Investigation into the production and conversion of energy

Aim:

Investigate a range of fuels and find out how much energy each one releases when it burns? I will use spirit burners with the compounds Methanol, Ethanol, Propanol and Butanol to heat water to find out how much energy was released.

Research:

The fuels I will burn are all hydrocarbons. When the fuels I chose burn, oxygen will be added to the substance. Below is one of the reactions I hope to create:

$$CH_{4\,(g)} + 2O_{2\,(g)} \rightarrow CO_{2\,(g)} + 2H_2O_{(g)} + \text{Energy}$$

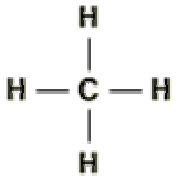
Methane + Oxygen → Carbon dioxide + Water + Energy

This reaction will also release heat as a form of energy. In my experiment I hope to achieve complete combustion with a blue flame. If the combustion is incomplete not enough oxygen will be getting to the hydrocarbon fuel and it won't be burning fully and therefore it will produce a smoky yellow flame. The reaction would then also produce carbon and carbon monoxide as seen below.

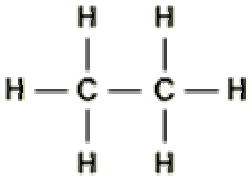
$$2CH_{4\,(g)} + 3O_{2\,(g)} \rightarrow 2CO_{(g)} + 4H_2O_{(g)} + \text{Heat energy}$$

Methane + Oxygen → Carbon monoxide + Water + Heat energy

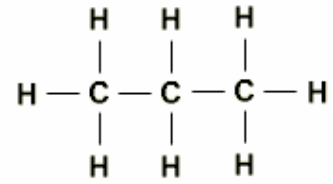
The fuels are alkanes, which have single covalent bonds. You can see below the hydrocarbons name, and structural formula.



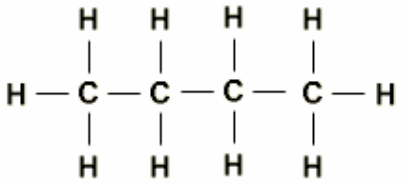
Methane, CH_4



Ethane, C_2H_6



Propane, C_3H_8



Butane, C_4H_{10}

The diagrams show the unsaturated hydrocarbons. Each particle has a weight: H = 1

C = 12

A hydrocarbons weight per mole can be calculated by adding all the particles in chain. Below you can see the weight of 1 mole for each fuel I am testing.

- Methanol = 16g
- Ethanol = 30g
- Propanol = 44g
- Butanol = 58g

Hydrocarbons are very useful but as the chains get longer it becomes thick and loses its usefulness. Hydrocarbons are useful for many reasons but the main one is that it produces a lot of energy. I will burn the hydrocarbons in the experiment, which will produce a lot of energy given off as heat.

Prediction:

I predict that the heavier/longer chain hydrocarbon e.g. Butanol will be produce more energy per mole than the smaller chains such as Methane. As the mass of the molecule gets heavier the energy it produces will be more. I believe this because the heavier the molecule the more atoms it has to release more energy. The longer the chain of the hydrocarbon the more atoms they're to produce more energy.

Fair Test:

To assure this is a fair test we must measure exactly 100cm³ of water every time. I must also record the weight of the spirit burner as soon as the water reaches the desired temperature. I must not leave it burning. To assure correct reliable results I will carry out the experiment 3 times with the fuels. I will also keep the wick length constant at 1cm. The can will be held 10cm above the wick each time.

Equipment I will need:

Spirit Burners
Spirits/Hydrocarbons (methanol, ethanol, Propanol and Butanol)
Clamp Stand
Tin can
Measuring Cylinder
Timer stop clock
Thermometer
Scales

Plan:

- Before the experiment begins I will have to have all the listed equipment above
- Using the scales I will weigh the spirit burners before and after each experiment and the amount of weight lost whilst it was burning.
- Measure 100cm³ of water and pour it into the tin can.
- Insert the thermometer into the can and note the starting temperature.
- Secure the can with the clamp in mid air and place the spirit burner underneath recording which spirit used.
- Then start the clock and time how long it takes to reach 50°C
- After the experiment weight the spirit burner. Then cool down the can and restart the experiment.

Formulas:

I have used the following formulas to calculate energy released in different formats:

To get the energy released per Joule:

Energy Release /J = Mass of Water x Temperature rise x 4.2

To get the energy released per gram:

Energy released / J/g = Energy released per Joule / Mass of fuel burned

To get the energy released per mole:

Energy released / J/m = Energy released / J/g x Weight of molecule (e.g. 46g)

Analysing the results:

I found out that as the size of the molecule increases so does the energy released. My tables of results, the average results and the graph clearly shows as the molecule chain size increases so does the energy released per mole. The graph shows a steady rate of increase suggesting my results are correct. My results also show that less fuel is used in the heavier compounds. My prediction was correct as the heavier the hydrocarbon the more energy it produces because of their increased chain length, meaning the more carbon and hydrogen atoms there are the more energy it produces and therefore making it bigger and weigh more. In my research I know that the number of particles such as carbon increased from 1 in Methanol, to 4 in Butanol. The more carbon atoms it had the more energy it produced.

Evaluation:

I believe I took enough results at 50°for each compound to get a fairly reliable result. Three results on each were good enough for me to get a good estimate average. I tried to keep to my original fair test plan but due to different types of spirit burners on some occasions I had to lower the can. Even though each time the wick was the same length the flame sometimes had problems with the flame touching the can and heating it. Sometimes due to drafts etc the stability of the flame was interrupted and resulted in it pointing in other directions, which may explain the large gap in my ethanol results. The chart is based on the averages, which don't really show any discrepancies however individual results do. The difference between result 2 and 3 was over 83,000 J/m released which is a very large gap compared with the other results. Although I believe he average is quite accurate I cannot say they are totally reliable, as those results didn't fit the pattern. Both Methanol and Propanol gave good constant results but once again with a large gap of 75,000 J/m energy released in the Butanol experiment however 2 results were virtually the same. These results I believe were caused by problems with the flame heating the can. As the flame was a yellow flame the experiment was not burning all the fuel and not enough oxygen was getting to the fuel. If I were to repeat the experiment I would maybe use an isolated incubation filled with oxygen so results are more accurate due to complete combustion. Things such as drafts and other gases would be kept out of the reaction. Because of drafts etc the fuel was not always being heated so my results for that reason may be a little inaccurate. I might also try using the same type of bottle and wick for each experiment so the wick is always the same distance from the beaker of water. This would make sense as some bottles were smaller than others and the flames had trouble touching and heating the water. We changed the bottle but it was still not quite right and flames were different for each experiment. This could also be the fault of the wick as some were thick and others thin. With all these differences I don't believe my results are as accurate as they could be. Maybe if I had more time I would have extended the range of compounds tested and probably at lower

temperatures to get accurate results. This would allow me to see further what happens when you increase the amount of particles in a molecule and the affect it has on the amount of energy released. I might also try how long it takes the fuel to heat different amounts of water or even a totally different compound.