Heat energy from alcohols

Class practical

This experiment compares the amounts of **heat energy** produced by **burning** various **alcohols**.

Lesson organisation

This experiment is suitable for pre-16 students, possibly as an introduction to a topic on fuels. It can be taken further if used with post-16 students who can calculate values for enthalpy changes of combustion, with subsequent discussion about heat losses and incomplete combustion.

The alcohols should be provided in spanled spirit burners ready to use. If each group investigates one alcohol, the experiment can be done in around 20 mins. It is better if each spirit burner is used by more than one group of students. Variation of results will add substance to a discussion about errors.

Apparatus	Chemicals
Eye protection **Each group of students requires:** **Retort stand and clamp** **Conical flask (150 cm^3 or larger)** **Measuring cylinder (100 cm^3)** **Thermometer (-10 °C to +110 °C)** **Access to balances, preferably several, to avoid queuing.** **Access to spirit burners with wicks and caps, containing the alcohols listed. (Note 1)**	Methanol (HIGHLY FLAMMABLE, TOXIC) Ethanol (HIGHLY FLAMMABLE) Propan-1-ol (HIGHLY FLAMMABLE, IRRITANT) Propan-2-ol (HIGHLY FLAMMABLE, IRRITANT) Butan-1-ol (FLAMMABLE, IRRITANT, HARMFUL) **Refer to Health & Safety and Technical notes section below for additional information.**

Health & Safety and Technical notes

Read our standard health & safety guidance

Methanol, $CH_3OH(l)$, (HIGHLY FLAMMABLE, TOXIC) - see CLEAPSS *Hazcard*. Methanol is volatile and has a low flash point.

Ethanol, $CH_3CH_2OH(l)$, (HIGHLY FLAMMABLE) - see CLEAPSS *Hazcard*. Ethanol is volatile and has a low flash point.

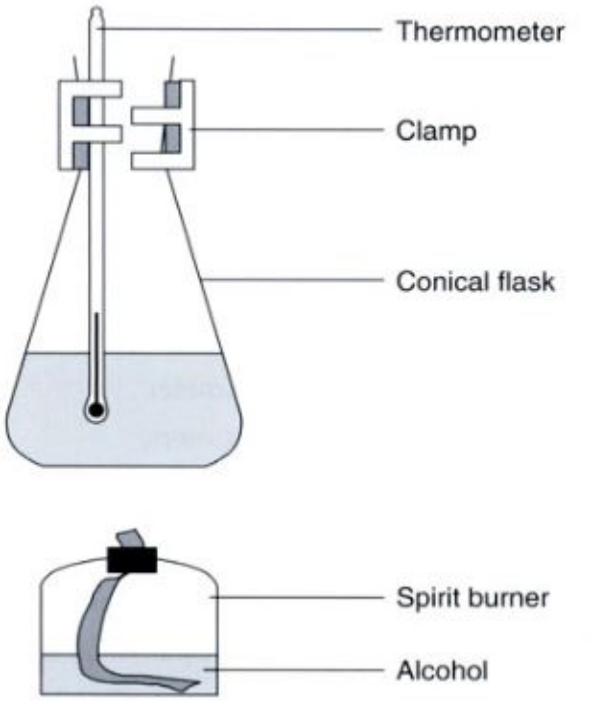
Propan-1-ol, $CH_3CH_2CH_2OH(l)$, (HIGHLY FLAMMABLE, IRRITANT, HARMFUL) - see CLEAPSS *Hazcard* . Propan-1-ol is volatile and has a low flash point.

Propan-2-ol, $CH_3CHOHCH_3(l)$, (HIGHLY FLAMMABLE, IRRITANT, HARMFUL) - see CLEAPSS *Hazcard* . Propan-2-ol is volatile and has a low flash point.

Butan-1-ol, $CH3CH_2CH_2$ $CH_2OH(l)$, (HARMFUL) - see CLEAPSS *Hazcard* . Butan-1-ol is volatile and has a low flash point.

1 Suitable spirit burners are hard to come by. Ideally they should be small, with a capacity of 50 cm^3 or less. Pictures and information in suppliers' catalogues can be misleading. It is important that the wick fits tightly in the wick holder and that the wick holder fits tightly in the burner. If capacity is more than 50 cm^3, reduce it, for instance by packing with mineral wool, or partially filling with epoxy. Refer to CLEASPSS L195 *Safer chemicals, safer reactions*. One possible source is: A.J.Cope & Son Ltd – Laboratory suppliers, Unit 10, Cliffside Trade Park, Motherwell Way, Grays, Essex, RM20 3XD

Procedure



a Measure 100 cm^3 of cold tap water into a conical flask.

b Clamp the flask at a suitable height so that a spirit burner can easily be placed below.

c Weigh the spirit burner (and cap) containing the alcohol and record this mass and the name of the alcohol.

d Record the initial temperature of the water in the flask.

e Place the spirit burner under the flask and light the wick.

f Allow the alcohol to heat the water so the temperature rises by about 40^oC.

g Replace the cap to extinguish the flame.

h Re-weigh the spirit burner and cap, and record this mass.

i Work out the mass of alcohol used.

j Using a fresh 100 cm^3 of cold tap water, repeat the experiment with another alcohol.

Teaching notes

Get the class to record and share the results. Do not be surprised if groups get different answers for a given alcohol. Heat losses will almost certainly vary considerably.

Subsequent discussion depends on the level of the students' experience.

Student questions

Here are some possible questions to ask students.

1. Which alcohol produces the most energy per gram?
2. Which alcohol produces the most energy per mole?
3. Write equations for the complete combustion of each alcohol.

4. Propan-1-ol and propan-2-ol are isomers (same molecular formula, different structures) Do they produce the same amount of heat on combustion?
5. Does all the heat produced by combustion go into raising the temperature of the water?
6. Is it possible that combustion may be incomplete, giving carbon monoxide amongst the products? (Stress the dangers of this.)
7. Alcohols can be used as a substitute for hydrocarbon fuels, and so methods of producing alcohols are very important. What process converts sugar into alcohol - and carbon dioxide?

Health & Safety checked, 2016

Credits
This Practical Chemistry resource was developed by the Nuffield Foundation and the Royal Society of Chemistry.

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