# What's the best fuel?

***Education in Chemistry***
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**These experiments accompany the above article 'Taking care of the air'.**

## Teacher notes

For both experiments, make sure the room is well ventilated and other hazards, eg trip hazards from stray bags are controlled.

Prior to doing the experiment with pupils, carry out a trial with each fuel to make sure the burn time and smoke level is appropriate (this is especially important for determining how much firelighter you will allow each group).

Both experiments involve pupils potentially handling hot equipment. Clear guidance needs to be given on how pupils conduct themselves during the experiment.

### Experiment a

The fuel chosen by pupils as 'best' isn't crucial here. It is more important that they are able to construct a good supporting argument, ideally using and quoting from the data they collected.

*Why can the burn time on its own not be used as an accurate measure of how good the fuel is?*
Good responses here will discuss the relationship between the mass of the fuel (or 'amount') and the burn time.

### Experiment b

The fuel chosen by pupils as 'best' isn't crucial here. It is more important that they are able to construct a good supporting argument, ideally using and quoting from the data they collected. Students should be guided to use all the data collected and the observations made to come to their conclusion.

*We measured the mass of the fuel used. Suggest how this information can be used to make a fairer comparison between the fuels.*
At this age range pupils should discuss how the mass can be used to find out about the amount of substance.

For some of the fuels, eg hexane, it would be possible to calculate the amount of fuel burned in moles and then extend this to a calculation of the energy change.

This involves the use of the equation $q = mc\Delta T$, where q = energy change in J, m = mass of water (water has a density of 1.0 $gcm^{-3}$ so the mass of water in grams is the same as the volume of water in $cm^3$), and c = specific heat capacity of water (4.2 $J°C^{-1}g^{-1}$).

Different levels of qualifications in different countries may write this equation differently, for example as Energy transferred = mass of water heated × specific heat capacity of water × temperature rise, $E_h = mc\Delta T$.

The experiment could be extended with further calculations around energy change calculations. Here are some examples:

0.5 g of hexane ($C_6H_{14}$) burned. The temperature of 25 cm$^3$ of water (specific heat capacity 4.2 J°C$^{-1}$g$^{-1}$) increased by 31 °C.

**Calculating energy change (foundation level difficulty for age 14–16)**

1.  Use the equation q = mcΔT to calculate the energy change q.

    *m = 2.5 g, c = 4.2 J°C$^{-1}$g$^{-1}$, ΔT = 31 °C*
    *q = 25 x 4.2 x 31 = 3255 J*

**Calculating energy change per gram of fuel (medium level difficulty)**

1.  Use the equation q = mcΔT to calculate the energy q

    *q = 25 x 4.2 x 31 = 3255 J*

2.  Divide the energy change by the mass of hexane (0.5 g) to get the energy change per gram of fuel.

    $$Energy\ change\ per\ mole = \frac{3255}{0.5} = 6510\ J/mol$$
    *The number is large so would be more sensibly expressed as 6.51 kJmol$^{-1}$*

**Calculating energy change per mole of fuel (higher level difficulty)**

1.  Calculate the relative molar mass of hexane

    *(12 x 6)+14 = 86*

2.  Calculate the amount of hexane in moles

    $$moles\ of\ hexane = \frac{0.5}{86} = 0.00581$$

3.  Use the equation q = mcΔT to calculate the energy change q.

    *q = 25 x 4.2 x 31 = 3255 J*

4.  Divide the energy change by the amount of hexane to get the energy change per mole.

    $$Energy\ change\ per\ mole = \frac{3255}{0.00581} = 560241\ J/mol$$
    *The number is large so would be more sensibly expressed as 560.2 kJmol$^{-1}$*

**Common pitfalls for pupils**
The most common error pupils make in these calculations is to use the mass of the fuel as *m*.