REAL-LIFE CHEMISTRY

Nature's Chemistry

Teacher guide

For the National 5 Chemistry workbook



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Blewis LEARNING

Using the workbooks

The National 5 Chemistry workbook for **Nature's Chemistry** has five 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.

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TEACHER NOTES

Practical 1: Which hydrocarbons are unsaturated?

Time	One 50-minute lesson: planning (15 min), teacher demonstration with learners recording (20 min), analysis (15 min).
Kit	Fume cupboard; small stoppered bottles of heptane, cyclohexane, hex-1-ene and cyclohexene (or a cooking oil as the unsaturated example); a non-flammable solvent to dissolve them in, as advised by SSERC; dilute bromine water in a dropper bottle; test tubes and rack; 1 cm^3 graduated pipettes; white tile; eye protection and gloves.
Prep	Use 0.10 cm^3 (2 drops) of each hydrocarbon in 2.0 cm^3 of the solvent. Make the bromine water fresh and very dilute, and do a trial first: adjust its strength so cyclohexene takes about 15 drops. Keep everything in the fume cupboard with lids on. No naked flames in the room.
Expected results	Alkanes and cycloalkanes leave the first drop orange. Alkenes and cycloalkenes decolourise the bromine water at once; drop counts depend on the bromine water concentration and are only comparable within one batch.
Level	N5 plans the test, names variables, records repeats with a mean, draws a bar chart, concludes and evaluates.

Safety and inclusion

- Teacher demonstration only: the hydrocarbons are highly flammable and their vapours harmful; bromine water is harmful and an irritant. Work in a fume cupboard with eye protection and gloves.
- Learners can record from a visualiser or a video of the demonstration if the room layout makes viewing difficult.
- Risk assess this practical for your own learners, room and kit, following your employer's policies and SSERC guidance.

Common problems

- **"Goes clear":** the correct word is **decolourised**.
- **Calling heptane and cyclohexane isomers:** compare the molecular formulae first.
- **Thinking cycloalkanes are unsaturated** because they are rings: all the bonds are single.

No lab, no time, or a learner absent?

The sample results let learners find the means, draw the bar chart and complete the conclusion and evaluation.

Assessment link

Practises assignment skills: identifying variables, recording raw data with a mean, a bar chart with labelled axes, and comparing results with a referenced source.

Answers: Topic 1

Topic 1: Hydrocarbons (N5)

1 Families of hydrocarbons

1 pentane C_5H_{12}; hexane C_6H_{14}; heptane C_7H_{16}; octane C_8H_{18}

2 $C_{10}H_{22}$

3 Methane, ethane, propane and butane: their boiling points are below 20 °C, so at room temperature they are above their boiling point.

4 Pentane has larger molecules with stronger forces of attraction between them, so it has the higher boiling point (36 °C against −1 °C) and condenses first as the mixture cools.

2 Drawing and naming alkanes

1 A 2,3-dimethylpentane; B 3-ethylhexane.

2 A chain of six carbons with one CH_3 branch on carbon 2, and every carbon with four bonds (C_7H_{16}, $CH_3CH(CH_3)CH_2CH_2CH_2CH_3$).

3 The chain must be numbered from the end nearer the branch, so the branch is on carbon 2: **2-methylpentane**.

3 Rings, isomers and bromine water

1 C_7H_{14}

2 Isomers of hexane (C_6H_{14}): 2-methylpentane.

Isomers of cyclohexane (C_6H_{12}): hex-1-ene.

3 2-methylpropane: a chain of three carbons with a CH_3 branch on the middle carbon (C_4H_{10}).

4 Cycloalkanes are saturated, so they do not decolourise bromine water. A sample that does is unsaturated, for example an alkene.

Practical 1: Which hydrocarbons are unsaturated?

Change: the hydrocarbon. Measure: drops of bromine water decolourised (or whether it decolourises). Keep the same: volume of hydrocarbon (0.10 cm³) and of solvent (2.0 cm³), the same bromine water and dropper (drop size), shaking after each drop, temperature.

