

I am going to investigate the difference in enthalpy of combustion for a number of alcohols, the enthalpy of combustion being the 'enthalpy change when one mole of any substance is completely burnt in oxygen under the stated conditions'. I will be attempting to find how the number of carbon atoms the alcohol contains effects the enthalpy change that occurs during the combustion of the alcohol.

Method

I plan to measure the enthalpy change by burning the alcohol, using a spirit burner, I will then use the heat produced during the combustion of the alcohol to heat 100ml of water that will be situated in a copper calorimeter directly above the burning alcohol. The calorimeter is made of copper as copper has a high thermal conduction value, this basically means that it is a good conductor of heat so a lot of the heat the copper receives will be passed on to the water which I am then able to measure, by using a calculation that it takes 4.2J of energy to heat 1g of water by 1 c

I plan to compare the enthalpy changes of combustion of different alcohol 's. As I know that combusting different substances produces differing amounts of energy, I plan to find out which alcohol, out of methanol, ethanol, propanol and butanol, produces the most energy when burned in air. I will do this by heating 100ml of water by 50°C and using the calculation of it takes **4.2j of energy to heat 1g of water by 1°C**. To do this I will need:

During the experiment I will be taking a number of measurements, I will firstly take the initial temperature of the water and initial mass of the alcohol I will then burn the alcohol until an increase in temperature of 20oc has occurred in the water I will then reweigh the alcohol.

The measurements

- * Mass of alcohol burned (g)
- * Temperature increase (oc)

will tell me what mass of alcohol is used during combustion to cause the temperature increase of 20oc in the water, I can then work out the energy released per mole and compare these values and see which has the highest enthalpy of combustion. I will need to repeat my experiment a number of times and take an average so I am sure of an accurate result. The set up of the apparatus that I plan to use is shown below

The set up of the apparatus as you can see is very simple, the calorimeter, which contains the 100ml of water, is held directly above the spirit burner by a retort stand and clamp. The calorimeter has **a mercury** thermometer in it, which are very accurate, this will be used to measure the water temperature. I have decided that the calorimeter should be held 1cm above the top of the flame produced by the burning alcohols as so to keep the experiment fair, this being as apposed to having it at a random height. I have also decided that the size of the wick from which the alcohol burns from should be constant on all the spirit burners, so to keep the experiment as fair as possible so I will adjust them accordingly so they are all the same length. I have decided that the length should be should be one cm, I will do this so that all the alcohols burn from the same surface area, this will mean that I will also have to use wicks of the same thickness. The experiments will be taking place in a laboratory so this means that

the environment each experiment takes place in should be pretty constant i.e. room temperature etc, this will also help improve my results.

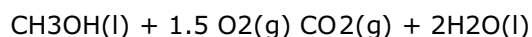
Prediction

I am expecting that the alcohols with a greater number of carbon atoms within the molecule to have a higher enthalpy of combustion than the ones with less.

For any reaction to take place bonds must be broken and made, bond breaking requires energy while bond making releases energy. Bonds between different atoms require or release different amounts of energy when broken or made because they are different in strength. By looking at the equation for the reaction and more importantly looking at the bonds that are being broken and made, it is possible to work out an estimation for the amount of energy that will be released in the reaction. The estimation is worked out by applying the average bond enthalpies, an example for doing this is shown below for methanol

Methanol (CH₃OH)

The balanced equation for the combustion of methanol is



Below is the type and number of bonds within each mole of reactants and products, they are shown with the amount of energy, measured in kilo joules per mole (DH/KJ mol⁻¹) released or required for the particular bond

Methanol Oxygen Carbon Dioxide Water
CH₃OH 1.5 O₂ CO₂ 2H₂O

3 C—H	413	1.5 O=O	497	2 C=O	740	4 O—H	463
C—O	360						
O—H	463						
	2062		745.5		1480		1852

The total energy required to break The total energy released in the forming the bonds in the reactants is of the bonds in the products is

2807.5 DH/KJ mol⁻¹ 3332 DH/KJ mol⁻¹

the difference between the reactants and products is
-524.5 DH/KJ mol⁻¹

From above, there are 2807.5 kJ mol⁻¹ of energy absorbed initially by the reaction when the bonds are broken. Then 3332KJ mol⁻¹ of energy is released by the reaction when the new bond are formed, overall this leaves a difference of 524.5 kJ mol⁻¹ between the reactants and products, this energy is released by the reaction in the form of heat energy.

