REAL-LIFE CHEMISTRY

Chemistry in Society

Teacher guide

For the National 5 Chemistry workbook



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Blewis LEARNING

Using the workbooks

The National 5 Chemistry workbook for **Chemistry in Society** has six topics. Every topic has learning pages, a practical the learner plans and evaluates, a brain break and an exam-style check-up.

PRACTICALS

Learners plan each investigation (variables, prediction, kit, risk, method), take repeat readings, work out averages, draw graphs with their own scales, and write conclusions and evaluations.

PRACTICAL SAFETY

Every practical has a Stay safe table and a teacher note with hazards, adapted versions and common problems. The Stay safe tables and these notes are a starting point, not a complete risk assessment: the teacher or school must risk assess every practical for their own learners, room and kit before use, following their employer's policies and national guidance (in Scotland, SSERC). Always check learners' care plans and medical information. Activities with flames or microbes are teacher demonstrations, with example results provided.

NO LAB, NO KIT, OR A LEARNER ABSENT

Each practical includes example results so learners can still complete the results, graph, conclusion and evaluation.

EVIDENCE

The practicals develop the skills needed for the assignment and for questions on experimental work in the exam; the learn pages and check-ups build knowledge and problem solving. The skills tracker at the back of each workbook can be signed off as you go. Always check the latest course documents and your centre's arrangements.

Contents

Topic 1	Metals	**4**
Topic 2	Electrochemical cells	**6**
Topic 3	Plastics	**8**
Topic 4	Fertilisers	**10**
Topic 5	Nuclear chemistry	**12**
Topic 6	Chemical analysis	**14**

TEACHER NOTES

Practical 1: Which metal reacts most with acid?

Time	One 50-minute lesson in pairs. Four metals with three repeats takes about 30 minutes.
Kit per group	Magnesium ribbon (cut into small pieces), zinc powder, iron filings or powder, copper powder (about 2 g of each), 1.0 mol l^{-1} hydrochloric acid, 25 cm^3 measuring cylinder, polystyrene cups standing in beakers, thermometer or digital probe, balance, spatulas, eye protection.
Prep	Pre-weigh 0.50 g portions in labelled containers if time is short. Clean magnesium with emery paper.
Expected results	Magnesium gives a rise of about 15 to 20 °C, zinc about 3 to 5 °C, iron about 2 °C and copper none. Fine zinc powder can react faster than expected.
Level	N5 plans a fair test, repeats, finds the mean, draws a bar graph and evaluates the fairness of the comparison.

Safety and inclusion

- Eye protection throughout. Hydrogen is produced: no naked flames in the room. Good ventilation.
- Dilute hydrochloric acid (1.0 mol l^{-1}) is low hazard but can sting eyes and cuts; keep eye protection on and wipe up spills.
- Use only small portions of metal powder; magnesium powder is not needed and should not be used. Dispose of residues as your local rules require.
- Risk assess for your own class, room and kit, following your employer's policies and SSERC guidance.
- Roles can be shared: one learner reads the thermometer, one adds the metal, one records; all can be done seated.

Common problems

- **Missing the highest temperature:** keep stirring and read every 15 seconds until the reading starts to fall.
- **Reusing acid:** use fresh acid for each run.
- **Line graph instead of bar graph:** the metal is not a number, so a bar graph is needed.

No lab, no time, or a learner absent?

The sample results let learners calculate the means, draw the bar graph and complete the conclusion and evaluation.

Assessment link

Evidence of planning, recording, means, graphing and evaluating. Assignment practice: compare with a reactivity series from another source and reference it.

Answers: Topic 1

Topic 1: Metals (N5)

1 Metallic bonding and reactivity

1 Copper has delocalised electrons that are free to move through the structure, so they can flow when a voltage is applied.

2 calcium + water → calcium hydroxide + hydrogen

3 Gold is very low in the reactivity series (very unreactive), so it does not react with oxygen or sea water.

4 Zinc (it is above tin in the reactivity series). The gas is hydrogen.

2 Getting metals from ores

1 Aluminium is more reactive than carbon (high in the reactivity series), so carbon cannot remove the oxygen from aluminium oxide; electrolysis is needed.