Prediction, e.g. hex-1-ene and cyclohexene will decolourise bromine water because they have a C=C double bond.

Equipment: test tubes, rack, dropper, graduated pipette, eye protection. Not needed: thermometer, Bunsen burner.

Hazards, e.g. bromine water is harmful and irritates skin and eyes (eye protection, gloves, teacher handles it, fume cupboard); hydrocarbon vapour is harmful to breathe (fume cupboard, lids on); spills (small volumes, mop up at once).

Method key points: put 2.0 cm³ of the solvent in a clean test tube and add 0.10 cm³ (2 drops) of the hydrocarbon from a graduated pipette; add bromine water one drop at a time, shaking after each; count the drops until the orange colour stays; repeat three times; find the mean.

Headings: Hydrocarbon, Run 1 (drops), Run 2 (drops), Run 3 (drops), Mean (drops), Saturated?

Sample means: heptane 0, cyclohexane 0, hex-1-ene 13.3, cyclohexene 16.3 drops. Heptane and cyclohexane are saturated; hex-1-ene and cyclohexene are unsaturated. Cyclohexene needs more drops because 0.10 cm³ of it contains more molecules (it is denser and has a slightly smaller formula mass), each with one C=C.

8 The unsaturated hydrocarbons were hex-1-ene and cyclohexene, which decolourised bromine water; heptane and cyclohexane are saturated.

9a Heptane (C_7H_{16}) and cyclohexane (C_6H_{12}) have different molecular formulae, so they are not isomers. Neither decolourised bromine water, which shows both are saturated. 9b Reliable: repeat each test and use the mean. Accurate: use a burette or a graduated dropper for the bromine water, so each drop is the same size, and a white background to see the end point.

Check-up

1 B (1)

2 2,4-dimethylhexane (1)

3 A five-carbon chain with a C_2H_5 branch on carbon 3, all carbons with four bonds (1)

4 Larger molecules (1) have stronger forces of attraction between the molecules, so more energy is needed to separate them (1).

5 Add bromine water to each and shake (1). Hex-1-ene decolourises it rapidly; with cyclohexane it stays orange (1).

TEACHER NOTES

Practical 2: Which oil is the most unsaturated?

Time	One 50-minute lesson: planning (15 min), demonstration with learners recording (20 min), analysis (15 min).
Kit	Fume cupboard; sunflower, rapeseed and olive oil; butter and coconut oil; a water bath at about 40 °C for melting the fats; a non-flammable solvent for the oils, as advised by SSERC; dilute bromine water in a dropper bottle; test tubes and rack; 1 cm^3 graduated pipettes; white tile; eye protection and gloves.
Prep	Use 0.10 cm^3 (2 drops) of each oil in 2.0 cm^3 of the solvent. Make the bromine water fresh and very dilute, and do a trial first: adjust its strength so sunflower oil takes 20 to 30 drops. Melt the solid fats in the water bath before the lesson.
Expected results	Sunflower and rapeseed decolourise the most, olive oil less, butter and coconut oil very little. Exact counts depend on the batch of bromine water, so compare oils within one lesson.
Level	N5 plans the comparison, controls temperature and volume, finds means, draws a bar chart, links the results to C=C bonds and evaluates.

Safety and inclusion

- Teacher demonstration only: bromine water is harmful and an irritant. Fume cupboard, eye protection and gloves.
- Check for food allergies (nut or seed oils) before handling food products, even though nothing is eaten.
- Risk assess this practical for your own learners, room and kit, following your employer's policies and SSERC guidance.

Common problems

- **Thinking more drops means less unsaturated:** more bromine used up means more C=C bonds.
- **Hydrogenation and hydration mixed up:** hydrogen against water.
- **Numbering from the wrong end** when naming alkenes.

No lab, no time, or a learner absent?

The sample results let learners find the means, draw the bar chart and complete the conclusion and evaluation.