The value above for the energy released by the alcohol is only an approximation for the combustion of methanol this is because firstly the bond enthalpies vary slightly from one molecule to another and so the values used are only an average. The values given for the bond enthalpies also assume that the reactants and products are in a gaseous state but as you can see from the equation they are clearly not, with the water and the alcohol's both being in a liquid state.

The alcohols that I plan to use in my investigation are methanol, ethanol,

propanol and butanol. The estimation for the enthalpy of combustion, using the bond enthalpies are worked out below for each of the alcohols.

Methanol $\text{CH}_3\text{HO}(\text{l}) + 1.5\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$

3 C—H 413 1.5O=O 497 2C=O 740 4O—H 463
 C—O 369
 O—H 436
 2062 745.5 1480 1852

2807.5 DH/KJ mol⁻¹ 3332 DH/KJ mol⁻¹
 -524.5 DH/KJ mol⁻¹

Ethanol $\text{C}_2\text{H}_5\text{HO}(\text{l}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g}) + 3\text{H}_2\text{O}(\text{l})$

C—C 346 3O=O 497 4C=O 740 6O—H 463
 5 C—H 413
 C—O 369
 O—H 436
 3234 1491 2960 2778

4723 DH/KJ mol⁻¹ 5738 DH/KJ mol⁻¹
 -1013 DH/KJ mol⁻¹

Propanol $\text{C}_3\text{H}_7\text{HO}(\text{l}) + 4.5\text{O}_2(\text{g}) \rightarrow 3\text{CO}_2(\text{g}) + 4\text{H}_2\text{O}(\text{l})$

2 C—C 346 4.5O=O 497 6C=O 740 8O—H 463
 7 C—H 413
 C—O 369
 O—H 436
 4406 2236.5 4440 3704

6642.5 DH/KJ mol⁻¹ 8144 DH/KJ mol⁻¹
 -1501.5 DH/KJ mol⁻¹

Butanol $\text{C}_4\text{H}_9\text{HO}(\text{l}) + 6\text{O}_2(\text{g}) \rightarrow 4\text{CO}_2(\text{g}) + 5\text{H}_2\text{O}(\text{l})$

3 C—C 346 6O=O 497 8C=O 740 10O—H 463
 9 C—H 413
 C—O 369
 O—H 436
 5578 2982 5920 4630

8560 DH/KJ mol⁻¹ 10550 DH/KJ mol⁻¹
 -1990 DH/KJ mol⁻¹

The bond enthalpies worked out above clearly show an increase in the overall energy that is released as the alcohols increased in size. The table below shows the Calculated enthalpy of combustion, using bond enthalpy's for the stated alcohols. The difference in the enthalpies of combustion from alcohol to alcohol, as they get larger is constant, this is no surprise though as the only difference as the alcohols get larger is an increase in size of one carbon and two hydrogen's each time. Whether this difference is as constant in practice is another thing. Alcohol Calculated enthalpy of combustion (DHc) Difference In Enthalpy of combustion (DHc)

Methanol 524.5 DH/KJ mol⁻¹

Ethanol 1013 DH/KJ mol⁻¹ 488.5 DH/KJ mol⁻¹

Propanol 1501.5 DH/KJ mol⁻¹ 488.5 DH/KJ mol⁻¹

Butanol 1990 DH/KJ mol⁻¹ 488.5 DH/KJ mol⁻¹

Methanol is the smallest alcohol, it releases 524.5 kJ mol⁻¹, the next largest, Ethanol is one carbon and two hydrogen's larger, It release 1013 kJ mol⁻¹ this is a difference of 488.5 kJ mol⁻¹ this trend continues as the alcohols get larger. This is effectively because the only difference between the alcohol's is a increase in

size by one carbon and two hydrogen's each time.