2 With d.c. each electrode keeps the same charge (one always negative, one always positive), so the products at each electrode can be identified.

3 So that all the acid is used up (reacts), leaving only the salt in solution.

3 Oxidation, reduction and redox

1 (a) oxidation (electrons lost) (b) reduction (electrons gained).

2 $Pb^{2+} + 2e^{-} \rightarrow Pb$

3 Oxidation: $Mg \rightarrow Mg^{2+} + 2e^{-}$; reduction: $Fe^{2+} + 2e^{-} \rightarrow Fe$; redox: $Mg + Fe^{2+} \rightarrow Mg^{2+} + Fe$.

4 The iron atoms lose electrons ($Fe \rightarrow Fe^{3+} + 3e^{-}$), and loss of electrons is oxidation.

Practical 1: Which metal reacts most with acid?

Variables: change the metal; measure the temperature rise (°C); keep the same: mass of metal, volume and concentration of acid, starting temperature, size of pieces (powder), type of cup.

Prediction, e.g. magnesium, zinc, iron, copper, because that is their order in the reactivity series.

Equipment: measuring cylinder, thermometer, polystyrene cup in a beaker, balance, spatula, eye protection. Not needed: burette.

Hazards, e.g. hydrogen is flammable (no flames nearby); glass thermometer could break (handle carefully or use a digital probe); metal powders should not be breathed in or spilled (use a spatula, small amounts).

Method key points: 25 cm^3 of acid in the cup; record the starting temperature; add 0.50 g of metal, stir, and record the highest temperature; rise = highest − start; repeat three times for each metal with fresh acid; mean rise.

Sample results (means): magnesium: 18.7 °C; zinc: 4.1 °C; iron: 2.2 °C; copper: 0.0 °C.

Conclusion: magnesium, zinc, iron, copper (copper does not react with dilute acid).

Evaluate: (a) polystyrene is a good insulator, so less heat is lost and the temperature rise is more accurate. (b) Ribbon has a smaller surface area than powder, so the test is not fair (magnesium would react even faster as a powder); use the same form for every metal, e.g. all as granules or turnings of similar size (not magnesium powder).

Check-up

1 C (aluminium). 2 B.

3 The metallic bonds (attraction between positive ions and delocalised electrons) are strong, so a lot of energy is needed to melt the metal (1); the delocalised electrons are free to move, so they carry the current (1).

4 (a) $Zn \rightarrow Zn^{2+} + 2e^{-}$ (1) (b) $Zn + 2Ag^{+} \rightarrow Zn^{2+} + 2Ag$ (1)

5 GFM of PbO = 207.2 + 16.0 = 223.2 (1); % Pb = 207.2 ÷ 223.2 × 100 = 92.8% (1)

TEACHER NOTES

Practical 2: Does the choice of metal change the voltage?

Time	One 50-minute lesson in pairs. Four metals with three repeats takes about 20 to 25 minutes.
Kit per group	Strips of copper, magnesium, zinc, iron and tin of the same size, 1 mol l^{-1} sodium chloride solution (or a soaked filter-paper bridge), 100 cm^3 beaker, crocodile clips and leads, digital voltmeter, emery paper, measuring cylinder, ruler, eye protection.
Prep	Cut and label the strips in advance. Clean them with emery paper at the start of the lesson. A card spacer keeps the strips 3 cm apart.
Expected results	About 1.6 V for magnesium and copper, 0.9 V for zinc, 0.5 V for iron and 0.3 V for tin. Readings drift downwards over time, so read at a fixed time.
Level	N5 plans a fair test, repeats, finds the mean, draws a bar graph and links results to the electrochemical series.

