects in a beaker.

4. Check that the distilled water is pure: it boils at 100 °C and leaves no solid when evaporated.

Cold water enters the condenser at the BOTTOM and leaves at the top, so the condenser stays full and cold. Add anti-bumping granules to the flask so it boils smoothly.

Questions examiners ask about every practical

'Why use a polystyrene cup / a lid / a water bath?' – name the error it reduces: energy transfer to the surroundings; evaporation; temperature changing during the run.

'Suggest an improvement' – something specific: a gas syringe in place of collecting over water, a burette in place of a measuring cylinder, a light sensor in place of judging by eye.

'Describe the trend' – quote numbers: 'doubling the concentration from 0.5 to 1.0 mol/dm^3 halved the time from 48 s to 24 s, so it doubled the rate'.

'Give a hazard' – name the substance and the harm: 'hot sulfuric acid can burn the skin and eyes', then the matching precaution.