For my investigation I am going to use propan-1-ol and butan-1-ol as representatives of propanol and butanol. propanol and butanol are large enough molecules to form isomers etc, I have decided to use propan-1-ol and butan-1-ol because they have the closest structural arrangement to the other alcohols that I am going to be testing. Using butan-1-ol and propan-1-ol means all the alcohols that I am comparing have their OH group joined onto an end carbon and they are all straight chain alcohol's. I need to keep as many of the factors in my experiments as I can the same, only changing what I have to, the variables, so that I get as accurate results as possible showing the correct pattern. I don't know how or whether the positions of the OH group on the alcohol, and whether branching within the molecule effects the enthalpy change. I need to use alcohols with as similar structure as possible, with the only difference being the number of carbon atoms within the molecule as this is what I am investigating.

Risk Assessment

There are obvious risks with the experiment that I am going to do in the alcohol's that I am will be using

* The alcohol's are obviously flammable so need to be handled with care, avoiding spillages and kept in a suitable container, they should only used out of the way of other naked flames.

*I will be using a naked flame, so I will need keep my experiments out of the way of other experiments, people and flammable objects

* My experiment also produces heat and so the apparatus will heat up so they will need to be handled with care during and after the experiment has taken place.

Overall though my experiment is fairly safe, as long as it is carried out sensibly taking heed of the general laboratory rules.

Results

The results I have achieved from my experiments are shown below in the table, I repeated the experiment six times for each alcohol, this was decided mainly by the time that I had but I also thought it was a suitable number of tests. The experiments went pretty much to plan although I did have to make changes to the experiment to increase the accuracy of the results that I got, the details of this are explained later. Below in the table are the results that I got from my experiments

ALCOHOL INITIAL TEMPERATURE (oc) FINAL TEMPERATURE (oc) +/- (oc)

INITIAL WEIGHT (g) FINAL WEIGHT (g) +/- (g)

Methanol 21 43 22 213.18 212.06 1.12

21 43 22 216.06 211.08 0.98

20 41 21 211.08 210.05 1.03

20 40 20 208.49 209.58 1.09

21 43 22 205.70 204.77 0.93
21 41 20 204.77 203.76 1.01

Butanol 22 43 21 289.49 288.72 0.77
20 40 20 288.72 288.01 0.71
23 43 20 287.89 287.20 0.69
20 41 21 287.1 286.34 0.76
20 40 20 286.34 285.61 0.73
20 41 21 285.5 284.74 0.75

Propan-1-ol 22 42 20 287.45 286.93 0.52
22 42 20 287.01 286.51 0.5
22 42 20 286.46 286.06 0.4
21 41 20 286.04 285.54 0.5
21 42 21 285.50 284.93 0.57
21 41 20 284.9 284.39 0.51

Butan-1-ol 20 39 19 280.08 279.58 0.5
19 39 20 278.34 277.75 0.59
19 38 19 277.47 277.00 0.47
18 38 20 276.57 276.07 0.5
19 40 21 276.03 275.50 0.53

& data taken from essaybank.co.uk, 17 37 20 275.56 275.09 0.47

I have drawn a graph, below, that shows the temperature increase per gram for each alcohol. The temperature increase per gram although can not be used to compare for the enthalpy of combustion, as that is a measure of the enthalpy change per mole it highlights a problem that I found with my results for butan-1-ol. I started to notice that the results that I got from the butan-1-ol experiments were not showing the decrease in mass of alcohol needed to cause the temperature rise almost straight away and could not understand why this was happening. I checked the apparatus and then I noticed that the bottom of the calorimeter had a black sooty type substance on it, which I knew must have been affecting my results for butan-1-ol. I came to the conclusion that a black substance was carbon from the alcohol that had not been completely combusted in the reaction and was being deposited on the calorimeter, like soot in a chimney.

Although this may have also happened on the smaller alcohols it will not have been as severe as the activation energy for the combustion of the alcohols as they get smaller decreases. This can be explained by looking back to when I examined the bond energies, the smaller alcohols needed less energy to break the bonds in the reactions and so less energy is needed to initiate the reaction. The results that I got from my experiments for butan-1-ol will have been affected in two ways

*Firstly carbon is a better insulator than copper, it has a lower thermal conductivity value and so it will stop as much heat getting through to heat the water as there should be

*Secondly the carbon has come from the spirit burner and for my results I am assuming that all the alcohol that leaves the spirit burner is combusting and releasing heat to contribute to the heating of the water which it is quite clearly not. This will mean I am assuming that more alcohol is needed than really is to cause the increase in temperature.