Safety and inclusion

- Eye protection. Low-hazard solutions; wipe up spills. Keep the voltmeter dry.
- Avoid copper(II) sulfate if your risk assessment prefers salt solution for this class; the trend is the same.
- Risk assess for your own class, room and kit, following your employer's policies and SSERC guidance.
- Large-display digital meters help learners with visual impairments; one learner can read while another records.

Common problems

- **Negative readings:** the leads are the wrong way round; swap them and note the sign shows the direction of electron flow.
- **Very low voltage:** strips are dirty or touching each other.
- **Electrons "through the bridge":** stress that only ions move in the solution.

No lab, no time, or a learner absent?

The sample results let learners calculate the means, draw the bar graph and complete the conclusion and evaluation.

Assessment link

Evidence of planning, recording, means, graphing and evaluating. Assignment practice: compare with the electrochemical series from another source and reference it.

Answers: Topic 2

Topic 2: Electrochemical cells (N5)

1 Electricity from chemicals

1 It completes the circuit by allowing ions to move between the electrodes.

2 From magnesium to copper, because magnesium is the more reactive metal (higher in the electrochemical series) and loses electrons.

3 Pure water contains almost no ions, so it cannot complete the circuit (it is not an electrolyte).

4 Advantage, e.g. portable or safe at low voltage. Disadvantage, e.g. more expensive per unit of energy, or the chemicals run out and must be replaced or recharged.

2 The electrochemical series

1 Magnesium and silver: they are furthest apart in the series.

2 Magnesium and silver, zinc and copper, iron and tin.

3 Tin loses electrons: $Sn \rightarrow Sn^{2+} + 2e^{-}$.

4 No. Zinc and iron are closer together in the series than zinc and copper, so the zinc and iron cell gives a smaller voltage.

3 Half-cells and displacement

1 Graphite conducts electricity but does not react (it is inert); iodine is a non-metal and cannot itself be the electrode.

2 The nail becomes coated in brown/pink copper and the blue colour fades; $Fe + Cu^{2+} \rightarrow Fe^{2+} + Cu$.

Practical 2: Does the choice of metal change the voltage?

Variables: change the metal paired with copper; measure the voltage (V); keep the same: electrolyte and its concentration and volume, size of strips, distance apart, depth in the solution, the copper strip.

Prediction, e.g. magnesium, because it is furthest above copper in the electrochemical series.

Equipment: voltmeter, leads and clips, beaker, measuring cylinder, ruler, eye protection. Not needed: Bunsen burner.

Hazards, e.g. salt solution in eyes (eye protection); spills on electrical leads (keep the meter away from the beaker edge, wipe spills); emery paper dust (clean strips over a tray).

Method key points: 50 cm^3 of salt solution in a beaker; clean the strips; clip copper and the test metal 3 cm apart at the same depth; connect the voltmeter and read straight away; rinse and repeat three times; mean voltage.

Sample results (means): magnesium: 1.62 V; zinc: 0.92 V; iron: 0.55 V; tin: 0.31 V.

Conclusion: the further the metal is above copper in the electrochemical series, the larger the voltage (magnesium > zinc > iron > tin).

Evaluate: (a) to remove the oxide coating, so the metal itself is in contact with the electrolyte. (b) Read the voltage at the same time after connecting (e.g. at once or after 10 s), use fresh electrolyte and clean strips each time, and repeat.

Check-up

1 B (magnesium and tin are furthest apart of these pairs). 2 B.

3 (a) Arrow from zinc to copper through the wires (1). (b) $Cu^{2+} + 2e^{-} \rightarrow Cu$ (1). (c) The voltage increases (1) because magnesium and copper are further apart in the electrochemical series (1).

4 $Sn + 2Ag^{+} \rightarrow Sn^{2+} + 2Ag$: correct species (1), balanced (1).

TEACHER NOTES

Practical 3: Which plastic film stretches most?

