Core practical: combustion calorimetry

Student activity • practical and reasoning

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The question

How much of a fuel's energy reaches the water?

Measure a water temperature rise and fuel mass loss using an ethanol spirit burner. Evaluate why a simple apparatus captures only part of the energy released.

Equipment

- Eye protection, clamped metal calorimeter, 100 cm^3 measuring cylinder, thermometer and stirrer
- Heatproof mat, nonflammable ventilated draught shield, tongs and staff-filled ethanol spirit burner with snuffer cap
- Balance and 100.0 cm^3 water; no pupil fuel refilling

Ethanol is highly flammable. Wear eye protection and tie hair back; snuff with the cap using tongs. No hot-burner refilling; cool before weighing and keep ventilation around the flame.

Course coverage: Shared core: 3.2–3.4 and 3.8, combustion calorimetry. Ethanol is a named fuel here; its Chemistry-only reaction chemistry is not required.

Plan, model or apparatus sketch

Draw the clamped calorimeter, water, probe, spirit burner and ventilated shield. Label the heat-loss routes.

Method and reasoning

Read the whole sequence before starting

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1. Wear eye protection, tie hair back and clear flammables. Have the teacher check the stable calorimeter, flame clearance and ventilated shield.

2. Measure 100.0 cm^3 water into the calorimeter and record its temperature. Weigh the cool capped burner and record the fuel identity.

3. Remove the cap and light only when instructed. Stir the water gently and monitor temperature with the probe immersed clear of the metal.

4. At a planned rise of about 20 °C, or an absolute water temperature of 60 °C if reached first, use tongs to replace the snuffer cap. Never blow out the flame or refill a hot burner.

5. Keep recording to find the maximum water temperature. Let the capped burner cool as directed before weighing it again; record mass loss and possible evaporation.

6. Calculate $q(water)=mc\Delta T$ and energy per gram of fuel lost. For pure ethanol use $M=46.0\ g\ mol^{-1}$ to estimate molar ΔH with a negative sign; evaluate heat losses and incomplete combustion.

Cleanup

• Staff confirm every flame is extinguished, collect cooled capped burners and store fuel safely. Leave hot calorimeters to cool before emptying water.

Record your evidence

Blank spaces are for your own work

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Reference and task data

Invented practice data only: water mass 100.0 g; initial 20.0 °C, maximum 40.0 °C; capped burner 150.00 g before and 149.20 g after. Use c(water)=4.18 J g^{-1} $°C^{-1}$; M(ethanol)=46.0 g mol^{-1}. A burner mass loss may include evaporation, so it is not automatically all combusted fuel.

Measurement	Initial / final	Working / units
Water temperature		
Capped burner mass		
q / mass loss / ΔH		

Show your calculations, labelled model or correction here.

Explain and evaluate

Use evidence and show calculation steps where relevant

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1. Calculate ΔT and energy gained by water for your actual data or the labelled example.

2. Calculate the example fuel mass loss and energy per gram.

3. Estimate the example molar enthalpy change for pure ethanol.

4. Explain why heat absorbed by apparatus reduces the measured magnitude.

5. Explain how evaporation can bias the result.

6. Suggest an improvement that retains adequate oxygen supply.