Assessment link

Practises assignment skills: controlled variables, raw data with means, a bar chart, a conclusion linked to the underlying chemistry, and a referenced comparison.

Answers: Topic 2

Topic 2: Alkenes (N5)

1 The carbon to carbon double bond

1 C_7H_{14}

2 pent-2-ene

3 A chain of six carbons with the double bond between carbons 3 and 4 and every carbon making four bonds ($CH_3CH_2CH{=}CHCH_2CH_3$).

4 He numbered from the wrong end. Numbering from the end nearer the double bond gives **pent-1-ene**.

2 Addition reactions

1 ethane

2 2,3-dibromobutane: a four-carbon chain with one Br on carbon 2 and one Br on carbon 3, all single bonds.

3 hydration (an addition reaction)

4 The small molecule adds on across the C=C double bond; the two reactants join to make one product and nothing else is formed.

3 Isomers and unsaturated oils

1 C_5H_{10}

2 cyclobutane (a four-carbon ring with two H on each carbon) or methylcyclopropane.

3 Cyclohexane is saturated (only single C–C bonds), so bromine cannot add on. Hex-1-ene has a C=C double bond, so bromine adds across it and the colour goes.

4 Hydrogen adds across some of the C=C double bonds, so the oil is less unsaturated; the molecules pack more closely, raising the melting point above room temperature.

Practical 2: Which oil is the most unsaturated?

Change: the oil or fat. Measure: number of drops of bromine water decolourised. Keep the same: volume of oil (0.10 cm^3) and of solvent (2.0 cm^3), same dropper and bromine water, shaking after each drop, temperature.

Prediction, e.g. sunflower oil will decolourise the most bromine water because it has the most C=C double bonds.

Equipment: test tubes, dropper, graduated pipette, warm-water bath, eye protection. Not needed: filter funnel, spirit burner.

Hazards, e.g. hot water bath for melting the fats (scalds: water no hotter than 50 °C); bromine water on skin (gloves, wash off at once); slippery spilt oil (wipe up).

Method key points: melt the solid fats in a warm water bath; put 2.0 cm^3 of the solvent in a test tube and add 0.10 cm^3 of the oil from a graduated pipette; add bromine water one drop at a time, shaking, until the orange colour stays; repeat three times; find the mean.

Headings: Oil or fat, Run 1 (drops), Run 2 (drops), Run 3 (drops), Mean (drops).

Sample means: sunflower oil 26, rapeseed oil 22.3, olive oil 16.7, butter (melted) 5.7, coconut oil (melted) 1.7 drops.

8 Sunflower oil was the most unsaturated (most C=C bonds), then rapeseed, olive, butter and coconut oil.

9a They decolourised very little bromine water, so they have few C=C bonds (more saturated); saturated molecules pack closely, so they have higher melting points. 9b The number of drops depends on how much oil there is, so the same volume is needed for a fair test; e.g. use a burette for the bromine water, or a white background to judge the end point.

Check-up

1 C (1)

2 4-methylpent-1-ene (1)

3 hydrogenation (or addition) (1); pentane (1)

4 ethanol: CH_3 bonded to CH_2 bonded to O–H, all bonds drawn (1)

5 Sunflower oil decolourises more bromine water (1), so it has more C=C double bonds / is more unsaturated than olive oil (1).

TEACHER NOTES

Practical 3: Which alcohols mix with water?

Time	One 50-minute lesson: planning (15 min), practical (20 min), graph and evaluation (15 min).
Kit per group	25 cm^3 stoppered measuring cylinders, small dropper bottles of ethanol, propan-1-ol, butan-1-ol and pentan-1-ol (hexan-1-ol optional), distilled water, eye protection. Methanol is not used by learners: it is toxic, so if it is shown at all the teacher handles it wearing gloves.
Prep	Dispense the alcohols into small labelled bottles. A drop of food colouring in the water makes the layers much easier to see. No naked flames anywhere in the room.
Expected results	Ethanol and the propanols mix completely (one layer). Butan-1-ol and larger alcohols form two layers. Measure the lower water layer: about 4.4 cm^3 for butan-1-ol, about 4.8 cm^3 for pentan-1-ol and about 4.9 cm^3 for hexan-1-ol, because some alcohol and water dissolve in each other.
Level	**N5** plans the test, controls volumes and times, finds means, draws a line graph, concludes and evaluates.