Time	One 50-minute lesson in groups of three. Four films with three strips each takes about 30 minutes.
Kit per group	Four types of plastic film (bread bag, freezer bag, thin carrier bag, bin liner), scissors, ruler, clamp stand with boss and clamp, 100 g hanger and slotted masses, tape, tray of sand, eye protection.
Prep	Collect clean bags in advance. A cardboard template makes cutting 2 cm × 10 cm strips quick. Mark the cutting direction on each bag.
Expected results	Stretches of 2 to 7 cm with 300 g, depending on film thickness; thin carrier bags stretch most. Some thin films may snap; record that as a result.
Level	N5 plans a fair test, repeats, finds the mean, draws a bar graph and evaluates the fairness of comparing films of different thickness.

Safety and inclusion

- Eye protection, as strips can snap and flick. Tray of sand under the masses and feet kept clear. Clamp stands secured.
- Low hazard overall. Risk assess for your own class, room and kit, following your employer's policies and SSERC guidance.
- Learners who find fine cutting hard can use pre-cut strips; one learner can add masses while another measures.

Common problems

- **Measuring the total length instead of the stretch:** subtract the starting length.
- **Strips cut in different directions:** films stretch differently along and across, so keep the direction the same.
- **Line graph:** the film type is not a number, so a bar graph is needed.

No lab, no time, or a learner absent?

The sample results let learners calculate the means, draw the bar graph and complete the conclusion and evaluation.

Assessment link

Evidence of planning, recording, means, graphing and evaluating. Assignment practice: compare with published property data and reference the source.

Answers: Topic 3

Topic 3: Plastics (N5)

1 Making polymers

1 Ethane is saturated (only single bonds), so there is no C=C bond to open up. Ethene has a C=C double bond, which opens so the molecules can join.

2 (a) poly(propene) (b) poly(tetrafluoroethene)

3 The monomer: it is unsaturated (has a C=C bond). The polymer has only single carbon to carbon bonds (it is saturated), so it reacts only very slowly.

2 Repeating units and monomers

1 A chain of six carbons in a line, joined by single bonds, with an open bond at each end; every second carbon carries a $-CH_2CH_3$ (ethyl) group and an H; the other carbons carry two H atoms.

2 Tetrafluoroethene: two carbons joined by a double bond, each carbon with two F atoms ($CF_2=CF_2$).

3 Plastics: useful but a problem

1 It is tough and does not soak up water, so the net stays strong and light in the sea.

2 Any two: it is not biodegradable, so it stays for hundreds of years; animals swallow it or get tangled; it breaks into tiny pieces that enter food chains; it spoils the beach.

3 It contains chlorine, so burning it gives off toxic (poisonous) gases such as hydrogen chloride.

4 For, e.g. less litter and less use of oil. Against, e.g. plastics are useful in medicine, food hygiene and safety equipment, and alternatives may use more energy.

Practical 3: Which plastic film stretches most?

Variables: change the type of plastic film; measure the stretch (increase in length, cm); keep the same: size of strip, direction of cutting, mass hung, time hung, how the strip is held.

Prediction, e.g. the carrier bag, because it is the thinnest film.

Equipment: clamp stand, slotted masses (and hanger), ruler, tape, tray of sand, eye protection. Not needed: thermometer.

Hazards, e.g. clamp stand tipping (clamp to the bench or add a weight to the base); strip snapping and flicking (eye protection); scissors when cutting strips (cut away from the hand).

Method key points: cut strips 2 cm × 10 cm in the same direction; clamp the top and tape a hanger to the bottom; measure the length; hang 300 g for 1 minute and measure again; stretch = new length − original length; three strips of each film; mean.

Sample results (means): bread bag: 3.7 cm; freezer bag: 2.4 cm; carrier bag: 6.0 cm; bin liner: 4.4 cm.

Conclusion: the carrier bag stretched most and the freezer bag least.

Evaluate: (a) thicker films stretch less for the same mass, so the test compares thickness as well as type of plastic; it is only fair if the strips are the same thickness. (b) The freezer bag: it stretched least (2.4 cm), so it keeps its shape under a heavy load.

