CHEMISTRY LAB REPORT

Aim:

The combustion of organic compounds produces large quantities of energy. These compounds range from that of alkanes, to alkenes to even alcohols. Ethanol is a commonly used fuel in motor-cars and its usage is increasing because it is a form of renewable energy. However, what makes a good fuel?

A good fuel is any substance which gives out large amounts of energy when it is burnt. In most cases, fuels are burnt in oxygen (air) i.e. they are oxidized. Nonetheless, is there any relationship between the energy released by one alcohol and another alcohol?

Therefore, the aim of this experiment is to investigate the relationship between the number of carbon atoms in an alcohol chain and its standard enthalpy change of combustion.

Research Question:

To investigate the relationship between the numbers of carbon atoms in an alcohol chain; methanol, ethanol, propanol, butanol and pentanol and their respective standard enthalpy change of combustions.

Hypothesis:

It can be hypothesized that as the number of Carbon atoms in an alcohol increases; the enthalpy of combustion will also become more negative.

This is because as the number of Carbon atoms increase, the molecule's shape differs. The hydrocarbon chain becomes longer. As we move down the homologous group, a spate CH_3 molecule is being added into the alcohol chain. Thus, the extra energy is required to break apart this new molecule. It is much harder to break up a longer hydrocarbon chain than a shorter one as there are more bonds to break. Therefore, more energy is required to break a longer hydrocarbon. This can be explained by each successive member of the series contains one more methylene group ($-CH_2-$) than the previous one. When it is burnt, there will be one extra C-C bond and two extra C-H bonds to be broken. Therefore, much more energy is required for combustion.

Moreover, this prediction is made more valid if one talks in terms of the Van der Waal's forces of each molecule. As the carbon atoms are added into the alcohol chain, its mass increases. This will increase the Van der Waal's forces amidst the alcohols, resulting in stronger intermolecular forces of attraction. Therefore, this leads to an increase in the enthalpy of combustion of the alcohols.

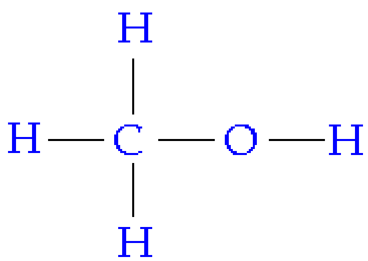
Thus, on increasing the number of carbon atoms in an alcohol chain, the respective enthalpy of combustions is expected to become more negative.

Background Information:

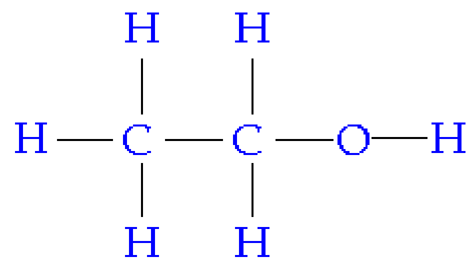
Alcohols are organic compounds containing Oxygen, Hydrogen and Carbon. They are a family of hydrocarbons that contain the –OH group. The alcohols are a homologous series containing the functional –OH group, which determines the characteristic reactions of a compound.

The general formula of alcohols is $C_nH_{2n+1}OH$, where *n* is a number. Alcohols are also referred to as alkanols. The simplest alcohol contains a single Carbon atom and is called Methanol. Its molecular formula is CH_3OH. As we move down the homologous series of alcohols, the number of Carbon atoms increase. Each alcohol molecule differs by $–CH_2$; a single Carbon atom and two Hydrogen atoms.

The figure below is the structural formula of Methanol (CH_3OH) and Ethanol (C_2H_5OH) respectively:



Methanol



Ethanol

(Pictures taken From: http://www.gcsescience.com/Methanol.gif and http://www.gcsescience.com/Ethanol.gif)

This table below shows the molecular formulas of the early members of the alcohol homologous series.

Alcohol	Molecular Formula ($C_nH_{2n+1}OH$)
Methanol	CH_3OH
Ethanol	C_2H_5OH
Propanol	C_3H_7OH
Butanol	C_4H_9OH
Pentanol	$C_5H_{11}OH$

It can be seen as we go down the homologous series of alcohols, carbon atoms are added onto the hydrocarbon chains. These chains are becoming longer and much more complex. Moreover, as we go down the group, the alcohols' boiling points, heat of combustions, and other characteristics show changes as well.

Combustion is principally the oxidation of carbon compounds by oxygen in air to form CO_2 if there is a sufficient amount of oxygen. The hydrogen in a compound forms H2O. Combustion produces heat as well as carbon dioxide and water. The enthalpy change of combustion is the enthalpy change that occurs when 1 mole of a fuel is burned completely in oxygen.