Apart from the butan-1-ol my results are as expected showing a clear increase in the energy released per unit mass of alcohol.

So that it is possible for me to see which alcohol has the highest energy per combustion I need to find which alcohol releases the most energy per mole. From the measurements I have taken I have the temperature increase per gram.

If you raise the temperature of an object you increase the energy of the particles it is made from, so to this you need to supply energy. The energy needed to raise the temperature is proportional to the mass of the substance and the temperature rise

$$\text{Energy} \propto \text{mass} \times \text{temp increase}$$

The constant of proportionality depends on the substance you are heating, it is called the specific heat capacity.

$$\text{Energy} = \text{specific heat capacity} \times \text{mass} \times \text{temp increase}$$

(J) (J/g/ °C) (g) (°C)

The results that I am going to use are

Alcohol	Initial Temperature	Final Temperature	+/- Mass of Alcohol Burnt
Methanol	27°C	49°C	22g
			1.12g

First I need to find the heat exchanged to the water. Specific heat Capacity of water, 4.2

Mass of

water heated, 100g

$$\text{Heat energy exchanged} = \text{Mass} \times \text{Specific Heat} \times \text{Temperature}$$

To the water (g) Capacity Rise

(J) (J/g/ °C) (°C)

$$= 100 \times 4.2 \times 22$$

$$= 9240\text{J}$$

9240J is the heat energy taken in during the experiment, this needs to be converted to heat taken in per mole of alcohol burnt.

$$1.12\text{g Methanol} \rightarrow 9240\text{J}$$

$$1\text{ g} \rightarrow 9240\text{J}/1.12$$

$$32\text{g} \rightarrow 9240\text{J}/1.12 \times 32$$

$$26400\text{J/mole}^{-1}$$

So there is 264000 J released from 32g which is one mole, to change to KJ simply divide by 1000

Which gives

$$264\text{kJ/mole}^{-1}$$

There is also heat absorbed by the calorimeter that I can also work out

Specific

heat capacity of copper, 0.385

Mass of calorimeter 0.55g

$$\text{Heat energy exchanged} = \text{Mass} \times \text{Specific Heat} \times \text{Temperature}$$

To the copper (g) Capacity Rise

(J) (J/g/ °C) (°C)

$$= 66.55 \times 0.385 \times 22$$

$$= 521.3\text{J}$$

Again this is the heat taken in during the experiment and needs to be converted to heat taken in per mole of alcohol burned

$$1.12\text{g Methanol } 521.3\text{J}$$

$$1\text{g} = 521.3\text{J}/1.12\text{g}$$

$$32\text{g} = 521.3\text{J}/1.12\text{g} \times 32\text{g}$$

$$14894.3\text{Jmole}^{-1}$$

This can also be changed to kJm^{-1} by dividing by 1000 giving 14.9kJm^{-1}

Adding the two values worked out above for the energy absorbed by the water and the calorimeter gives the total energy that I have measured to have been released by the combustion of the alcohol.

The total energy that I measured for the combustion of methanol example above is

$$264\text{kJmole}^{-1} + 14.9\text{kJmole}^{-1} = 278.9\text{kJmole}^{-1}$$

Below I have put in a table the average enthalpy of combustion for my results

Alcohol Average measured enthalpy of combustion

Methanol 278.4kJmole^{-1}

Ethanol 339.2kJmole^{-1}

Propan-1-ol 995.6kJmole^{-1}

Butan-1-ol 1214.6kJmole^{-1}

My results show a clear increase in the enthalpy of combustion as the alcohols get larger. Butan-1-ol, the largest alcohol that I have tested, shows the highest enthalpy of combustion and methanol, the smallest in size, has the smallest value for the enthalpy of combustion. This is as I had expected, as the enthalpy of combustion that I calculated earlier using average bond enthalpies had predicted. Below is a graph, which compares my results to the bond enthalpy values that I had worked out earlier.