Check-up

1 C (propene: it is unsaturated). 2 B.

3 (a) Two carbons joined by a single bond with open bonds at each end: one carbon with two H atoms, the other with one H and one $-C_2H_5$ group (1). (b) But-1-ene (1).

4 Small unsaturated molecules (monomers) with a C=C bond (1) join together to make a long chain, the double bond opening up and no atoms being lost (1).

5 Advantage, e.g. light, waterproof, cheap or easily moulded (1). Problem, e.g. not biodegradable so it builds up as litter, or toxic gases when burned, or made from a finite resource (1).

TEACHER NOTES

Practical 4: How much fertiliser is best?

Time	20 minutes to set up, about 5 minutes a day to water, and 20 minutes on day 7 to measure. Results can be shared across the class so each group runs one or two concentrations.
Kit per group	Cress seeds, seed trays or Petri dishes with damp paper towel, general garden fertiliser (or ammonium nitrate supplied as a dilute solution), 1 litre stock bottle, measuring cylinders, droppers, ruler, labels, eye protection.
Prep	Make the 8 g l^{-1} stock solution in advance and let learners carry out the dilutions. Agree who waters at weekends, or start on a Monday.
Expected results	Growth rises from about 20 mm with water only to a peak near 4 g l^{-1}, then falls at high concentrations as the roots are damaged. Exact values depend on the fertiliser used.
Level	N5 plans a fair test with a control, repeats, finds the mean, draws a line graph and links the result to farming.

Safety and inclusion

- Eye protection when handling fertiliser powder and solutions; wash hands afterwards. Store solutions labelled and out of reach.
- Ammonium nitrate solids must be stored and handled as your local rules require; a general garden fertiliser is a lower-risk choice.
- Risk assess for your own class, room and kit, following your employer's policies and SSERC guidance.
- Measuring seedlings can be fiddly: a ruler taped to the bench or a photo with a scale helps.

Common problems

- **Trays drying out:** cover with cling film or a lid for the first two days.
- **Measuring the tallest seedling only:** measure 10 chosen at random.
- **Straight line through the points:** encourage a smooth curve that shows the peak.

No lab, no time, or a learner absent?

The sample results let learners calculate the means, draw the graph and complete the conclusion and evaluation.

Assessment link

Evidence of planning with a control, recording, means, graphing and evaluating. Assignment practice: compare with a fertiliser label or published advice and reference it.

Answers: Topic 4

Topic 4: Fertilisers (N5)

1 Why plants need fertilisers

1 Plants take in nutrients dissolved in water through their roots, so the fertiliser must dissolve.

2 Nitrogen, phosphorus and potassium.

3 Formula mass = 14.0 + 4.0 + 35.5 = 53.5; % N = 14.0 ÷ 53.5 × 100 = 26.2%

4 The proportions (percentages) of nitrogen, phosphorus and potassium in the fertiliser.

2 Making ammonia: the Haber process

1 The reaction is reversible, so only some of the gases react each time; recycling them means none is wasted and more ammonia is made.

2 At a low temperature the reaction is too slow, so ammonia would be made too slowly to be economic; a moderately high temperature gives a reasonable yield at a reasonable rate.

3 Blue (or purple): ammonia dissolves in the water on the paper to form an alkaline solution.

3 Nitric acid and ammonium salts

1 (a) iron (b) platinum

2 The reaction is exothermic, so the heat given out keeps the catalyst hot.

3 Ammonium sulfate. It is soluble and contains nitrogen, which plants need.

Practical 4: How much fertiliser is best?

Variables: change the concentration of fertiliser solution; measure the height of the seedlings (mm) after 7 days; keep the same: type and number of seeds, volume of solution each day, light, temperature, type of tray and growing material.

Prediction, e.g. the cress grows taller as the concentration increases, up to a point, because the plants get more nitrogen.

Equipment: measuring cylinder, balance, ruler, dropper, seed trays, eye protection. Not needed: Bunsen burner.

