Comparing alcohols by heating water

Edexcel GCSE Chemistry (1CH0) · Foundation and Higher

Show your working where needed. Check the worked answers when you finish.

Name _____ Date _____

1. Compare the temperature changes

Equal masses of two fuels heat equal masses of water. With ethanol the water goes from 18.0 °C to 43.0 °C. With butan-1-ol it goes from 21.0 °C to 44.0 °C. Which fuel gives the larger rise in these trials? Show both calculations.

2. Measurements on the balance

A capped burner containing propan-1-ol has a mass of 91.37 g before heating. It is capped and cooled afterwards and has a mass of 90.79 g. Calculate the mass lost and explain why both measurements include the burner.

3. Conditions for a fair comparison

A teacher compares the rise when the same mass of each alcohol is burned to heat the same mass of water. One burner sits farther below the water container. Explain how this can affect the result. Give one other apparatus control.

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4. A problem in one repeat

Four repeats with ethanol give temperature rises of 20.0, 20.4, 19.9 and 14.1 °C. A note says the draught shield fell during the last run. Decide which readings to use for a mean and calculate it to one decimal place.

5. Test a claim about the series

Under the same test conditions, mean rises for ethanol, propan-1-ol, butan-1-ol and pentan-1-ol are 14.8, 16.1, 18.2 and 17.9 °C. Sketch a bar chart and decide whether these means increase at every step in the series.

6. A deposit on the container

After one run, there is a black, sooty deposit on the bottom of the container. What does this suggest about the reaction? Explain one reason the temperature rise may differ from a run with complete combustion.

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7. The same rise by two routes

In one apparatus, heating the same mass of water by 20.0 °C uses 0.78 g of ethanol or 0.65 g of propan-1-ol. Which fuel transferred more energy to the water per gram lost in this test? Explain.

8. Match the amounts of fuel (Higher)

A class wants to burn the same number of moles of each fuel. They plan to use 0.920 g of ethanol. Calculate the mass of butan-1-ol to use. The relative formula masses are 46.0 for ethanol and 74.0 for butan-1-ol.

9. Extra challenge · Check the ranking after two changes

A class heats equal masses of water. In an open container, 0.80 g of ethanol raises the temperature by 24 °C and 0.50 g of butan-1-ol raises it by 18 °C. On repeating only the ethanol trial with a lid, 0.75 g raises it by 28 °C.

Compare the temperature rise per gram for all three results. Explain which comparison is fair and how to test whether the lid caused the change.

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Worked answers

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1. Compare the temperature changes

For ethanol the rise is 43.0 − 18.0 = 25.0 °C. For butan-1-ol it is 44.0 − 21.0 = 23.0 °C. Ethanol gives the larger measured rise even though its final temperature is lower.

2. Measurements on the balance

Mass lost = 91.37 − 90.79 = 0.58 g. The mass of the same empty burner and cap is included in both readings, so it cancels when they are subtracted.

3. Conditions for a fair comparison

A larger gap can reduce the proportion of energy that reaches the water, so the rise could be smaller for a reason unrelated to the fuel. Keep the burner-to-container distance the same. Also keep the wick length or the container material and shape the same.

4. A problem in one repeat

Use the first three readings. The note identifies a changed condition during the last run, which could have increased energy loss. Record that reading but exclude it from the mean and repeat that run under the intended conditions.

Mean rise = (20.0 + 20.4 + 19.9) ÷ 3 = 20.1 °C.

5. Test a claim about the series

Put the four alcohols along the horizontal axis and mean temperature rise in °C on the vertical axis. Draw bars of heights 14.8, 16.1, 18.2 and 17.9.

The rise increases from ethanol to butan-1-ol, then decreases by 0.3 °C for pentan-1-ol. These means do not show an increase at every step.

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Worked answers

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6. A deposit on the container

Soot is evidence of incomplete combustion. Some carbon in the fuel has formed solid carbon rather than carbon dioxide. This releases less energy than fully burning the same amount of fuel, so a smaller temperature rise is possible.

7. The same rise by two routes

Propan-1-ol. The same mass of water has the same temperature rise, so the energy transferred to the water is the same. The measured mass lost is smaller for propan-1-ol, so the transfer per gram lost is greater.

8. Match the amounts of fuel (Higher)

Amount of ethanol = 0.920 ÷ 46.0 = 0.0200 mol. To match this amount, mass of butan-1-ol = 0.0200 × 74.0 = 1.48 g.

9. Extra challenge · Check the ranking after two changes

Ethanol without lid: 24 ÷ 0.80 = 30 °C/g. Butan-1-ol without lid: 18 ÷ 0.50 = 36 °C/g. Ethanol with lid: 28 ÷ 0.75 ≈ 37 °C/g.

The open-container trials compare the fuels with the same apparatus. A lid can reduce heat loss, making the ethanol figures from different setups unsuitable for ranking the fuels. Repeat matched ethanol trials with and without the lid, holding the starting water temperature, water mass and burner distance constant.

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