Safety and inclusion

- All the alcohols are flammable and harmful. Small volumes, good ventilation, eye protection, no flames. Teacher dispenses. Methanol is toxic and is not used by learners.
- Learners who cannot shake a cylinder safely can invert it gently, or a partner can do it.
- Risk assess this practical for your own learners, room and kit, following your employer's policies and SSERC guidance.

Common problems

- **Reading the wrong layer** (measure the lower water layer) or not at eye level.
- **Forgetting the O in –OH** when balancing combustion equations.
- **Numbering the chain from the wrong end** when naming alcohols.

No lab, no time, or a learner absent?

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

Assessment link

Practises assignment skills: raw data with units, means, a line graph with labelled axes, a conclusion and a comparison with referenced data.

Answers: Topic 3

Topic 3: Alcohols (N5)

1 The hydroxyl group

1 $C_6H_{13}OH$

2 propan-2-ol

3 A chain of five carbons with the –OH on the middle carbon (carbon 3), every carbon with four bonds.

4 The chain must be numbered from the end nearer the –OH, so it is **butan-1-ol**.

2 Fuels, solvents and mixing with water

1 The boiling point increases as the number of carbon atoms increases (65 °C to 138 °C), because larger molecules have stronger forces of attraction between them.

2 Ethanol is miscible with water, so it makes one even mixture; pentan-1-ol does not mix and would form a layer.

3 No (immiscible): it has a long carbon chain, and alcohols from butanol upwards form a separate layer.

4 Fuel, e.g. camping stove fuel or added to petrol. Solvent, e.g. in hand gel, perfume, ink or lens cleaner.

3 Burning alcohols and isomers

1 $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

2 Carbon dioxide and water. Carbon dioxide turns limewater cloudy (milky), or water turns blue cobalt chloride paper pink.

3 butan-2-ol (–OH on carbon 2), or 2-methylpropan-1-ol, or 2-methylpropan-2-ol.

Practical 3: Which alcohols mix with water?

Change: the alcohol (number of carbon atoms). Measure: volume of the lower water layer (cm³), or whether there is only one layer. Keep the same: volumes of alcohol and water (5.0 cm³ each), shaking time, settling time (2 minutes), temperature.

Prediction, e.g. the larger alcohols will not mix and will form a layer, because their long carbon chains do not mix with water.

Equipment: 25 cm³ stoppered measuring cylinders, pipette, eye protection, timer. Not needed: filter funnel, Bunsen burner, balance.

Hazards, e.g. alcohol vapours are harmful (well-ventilated room, lids on); alcohols in the eyes (eye protection); a stopper popping off when shaking (hold it in place, point it away from people). Methanol is toxic, so it is not used by learners; if it is shown at all, the teacher handles it wearing gloves.

Method key points: measure 5.0 cm³ of water and 5.0 cm³ of alcohol into a 25 cm³ stoppered measuring cylinder; shake for 10 s; leave for 2 minutes; read the volume of the lower (water) layer at eye level; repeat three times; find the mean.

Headings: Alcohol, Number of carbons, Run 1 (cm³), Run 2 (cm³), Run 3 (cm³), Mean (cm³).

Sample means: ethanol and propan-1-ol one layer; butan-1-ol 4.4 cm³, pentan-1-ol 4.8 cm³, hexan-1-ol 4.9 cm³.

8 Ethanol and propan-1-ol mixed completely with water (one layer). From butan-1-ol upwards two layers formed, and the water layer got closer to 5.0 cm³ as the chain got longer, so less alcohol mixed with water.