Hazards, e.g. spilled solution on the floor (wipe up, slip risk); mould on damp trays (do not handle mouldy material, dispose of safely); confusing solutions (label every bottle and tray).

Method key points: dissolve 8 g of fertiliser in 1 litre and dilute to make 4, 2 and 1 g l^{-1}; sow the same number of seeds on damp paper in each tray; add 5 cm^3 of the right solution each day; keep trays side by side on the same windowsill; after 7 days measure 10 seedlings per tray and find the mean; three trays per concentration.

Sample results (means): 0 g l^{-1}: 22 mm; 1 g l^{-1}: 31 mm; 2 g l^{-1}: 38 mm; 4 g l^{-1}: 43 mm; 8 g l^{-1}: 30 mm.

Graph: concentration on x (g l^{-1}), mean height on y (mm); a curve that rises to a peak at about 4 g l^{-1} and then falls.

Conclusion: as the concentration increased, the cress grew taller up to about 4 g l^{-1}, but grew less at 8 g l^{-1}.

Evaluate: (a) as a control, to show that any extra growth is caused by the fertiliser. (b) Too much fertiliser harms the roots (the solution is too concentrated and draws water out); a farmer should use the recommended amount, which also saves money and reduces run-off into rivers.

Check-up

1 A (potassium nitrate: it contains potassium and is soluble). 2 B.

3 Formula mass = 40.1 + 2 × (14.0 + 3 × 16.0) = 164.1 (1); % N = 28.0 ÷ 164.1 × 100 (1) = 17.1% (1)

4 (a) To speed up the reaction (1). (b) A lower temperature gives a higher yield of ammonia (1), but the reaction would be too slow, so a moderately high temperature balances rate and yield (1).

5 ammonia + nitric acid → ammonium nitrate (1)

TEACHER NOTES

Practical 5: Finding a half-life with dice

Time	About 30 minutes for three runs in pairs; results from the whole class can be pooled.
Kit per group	100 small dice (or 100 coins, or cubes with one marked face), a plastic container with a lid for shaking, a large tray.
Prep	Count the dice into bags of 100 before the lesson. Pooling the class's results gives a smoother curve.
Expected results	With sixes removed, about 17% of the dice go each throw; the number falls to half in about 3.8 throws. With coins (heads removed) the half-life is 1 throw.
Level	N5 models a random process, repeats, finds the mean, draws a decay curve and reads a half-life from it.

Safety and inclusion

- This is a model: no radioactive sources are used. Any demonstration with real sources must be carried out by staff only, following local rules and SSERC guidance.
- Pick up dropped dice to prevent slips. Risk assess for your own class and room.
- Large dice or a digital dice simulation help learners with fine motor difficulties.

Common problems

- **Counting the dice removed instead of those left:** record the number left after each throw.
- **Joining points with straight lines:** draw a smooth curve of best fit.
- **Reading the half-life:** draw a line across from 50 to the curve and then down.

No lab, no time, or a learner absent?

The sample results let learners calculate the means, draw the curve and find the half-life.

Assessment link

Evidence of recording, means, graphing and reading values from a graph. Assignment practice: compare with a theoretical value from another source and reference it.

Answers: Topic 5

Topic 5: Nuclear chemistry (N5)

1 Alpha, beta and gamma

1 Gamma: it is only reduced by thick lead or concrete, while alpha is stopped by paper and beta by a few mm of aluminium.

2 They have opposite charges: alpha is positive (attracted to the negative plate) and beta is negative (attracted to the positive plate).

3 Beta (it passes through paper but is stopped by aluminium).

2 Nuclear equations

1 $^{226}_{88}$Ra (radium-226).

2 $^{32}_{15}P \rightarrow {}^{32}_{16}S + {}^{0}_{-1}e$; the new element is sulfur.

3 (a) The mass number falls by 4 (b) the atomic number falls by 1 (−2 then +1).

3 Half-life and uses

1 The count rate falls from 640 to 320 counts per minute in 6 hours, so the half-life is 6 hours, as in the worked example.