(Taken from: http://www.coursework.info/AS_and_A_Level/Chemistry/Organic_Chemistry/Find_the_enthalpy_change_of_combustion_o_L61656.html#ixzz0fokacpwD)

The heat of combustion (standard enthalpy change of combustion) is the enthalpy change when one mole of the compound undergoes complete combustion in excess oxygen under standard conditions. It is given the symbol ΔH°_{comb} and standard conditions simply refer to room conditions with a temperature of 298K and pressure of 1 atm.

As a result, the aim of the experiment is to determine whether there is a relationship between the number of carbon atoms in an alcohol chain and its respective standard enthalpy change of combustion.

Variables:

To get accurate results in my experiment, results should be obtained in a systematic order. To do this, the variables affecting the results, must be noted down. The variables are:

Independent Variable	Controlled Variables	Dependant Variable
Number of Carbon atoms in the alcohol molecule (Different Alcohols)	Mass of Distilled Water Distance of Wick and Bottom of Calorimeter Temperature Rise	Mass Of Alcohol Burnt

Manipulation of Variables:

Number of Carbon atoms in the alcohol molecule:

This is our independent variable and can be easily measured from the formula itself. The homologous series (first five members and their formulas) is shown below:

Alcohol	Molecular Formula ($C_nH_{2n+1}OH$)
Methanol	CH_3OH
Ethanol	C_2H_5OH
Propanol	C_3H_7OH
Butanol	C_4H_9OH
Pentanol	$C_5H_{11}OH$

Therefore, the enthalpy of combustion of methanol would give us the result for an alcohol with a single Carbon atom. The enthalpy of combustion of ethanol would give us the result for an alcohol with two such Carbon atoms; and so on.

In this manner, a total of five sets of data will be recorded. This variable will be varied as five different alcohols are compared.

<u>Mass of Distilled Water:</u>

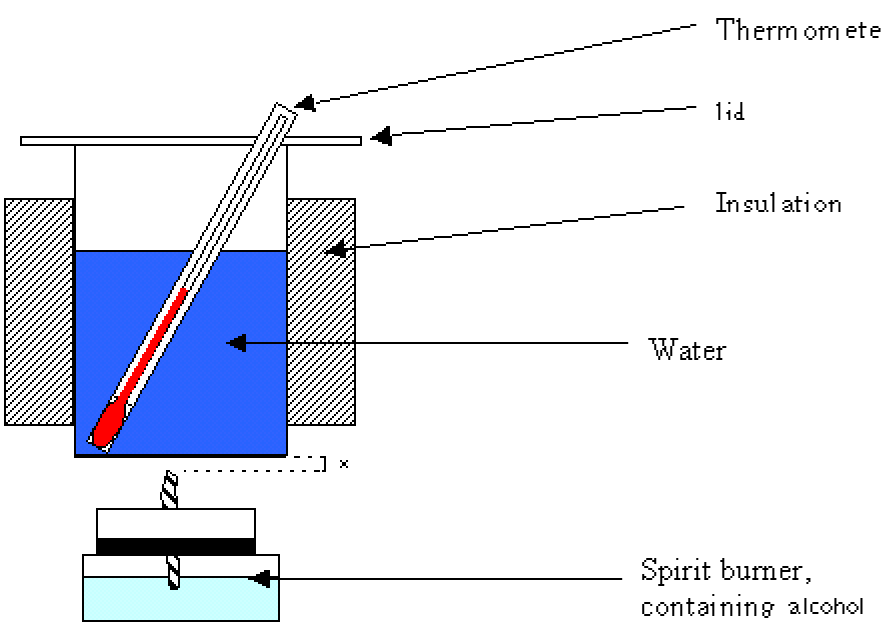
This is one of the constant variables. In other words, throughout the experiment, the mass of water being used will not be changed at all. To keep this variable fixed, it can be agreed upon to take a constant volume of water (in this case: $100cm^3$). The fact that the density of distilled water is exactly $1g/cm^3$ makes the calculations a lot easier.

Mass of Distilled Water = Volume of Distilled Water x Density of Distilled Water

As a result, the mass of water is kept constant by taking a fixed volume of water through all stages of the experiment.

<u>Distance of Wick and the bottom of the Calorimeter:</u>

This is another controlled variable, and has to be kept constant throughout the experiment. The distance between the wick of the spirit burner and the bottom of the calorimeter should be kept fixed. As this distance increases, more heat is lost to the surroundings and less heat reaches the bottom of the calorimeter. This will lead to a low rise in temperature of water (ΔT), and finally, an incorrect ΔH.



(Picture Taken From: http://www.webchem.net/notes/how_far/enthalpy/measurement_of_enthalpy.htm)

The distance between the wick and the bottom of the calorimeter is denoted by the distance *x* in the diagram above. This is the basic experimental set-up as well.

Thus, it would be better to keep the distance between the wick and the calorimeter as low as possible. As a result a distance of about 1 cm is quite suitable for this purpose. In this manner, this variable will be kept constant.

