Objectives

C9.26C Recall the formulae of molecules of the alcohols, methanol, ethanol, propanol (propan-1-ol only) and butanol (butan-1-ol only), and draw the structures of these molecules, showing all covalent bonds.

C9.27C Recall that the functional group in alcohols is –OH.

C9.28C *Core practical: Investigate the temperature rise produced in a known mass of water by the combustion of the alcohols, ethanol, propanol, butanol and pentanol.*

C9.32C Recall members of a given homologous series have similar reactions because their molecules contain the same functional group and use this to predict the products of other members of these series.

Maths requirements

1a Recognise and use expressions in decimal form.

2c Construct and interpret frequency tables and diagrams, bar charts and histograms.

5b Visualise and represent 2D and 3D forms including two dimensional representations of 3D objects.

Learning outcomes

6th **SC9.26C** State the names, formulae and structures of the first four members of the alcohol homologous series.

6th **SC9.27C** State the functional group present in all alcohols.

6th **SC9.32C** Describe some chemical reactions of alcohols.

6th **SC9.32C** Explain why alcohols have similar chemical properties.

7th **SC9.32C** Use the chemical properties of the first four alcohols to predict the properties of other alcohols.

Exploring

1. Core practical – Combustion of alcohols

This practical forms part of the core practical requirement of the specification. It is supported by the information on *Students' sheet CP8(The combustion of alcohols)* and in the Student Book.

Students work in groups following the instructions of Students' sheet CP8(The combustion of alcohols) to investigate the temperature rise produced in a known mass of water by the combustion of the alcohols ethanol, propanol, butanol and pentanol. In this investigation pentanol has been substituted for methanol, due the specific hazards and toxicity of methanol. During the investigation the students measure the mass of alcohol burned to produce a particular temperature rise. To compare the alcohols, the students then calculate the mass burned to produce a 1 °C rise in temperature. There are other ways to compare the 'heat energy' given out by the alcohols, e.g. they could calculate the temperature rise produced by burning a set mass (1 g) of alcohol. If time is short each student group could use a different alcohol and share the results for analysis. Emphasise to the students that the main source of error in this investigation is the 'heat' lost during the experiment. Therefore the use of draught excluders and insulation needs to be as consistent as possible from one experiment to the next.

Most students should be able to carry out the practical and draw conclusions using the first page of the worksheet, which contains some directed questions at the bottom.

⚠ Safety

Wear eye protection at all times.

All alcohols are flammable. Handle the alcohols with care and keep the tops on burners when not in use.

Refer to CLEAPSS LABORATORY HANDBOOK (2009), Section 9.4.3 Using spirit burners in calorimetry.

Support: Some students will need to be shown how to set up and use the apparatus so that heat losses are kept to a minimum. Students should use the second page of the worksheet to fill in their results and draw conclusions.

Stretch: Ask students to calculate the actual energy released during each combustion by using the equation: $\Delta Q = m \times c \times \Delta\theta$ (energy transferred = mass of water × specific heat capacity of water (4.2) × change in water temperature). If the mass of water is in grams, the energy transferred is in joules. This could be extended by asking students to calculate the energy released per gram or even per mole. Some students could be challenged to write up the practical in their own words, without the help of the directed questions at the bottom of the first page of the worksheet; these can be removed before printing/photocopying.

Expected results

The theoretical calculated values for results are given in the table below. These have been calculated using the standard enthalpies of combustion of the alcohols. Note that students will not have used methanol.

Alcohol	Methanol	Ethanol	Propanol	Butanol	Pentanol
Energy released per gram of alcohol burned (kJ/g)	22.7	29.7	33.6	36.1	37.7
Mass of alcohol to produce a 40 °C rise in temperature 100 cm^3 of water (g)	0.74	0.57	0.50	0.47	0.44
Mass of alcohol to produce a 1 °C rise in temperature 100 cm^3 of water (g)	0.0185	0.0143	0.0125	0.0118	0.0110

Students' results will indicate that energy released per gram is lower than these theoretical values (so the mass of alcohol needed to produce a 1 °C rise in temperature is higher). This is due to heat loss in the practical and evaporation of the alcohol. However, the trend should be the same. The mass of alcohol needed to produce a 1 °C rise in temperature in 100 cm^3 of water will decrease as you go down the alcohol series.

Course resources

Chem Students' sheet CP8

Equipment

For each group: eye protection; spirit burners with lids, containing ethanol, propanol, butanol and pentanol; 100 cm^3 measuring cylinder; 250 cm^3 conical flask; stand, boss head and clamp; heat mat; thermometer; 2 × heat mats for insulation/draughts shield; electronic balance