2 One quarter = 2 half-lives; age = 2 × 5730 = 11 460 years.

3 Alpha cannot pass out of the body to reach the detector (and is very damaging inside the body); a 50-year half-life means the patient would stay radioactive for a very long time.

Practical 5: Finding a half-life with dice

Variables: change (count) the number of throws; measure the number of dice left; keep the same: the rule (remove sixes), the way the dice are shaken and thrown, the starting number of dice.

Prediction, e.g. the number of dice left will fall quickly at first and then more slowly, because each die has a 1 in 6 chance of being removed on each throw.

Equipment: 100 dice, large tray, container to shake, pencil. Not needed: stopwatch, eye protection, thermometer.

Hazards, e.g. noise from many groups shaking dice (shake gently, inside the container).

Method key points: shake all the dice in the container and tip into the tray; remove every six; count and record the dice left; repeat with the remaining dice until there are few left; three runs; mean for each throw.

Sample means (throws 0 to 8): 100, 86, 68, 58, 50, 42, 37, 32, 28.

Graph: throws on x, mean dice left on y; a smooth decay curve.

Conclusion: the number left falls to 50 after about 4.0 throws, so the half-life is about 4 throws (the theory value is 3.8 throws).

Evaluate: (a) decay is random, so each run is different; a mean of three runs is more reliable. (b) Remove more faces each throw (e.g. sixes and fives, or use coins and remove heads): each "nucleus" is more likely to decay, so half the sample goes in fewer throws.

Check-up

1 A. 2 C (54: beta emission increases the atomic number by 1).

3 $^{234}_{92}U \rightarrow {}^{230}_{90}Th + {}^{4}_{2}He$: correct products (1), numbers balanced (1).

4 60 ÷ 15 = 4 half-lives (1); 96 → 48 → 24 → 12 → 6 mg (1).

5 She is wrong: half-life is not affected by temperature, so cooling the tracer does not change how fast it decays. (1)

6 e.g. a beta emitter (passes through paper, and the amount getting through changes with thickness), or a long half-life so the count rate stays steady. (1)

TEACHER NOTES

Practical 6: How much gas does the metal make?

Time	One 50-minute lesson in groups of three. Four masses with three repeats is ambitious; groups can share masses and pool results.
Kit per group	Conical flask with bung and delivery tube, 100 cm^3 measuring cylinder, trough or large bowl of water, magnesium ribbon, balance (0.001 g ideal), 1.0 mol l^{-1} hydrochloric acid, 25 cm^3 measuring cylinder, eye protection.
Prep	Clean the magnesium with emery paper. With a 0.01 g balance, cut ribbon lengths using a known mass per centimetre (weigh 1 m and divide). Have spare water ready to refill troughs.
Expected results	About 9 to 10 cm^3 of hydrogen per 0.01 g of magnesium at room temperature (theory about 79 cm^3 for 0.080 g, using 24 dm^3 mol^{-1}), so a 100 cm^3 cylinder never overflows. Results are usually a little low because of gas lost while fitting the bung.
Level	N5 uses a gas collection technique, repeats, finds the mean, draws a line graph and evaluates sources of error.

Safety and inclusion

- Eye protection throughout. Hydrogen is flammable: no naked flames in the room; volumes are small.
- Do not heat the flask. When bubbling stops, lift the delivery tube out of the trough before the flask cools, to prevent suck-back of water into the flask.
- Dilute hydrochloric acid (1.0 mol l^{-1}) is low hazard but can sting eyes and cuts; keep eye protection on and wipe up spills. Mop up water spills to avoid slips.
- Risk assess for your own class, room and kit, following your employer's policies and SSERC guidance.
- Roles: one learner holds the cylinder steady, one adds the magnesium and fits the bung, one records.

Common problems

- **Air bubble in the cylinder at the start:** refill it fully before turning it over.
- **Gas lost before the bung is fitted:** hang the magnesium from the bung with thread, or use a small tube to tip it in.
- **Reading the scale upside down:** read at eye level and note the cylinder scale direction.

