The candle in the bell-jar

Time

2 h or longer.

Curriculum links

Hydrocarbon chemistry. Combustion.

Group size

2– 4.

Materials and equipment

Materials per group

- candles (the students may decide that they would like to experiment with different heights and thicknesses).

Equipment per group

- bell jar or large glass beaker
- beehive shelf
- glass trough
- matches
- general laboratory ware
- safety glasses.

Safety

Eye protection may be worn.

Keep away from flammable/combustible materials.

Risk assessment

It is the responsibility of the teacher to carry out a suitable risk assessment.

This is an open-ended problem solving activity, so the guidance given here is necessarily incomplete. Teachers need to be particularly vigilant, and a higher degree of supervision is needed than in activities which have more closed outcomes. Students must be encouraged to take a responsible attitude towards safety, both their own and that of others. In planning an activity students should always include safety as a factor to be considered. Plans should be checked by the teacher before implementing them.

You must always comply with your employer's procedures and in some cases may decide that a particular activity is inappropriate in your situation. Further information on Health and Safety should be obtained from reputable sources such as CLEAPSS [http://science.cleapss.org.uk/] in England, Wales and Northern Ireland and, in Scotland, SSERC [https://www.sserc.org.uk/].

Commentary

The first part of this challenge is to work out the three hypotheses given in the *Student Sheet* for this phenomenon:

(1) the rise in the water level is caused by the consumption of oxygen alone;

(2) the rise in the water level is caused by a combination of the oxygen consumed and the carbon dioxide released; and
(3) the rise in the water level is caused by the contraction of gases in the bell jar as they cool.

Each of these hypotheses gives rise to several lines of investigation. Students could, for instance, design a system for lighting the candle inside an enclosed volume of air to give the most accurate assessment of the rise in the water level. They might try introducing a layer of oil above the water to prevent carbon dioxide from dissolving, to see if this affects the rise in the water level. The candle could be replaced by a spirit burner so that the amount of fuel burned can be used to calculate the volume of oxygen consumed (and carbon dioxide released). An alternative method of heating the gases inside the bell jar to the same temperature as the lighted candle can be tried, to assess the rise in water level on cooling.

A critical appraisal of the experiment was published in 1967 by Richard Kempa[1] who showed that the combustion of a candle cannot be supported by an atmosphere containing less than about 14 per cent oxygen by volume. He suggested that the experiment may be used to introduce children to the idea that oxygen does not support combustion if it is insufficiently "concentrated".

Reference

1. R. F. Kempa, *Science teaching techniques 12.* London: John Murray, 1967.

Acknowledgement

This activity is based on a suggestion from John Barker.

Credits

Health & safety checked May 2018

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