9a The layers take time to separate; reading too soon gives a wrong layer volume, so the same time is needed for a fair test. 9b Accurate: read the bottom of the meniscus at eye level, or use a cylinder with finer scale divisions. Reliable: repeat each alcohol and use the mean.

Check-up

1 B (1)

2 butan-2-ol (1)

3 A three-carbon chain with a CH_3 branch on carbon 2 and the –OH on carbon 1, all bonds shown (1)

4 Butan-1-ol has a longer carbon chain, so it is less miscible with water (1).

5 Correct formulae for products CO_2 and H_2O (1); balanced: $2C_3H_7OH + 9O_2 \rightarrow 6CO_2 + 8H_2O$ (1)

TEACHER NOTES

Practical 4: Which vinegar is the strongest?

Time	Two 50-minute lessons: planning and one vinegar (lesson 1), the other vinegars, calculation and evaluation (lesson 2). Groups can share vinegars to save time.
Kit per group	Burette and stand, small funnel, 25 cm^3 pipette and pipette filler, conical flasks, white tile, phenolphthalein, 0.100 mol l^{-1} sodium hydroxide, three vinegars each diluted ten times (25 cm^3 made up to 250 cm^3 in a volumetric flask), eye protection.
Prep	Dilute the vinegars in advance. Make up and check the sodium hydroxide; label it clearly. Show how to read the burette at eye level and how to swirl.
Expected results	Supermarket vinegars of about 5% ethanoic acid give titres of about 20 to 22 cm^3 (diluted concentration about 0.08 mol l^{-1}, undiluted about 0.8 mol l^{-1}). Stronger pickling vinegars give larger titres.
Level	N5 carries out a titration, uses concordant titres, calculates concentrations with the four-step layout, draws a bar chart and evaluates.

Safety and inclusion

- Eye protection throughout. Fill burettes below eye level using a funnel, and remove the funnel before titrating. Always use a pipette filler.
- A learner with limited fine motor control can read the burette and record while a partner controls the tap.
- Risk assess this practical for your own learners, room and kit, following your employer's policies and SSERC guidance.

Common problems

- **Volumes left in cm^3** in n = c × V: divide by 1000.
- **Including the rough titre** in the mean.
- **Forgetting the dilution factor** for the original vinegar.

No lab, no time, or a learner absent?

The sample titres let learners pick concordant results, calculate all three concentrations and draw the bar chart.

Assessment link

Practises assignment skills: raw data with units, means of concordant results, a calculation set out step by step, a bar chart and a comparison with a referenced value (the bottle label).

Answers: Topic 4

Topic 4: Carboxylic acids (N5)

1 The carboxyl group

1 $CH_3CH_2CH_2COOH$ (or C_3H_7COOH)

2 propanoic acid

3 A three-carbon chain counting the –COOH carbon as carbon 1, with two CH_3 groups on carbon 2 (the carbon next to the –COOH).

4 $C_5H_{11}COOH$

2 Vinegar and other uses

1 Vinegar is acidic (it contains ethanoic acid), and most microbes cannot grow in acidic conditions, so the food does not decay.

2 The boiling point increases as the chain gets longer (101 °C to 205 °C), because larger molecules have stronger forces of attraction between them.

3 Red to orange, pH below 7 (about 3).

4 Pentanoic acid is only partly miscible and hexanoic acid barely mixes with water.

3 Reactions and salts

1 potassium methanoate

2 zinc + ethanoic acid → zinc ethanoate + hydrogen

3 calcium carbonate + ethanoic acid → calcium ethanoate + water + carbon dioxide. Carbon dioxide turns limewater cloudy (milky).

4 Propanoic acid and sodium hydroxide (or sodium oxide or sodium carbonate).

Practical 4: Which vinegar is the strongest?

Change: the vinegar. Measure: the titre (volume of sodium hydroxide, cm^3). Keep the same: volume of diluted vinegar (25.0 cm^3), dilution, concentration of sodium hydroxide, indicator and amount, end-point colour.