The changing of my results into the form kJmole^{-1} has eliminated the error that I highlighted before. My results, which had shown Propan-1-ol, releasing more energy than Butan-1-ol, now tell a different story. This is because although they may have been affected, it has not been enough to alter them completely, as changing them to kJmole^{-1} has meant that they now follow the pattern that they should. Butan-1-ol now releases more energy than Propan-1-ol. This change has occurred because one mole of Butan-1-ol is heavier than one mole of Propan-1-ol so although they release about the same energy per gram Butan-1-ol releases more energy per mole.

The graph above shows that my results show the same pattern for the enthalpy of combustion as the average bond enthalpy estimation worked out, but they do not show the same total amount of energy being released per mole.

Remembering that the bond enthalpies are only estimations I need to compare my results to other more reliable results to see how accurate the results that I have obtained are.

It is actually possible using something called a bomb calorimeter to measure the exact enthalpy of combustion. This means that I can compare these values against my results and it will be possible to work out how exact the results are. The bomb calorimeter that pandas's are specially designed to avoid heat loss by completely surrounding the bomb with water. Heat losses can be eliminated altogether if the thermochemical investigation is coupled with an electrical calibration. First of all, the chemical reaction is carried out in the calorimeter and the temperature is plotted against time before, during and after the reaction. The experiment is now repeated, but this time an electrical heating coil replaces the reaction. The current in the coil is carefully adjusted so as to give a temperature-time curve identical to that obtained in the chemical reaction. By recording the current during the time this electrical calibration, it is possible to calculate the electrical energy supplied with great accuracy. This electrical energy is exactly the same as the energy change in the reaction. As it includes both the heat absorbed by the system and the energy lost in the system and the heat lost from the system it eliminates the need for heat loss correction.

The values for the enthalpy of combustion given by the bomb calorimeter are
 Methanol 715 kJ mole⁻¹
 Ethanol 871 kJ mole⁻¹
 Propan-1-ol 2010 kJ mole⁻¹
 Butan-1-ol 2673 kJ mole⁻¹

They were measured under the conditions of a temperature of 289 Kelvin and a pressure of 1 atmosphere.
 By comparing these to my results I can work out the percentage error/accuracy of my results

Alcohol	Average Enthalpy of Combustion (my results)	Percentage of Exact Enthalpy of Combustion (bomb calorimeter)
Methanol	278.5 kJ mole ⁻¹	38.9%
Ethanol	339.2 kJ mole ⁻¹	39.3%
Propan-1-ol	995.6 kJ mole ⁻¹	49.5%
Butan-1-ol	1214.6 kJ mole ⁻¹	45.5%

As you can see from the table above the accuracy of my results from my experiments were not very good. Methanol was the least accurate at 38.9% of what it should have been and Propan-1-ol at 49.5% was the most accurate (note the increase in accuracy and then the drop of butan-1-ol, which I highlighted above).

The results I have got have been consistently inaccurate, the gap between the most accurate and the least accurate being only 10% they are all out by a long way, the most accurate is only 50% of what it should be. This gives me the impression that my results are not just wrong because of human error i.e.

*Reading of the thermometer (I can only read to accuracy of nearest degree)

*Measuring of the weight of the Alcohol

*Measuring of water to be heated

*Impurities in the water (may change the specific heat capacity of the water)

*The enthalpy's of combustion that I am comparing my results to were measured under different conditions so this means they would be different anyway

By looking at the set up of my experiment it is quite clear why the accuracy of the results are not very good.

A lot of heat produced in the experiment was allowed to escape before it had even entered the apparatus and even heat that got into the calorimeter could escape back out of the calorimeter, as the good conducting copper which let the heat in could just as easily let it out again. I decided to see if I could increase the accuracy of my results, by stopping the heat escaping once inside the apparatus so I added insulation to the calorimeter and repeated the experiment again. I took the experiment now using the insulation material, attaching it to the sides of the calorimeter. The results that I got from the experiment this time were an improvement on the previous attempt, the results are displayed in the table below they have already been converted to the form kJ mole^{-1} and averaged.