No lab, no time, or a learner absent?

The sample results let learners calculate the means, draw the graph and complete the conclusion and evaluation.

Assessment link

Evidence of a named technique (gas collection over water), recording, means, graphing and evaluating. Assignment practice: compare with calculated values from another source and reference it.

Answers: Topic 6

Topic 6: Chemical analysis (N5)

1 Apparatus and techniques

1 A pipette (with a safety filler).

2 Hydrogen does not dissolve well in water, so it pushes the water out of the tube instead of dissolving.

3 Residue: the mud (insoluble solid) left in the filter paper. Filtrate: the water (and anything dissolved in it) that passes through.

2 Tests to identify substances

1 Potassium.

2 Bubble the gas through limewater: carbon dioxide turns it cloudy (milky).

3 Yes: silver chloride is insoluble, so a (white) precipitate of silver chloride forms.

3 Titration and good results

1 To find the approximate end-point, so that the accurate titrations can be done carefully, drop by drop, near that volume.

2 18.20 and 18.05 cm^3 are concordant (0.15 cm^3 apart); mean = (18.20 + 18.05) ÷ 2 = 18.13 cm^3 (18.1 cm^3).

3 Any two: give each column a heading saying what was measured (e.g. rough, titre 1, titre 2); put the unit (cm^3) in the heading; record to 2 decimal places; mark which titres are concordant.

Practical 6: How much gas does the metal make?

Variables: change the mass of magnesium; measure the volume of hydrogen (cm^3); keep the same: volume and concentration of acid (in excess), temperature, form of the magnesium (ribbon), the collecting apparatus.

Prediction, e.g. doubling the mass of magnesium doubles the volume of hydrogen, because twice as many magnesium atoms react.

Equipment: conical flask and bung with delivery tube, measuring cylinder, trough of water, balance, magnesium ribbon, eye protection. Not needed: burette.

Hazards, e.g. dilute hydrochloric acid (1.0 mol l^{-1}) is low hazard but can sting eyes and cuts (eye protection, wipe spills); suck-back of water into the flask (do not heat the flask; lift the delivery tube out of the trough when bubbling stops); water spills on the floor (mop up, slip risk); glass delivery tube could break (handle the bung gently).

Method key points: fill the measuring cylinder with water and turn it upside down in the trough; put 25 cm^3 of acid in the flask; weigh the magnesium; drop it in and quickly fit the bung with the delivery tube under the cylinder; read the volume when the bubbling stops; repeat three times for each mass; mean.

Sample results (means): 0.020 g: 18 cm^3; 0.040 g: 38 cm^3; 0.060 g: 56 cm^3; 0.080 g: 76 cm^3. The theoretical volumes (24 dm^3 of gas per mole) are about 20, 40, 59, 79 cm^3, so the measured values are slightly lower, as expected when a little gas escapes.

Graph: mass on x (g), volume on y (cm^3); a straight line through the origin.

Conclusion: as the mass of magnesium increased, the volume of hydrogen increased in proportion (doubling the mass doubles the volume).

Evaluate: (a) the volumes would be too low; put the magnesium in a small tube inside the flask and tip it over after the bung is fitted, or use a gas syringe. (b) So that all the magnesium reacts and the volume depends only on the mass of magnesium.

Check-up

1 B (sodium). 2 B (burette).

3 Oxygen. (1)

4 (a) Copper(II) carbonate (1). (b) Filter it: the precipitate stays in the filter paper as the residue (1).

5 25.70 and 25.80 cm^3 are concordant (1); mean = (25.70 + 25.80) ÷ 2 = 25.75 cm^3 (1).

About the author



C. Blewis has taught for 17 years, including 10 years in Additional Support Needs (ASN) provision, teaching sciences, maths, PE and more.

In many schools, especially smaller and specialist settings, teachers are often asked to teach outside their own subject. These books are written for them, and for the young people they teach: clear, practical and ready to use from the first lesson.