Prediction, e.g. the white wine vinegar will be strongest because it is used for pickling.

Equipment: burette, 25 cm^3 pipette with filler, conical flask, white tile, small funnel. Not needed: Bunsen burner, thermometer.

Hazards, e.g. phenolphthalein solution is flammable (keep away from flames); broken glass from a burette or pipette (clamp the burette, handle carefully); vinegar in the eyes (eye protection).

Method key points: use a pipette and filler to put 25.0 cm^3 of diluted vinegar in the flask; add 2 or 3 drops of phenolphthalein; run in sodium hydroxide from the burette, swirling, until a permanent pale pink; do a rough titre then accurate titres, adding dropwise near the end point, until two are concordant (within 0.2 cm^3).

Headings: Vinegar, Rough titre (cm^3), Titre 1 (cm^3), Titre 2 (cm^3), Titre 3 (cm^3), Mean of concordant titres (cm^3).

7 A (malt): mean 20.90 cm^3, n = 0.00209 mol, diluted 0.0836 mol l^{-1}, undiluted 0.836 mol l^{-1}; B (cider): mean 18.63 cm^3, n = 0.00186 mol, diluted 0.0745 mol l^{-1}, undiluted 0.745 mol l^{-1}; C (white wine): mean 24.0 cm^3, n = 0.00240 mol, diluted 0.0960 mol l^{-1}, undiluted 0.960 mol l^{-1}.

8 Vinegar C was the strongest (0.96 mol l^{-1}) and B the weakest (0.75 mol l^{-1}). (Vinegar A, 0.836 mol l^{-1}, is about 50 g of ethanoic acid per litre.)

9a A pipette measures one fixed volume far more accurately than a measuring cylinder. 9b The rough titre overshoots the end point because the alkali is added quickly; it only shows roughly where the end point is.

Check-up

1 B (1)

2 2-methylpentanoic acid (1)

3 ethanoic acid + sodium carbonate → sodium ethanoate (1) + water + carbon dioxide (1)

4 Mole ratio 1 : 1; n(NaOH) = 0.150 × 0.0180 = 0.00270 mol (1); n(acid) = 0.00270 mol (1); c = 0.00270 ÷ 0.0250 = 0.108 mol l^{-1} (1)

5 e.g. pickling: vinegar is acidic and microbes cannot grow in it; or descaling: the acid reacts with limescale (calcium carbonate) (1).

TEACHER NOTES

Practical 5: Which alcohol releases the most energy?

Time	One or two 50-minute lessons, depending on how many alcohols and repeats. Learners can each record one alcohol and share data.
Kit (teacher)	Spirit burners of methanol, ethanol, propan-1-ol and butan-1-ol with caps; copper calorimeter can; clamp stand; heatproof mat; draught shields; thermometer or probe; stirrer; balance reading to 0.01 g; measuring cylinder; eye protection.
Prep	Check the burners are not overfilled and the wicks are trimmed. Set up the cans at a fixed height above the wick. Keep spare alcohol out of the room.
Expected results	Energy per gram about 15 to 20 kJ g^{-1} for methanol rising to about 25 to 30 kJ g^{-1} for butanol; about 60 to 80% of the data book values because of heat losses.
Level	N5 plans the comparison, records repeat masses from the demonstration, calculates E_h and energy per gram, draws a line graph, compares with data book values and evaluates.

Safety and inclusion

- Teacher demonstration only. Learners are seated at a marked safe distance, away from all flames and flammable liquids. Fire blanket available. Caps on spirit burners whenever they are not lit. Never refill a burner in the room or near a flame. Methanol is toxic.
- Learners who need to sit observe seated at the safe distance or via a visualiser. Eye protection for everyone; the teacher uses tongs for the hot can and lets it cool.
- Risk assess this practical for your own learners, room and kit, following your employer's policies and SSERC guidance.