Alcohol Average Enthalpy of combustion Percentage increase of my results on previous attempt

Methanol $302.1 \text{ kJ mole}^{-1}$ 9%

Ethanol $388.8 \text{ kJ mole}^{-1}$ 10%

Propan-1-ol $1086.2 \text{ kJ mole}^{-1}$ 9%

Butan-1-ol $1320.3 \text{ kJ mole}^{-1}$ 8%

My results show a clear increase of about 9% although this does vary from alcohol to alcohol. My results are still not very accurate, but that is because a lot of the heat that is produced does not even enter the apparatus, it is allowed to escape immediately.

This is an area where the accuracy of my experiment could have been improved a lot, by not allowing any heat escape, but to do this I would have to use a bomb calorimeter, which was not available to me.

The graph below compares the enthalpy of combustion from the bomb calorimeter to the results that I got from my experiments.

From the graph above it is possible to see why I have been pleased with the results that I have got from my experiments. The only thing that could have been improved would be to have been able to measure all the heat energy that had been released by the combustion of the alcohols, increasing the accuracy which was not possible with the equipment available to me. I was able to improve my experiment after I initially completed it but I don't think I could get much more accurate results. I did though manage to meet the aims of the investigation by finding how the number of carbon atoms within the alcohol affects the enthalpy of combustion. I did have an idea on how to further increase the accuracy of my results but I did not have time to put it to practice. I thought that I could make something that directed more of the heat produced towards the apparatus. A sketch of it is shown below.

This would keep more of the heat produced during combustion close to the calorimeter so more is absorbed. Lining the reflector with shiny / shiny surface would also mean a lot more of the heat is kept in the apparatus so that I am able to measure it.

There are other aspects of the enthalpy of combustion of alcohols that I could have also investigated. I say I could have looked into whether the position of the O groups within the molecule affects the enthalpy change and also whether branching within the molecule also has any effect on the enthalpy of combustion. Sadly I did not get time to do this.

Plan.

I plan to compare the enthalpy changes of combustion of different alcohol's. As I know that combusting different substances produces differing amounts of energy, I plan to find out which alcohol, out of methanol, ethanol, propanol and butanol, produces the most energy when burned in air. I will do this by heating 100ml of water by 50°C and using the calculation of it takes **4.2j of energy to heat 1g of water by 1°C**. To do this I will need:

- ? Spirit burner, to burn the alcohol.
- ? 500ml copper can, I used copper so all the energy would be transferred to the water.
- ? Clamp stand, I will clamp the beaker so as not to lose any energy in heating up a tripod.
- ? Electronic balance to 2 decimal places, I used this type of balance as this gives me enough detail to be accurate but not so much that it would be difficult to handle the result detail.
- ? Heat proof mat, so as to stop things from burning.
- ? Goggles, to protect the eyes.
- ? Measuring cylinder, to keep my measurements accurate.
- ? Thermometer to point one of a degree, again I used this scale to keep my results accurate but not confusing.
- ? Hazard cards, I'll use these to make sure that I know how to safely handle the chemicals that I am using.

I will use the fact that 1ml of water weighs 1g. However, before I start I will weigh 10ml of water to see if it weighs 10g, if it doesn't I will adjust my end calculations accordingly. I will do this by weighing a measuring cylinder, putting 10ml of water in it then weighing it again and taking off the weight of the empty cylinder. Once I have taken these measurements I shall carry out the following steps:

- ? Measure out 100ml of water, pour into copper beaker, this poses no safety risk but must be done carefully as to keep it a fair test.
- ? Place the heatproof mat, spirit burner and clamp stand as shown in the diagram. (see fig 1)
- ? Clamp the copper beaker with the clamp arm, being careful not to spill any water on the spirit burner.
- ? Weigh the spirit burner with the lid, then add the alcohol and weigh it again, record both weights.
- ? Replace the spirit burner and lower the clamp arm to 3cm above the spirit burner.
- ? Place the thermometer in the water and leave in for 2mins then record the starting temperature.
- ? Leaving the thermometer in place remove the lid of the spirit burner and light.
- ? When the water temperature has risen by 50°C replace the spirit burner lid, this will be taken from essaybank.co.uk extinguish the flame and stop any evaporation.
- ? Weigh the spirit burner with the lid on and record the weight.