Common problems

- **Water volume in cm^3** used as m: convert to kg (100 cm^3 = 0.100 kg).
- **Final temperature used as ΔT.**
- **Burner weighed without its cap,** so evaporation counts as fuel burned.

No lab, no time, or a learner absent?

The sample results let learners calculate E_h, the energy per gram, draw the line graph and complete the evaluation.

Assessment link

Practises assignment skills: raw data with units, means, a calculation set out clearly, a line graph, a comparison with referenced data and an evaluation of sources of error.

Answers: Topic 5

Topic 5: Energy from fuels (N5)

1 Exothermic and endothermic

1 burning propane: exo; cold pack: endo; neutralisation: exo; respiration: exo; photosynthesis: endo; ice melting: endo.

2 Endothermic: the temperature fell, so heat energy was taken in from the surroundings.

3 The reaction releases heat energy to the surroundings, including your hands.

4 e.g. releases a lot of energy per kg; burns easily and cleanly; easy to store and carry (propane is a gas that can be stored as a liquid under pressure); light.

2 Combustion equations

1 $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

2 $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$

3 $C_4H_9OH + 6O_2 \rightarrow 4CO_2 + 5H_2O$

4 The oxygen inside the tent gets used up, so incomplete combustion makes carbon monoxide, a poisonous gas (there is also a fire risk).

3 Calculating the energy

1 $\Delta T = E_h \div (c\ m) = 16.7 \div (4.18 \times 0.250) = 16.0$ °C

2 $E_h = c\ m\ \Delta T = 2.00 \times 1.5 \times 160 = 480$ kJ

3 $12.6 \div 0.60 = 21.0$ kJ g^{-1}

Practical 5: Which alcohol releases the most energy?

Change: the alcohol. Measure: mass of alcohol burned (g), start and final water temperature (°C). Keep the same: volume of water (100 cm³), the can, temperature rise (20 °C), distance from flame to can, draught shield.

Prediction, e.g. the larger alcohols will release more energy per gram, because a smaller fraction of each molecule's mass is the oxygen that is already part of the –OH group.

Equipment: spirit burners, copper can, thermometer, balance, measuring cylinder (and clamp stand and draught shields). Not needed: burette, white tile.

Hazards, e.g. hot copper can and water (teacher uses tongs and lets it cool); thermometer breaking (use a probe); spilt alcohol catching fire (caps on, fire blanket ready, learners kept back).

Method key points: weigh the burner with its cap on; measure 100 cm³ of water into the can and record the temperature; teacher lights the burner, stirs and heats until the temperature has risen by 20 °C; put the cap on and reweigh; repeat; $E_h = c\ m\ \Delta T$; energy per gram = $E_h \div$ mass burned.

Headings: Alcohol, Number of carbons, Mass burned run 1 (g), run 2 (g), run 3 (g), Mean mass burned (g).

7 $E_h = 4.18 \times 0.100 \times 20 = 8.36$ kJ. methanol: mean 0.48 g, 17.4 kJ g^{-1}; ethanol: mean 0.37 g, 22.6 kJ g^{-1}; propan-1-ol: mean 0.33 g, 25.3 kJ g^{-1}; butan-1-ol: mean 0.30 g, 27.9 kJ g^{-1}.

8 As the number of carbon atoms increased, the energy released per gram increased (by a smaller amount each time).

9a Heat is lost to the surroundings (air, can, clamp) rather than into the water; incomplete combustion (soot on the can); some alcohol evaporates from the wick. 9b e.g. a lid on the can, insulate the can, use draught shields, keep the flame close to the can, cap the burner as soon as it is put out.

Check-up

1 C (1)

2 Correct formulae CO_2 and H_2O as products (1); $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$ (1)

3 $E_h = c\ m\ \Delta T$ (1); $E_h = 4.18 \times 0.150 \times 20$ (1); $E_h = 12.5$ kJ (1)

4 $12.54 \div 0.45 = 27.9$ kJ g^{-1} (1)

5 e.g. use a draught shield, a lid or insulation on the can, or put the flame closer to the can (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.