When using the alcohol's there are several safety aspects that need to be taken into consideration, these are:

- ? The alcohol vapours catch fire at temperatures above 13°C so the lid must remain on the spirit burner.
- ? The vapours of Ethanol and higher alcohols produce narcotic effects if inhaled, victims should be removed to fresh air.
- ? If swallowed mouth must be washed out with water, if drunken like symptoms are shown seek medical attention.

- ? If spilt in eyes, flood the eyes with running tap water for 10 minutes, then seek medical attention.
- ? If spilt on skin or clothing remove affected clothing to prevent fire risk and wash affected area.
- ? If spilt in the lab shut off sources of ignition and apply mineral absorbent.

There are several variables to take into consideration when keeping this a fair test these are:

- ? Keeping the lid on the spirit burner in between weighing the spirit burner before and after lighting so there is no loss due to evaporation.
- ? Making sure that the copper cup is kept at the same temperature at the start of each test.
- ? Trying to keep the conditions around the spirit burner the same in each test, i.e. the amount of draft.
- ? The amount of soot build up on the bottom of the copper beaker, this needs to be removed in between tests.

Ideally there should be no build up of soot as this means that not all the energy used is being transferred to the water so there will be this slight anomaly to take into account however this should be negligible. The energy lost will go into the making and breaking of the bonds in the different alcohol's I have included an example by showing the energy change graph of methanol below.

I have used the first four alcohols as they have no or very few isomers, which will lead to more accurate results. I have chosen to use the method above based on previous work that I have done at GCSE level. Instead of weighing the alcohol and using the calculation of 1g of water takes 4.2J of energy to raise by 1°C, I timed the experiment for a temperature rise of 15°C. This gave me results, but they were fairly inaccurate. I hope that this will prove more accurate.

liquid changes state to gas condenses back and will be part of the calculation. Loss of the alcohol itself due to evaporation has also been carefully considered. I have decided to ensure that the lid remains on at all possible times, in-between weighing and after the experiment has finished. In regarding the position of certain equipment. I have already stated that the calorimeter should be placed at 1 cm above the flame at all times to ensure accurate heat transfer. The size and shape of the spirit burners is essential. The wick especially needs to have a constant length, width and surface area, so that the same amount of alcohol is in contact with the air to react at all times.

I have also decided that the distance the thermometer is suspended in the calorimeter should remain constant as an extra precaution to stirring. The temperature of the water may differ at the top to that at the bottom of the can because heat rises so I have decided to suspend the thermometer at an equal distance of half way up in the centre of the can to ensure fairness. Insulation has been another priority of mine to minimise heat loss. I have silvered the sides of the copper can to minimise heat loss by radiation and insulated the sides of the copper can and the insulation chamber to minimise heat loss by conduction and convection. Heat loss risks affecting the end results of the experiment. Measurements must be made as accurately as possible, because inaccuracy always develops due to human inaccuracy. Every effort must be made to ensure readings are

taken to as precise detail as possible using the equipment. % Error can be calculated with any inaccuracy and if this amounts up sp will the inaccuracy of the whole experiment.

The beaker I am using has a constant diameter of 10 cm. This is to ensure that the same surface area is exposed each time to the heat being produced.

Risk Assessment:

There are risks within the experiment and it is essential that I have everything under control when dealing with potential hazards.
Methanol and Ethanol

HIGHLY FLAMMABLE

Vapours will catch fire at temperatures above 13 oC. The narcotic effect of ethanol/methanol is well known and may result from inhalation of the vapour. Methanol and ethanol are TOXIC by inhalation, if swallowed and by skin absorption. There is a danger of very serious irreversible effects though inhalation, in contact with the skin and if swallowed.

If swallowed: Wash out mouth and give a glass or two of water. Seek medical attention if victim shows drunken symptoms.

If vapour inhaled: Remove victim to fresh air to rest. Keep warm.

If liquid splashed in eyes: Flood the eye with ...