Temperature Rise:

This is another constant variable in the experiment. The temperature rise (ΔT) can be calculated from the formula given below:

Temperature Rise (ΔT) = Final Temperature – Initial Temperature

This should be kept constant throughout the experiment. The final temperature or the initial temperature of the water does not matter much. It is the temperature change (rise) which will affect the dependent variable. The final and initial temperatures can be measured using a thermometer. An alcohol thermometer with a range of -10˚C – 110˚C would be most suitable.

It should be kept constant as different alcohols will have different enthalpy of combustions. This can be put in a different way. Different alcohols will give different amounts of heat to raise water by a constant temperature (ΔT). To raise water's temperature by a fixed amount, different masses of alcohols will be lost. This is the most important constant variable as it would directly affect the dependent variable as well. In the experiment, the temperature change or rise will be kept constant at 33˚C.

Mass of Alcohol Burnt:

This is the dependant variable. In other words, this will change in due course of the experiment. The mass of alcohol burnt can be calculated in a very simple manner.

Before heating, the mass of the spirit lamp and its alcohol content can be measured. This reading should be recorded carefully. After heating, the mass of the spirit lamp and the alcohol content should be measured once again. This reading should also be noted down carefully. The difference of these two mass readings will give us the mass of alcohol burnt during heating.

Mass of Alcohol burnt = Final Mass of Spirit Lamp – Initial Mass of Spirit Lamp

This is the dependent variable and it will change for each alcohol.

In this manner, all the variables can be manipulated and measured. The apparatus list is given on the next page.

Apparatus list:

To carry out the experiment, the following apparatus is needed:

1) 1 Tripod Stand
2) 4 Spirit lamps (burners)
3) 1 Calorimeter (including copper beaker)
4) 1 Thermometer (Range: -10˚C - 110˚C) (± 0.05˚C)
5) 1 Stirrer
6) 1 Electronic Mass Balance (± 0.001g)
7) 1 Stopwatch (±0.01s)
8) Cotton or Wool (For Insulation)
9) 3 Wooden blocks
10) 1 Measuring Cylinder (100cm^3) (±0.5 cm^3)
11) 1 Packet of Matchsticks

Chemicals list:

The following chemicals are also needed:

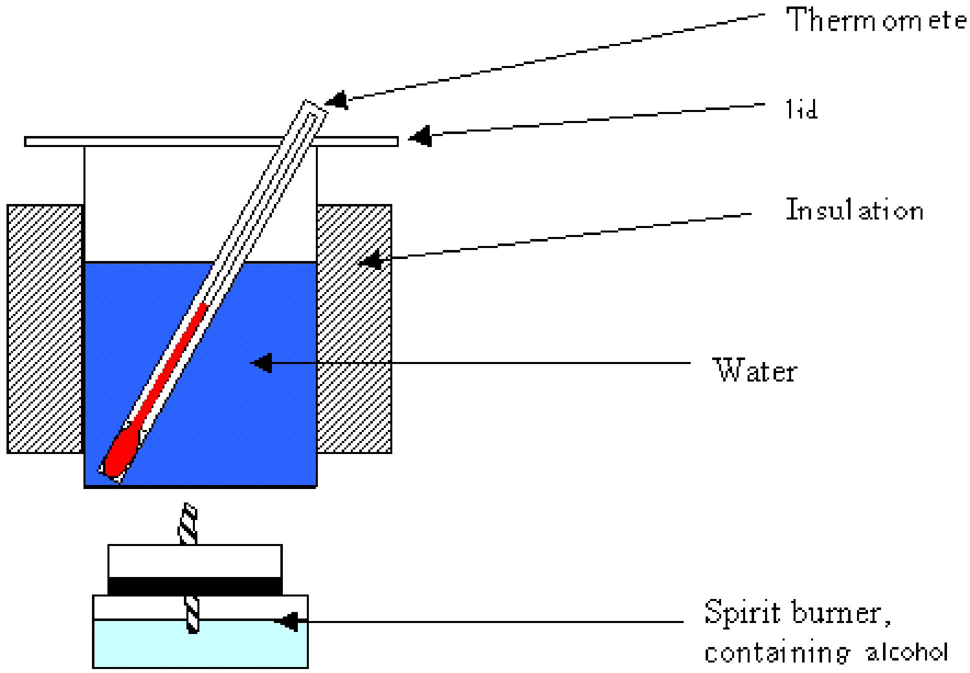
1) Distilled Water (1000cm^3)
2) Methanol (200 cm^3)
3) Ethanol (200 cm^3)
4) Propanol (200 cm^3)
5) Butanol (200 cm^3)
6) Pentanol (200 cm^3)

Method:

There are many steps which have to be followed to make sure that the experiment is carried out in a safe and precise manner:

1) Take the empty spirit lamp and weigh it using an electronic mass balance. Record this mass reading.
2) Add about 30-40 cm^3 of the alcohol being tested into the spirit lamp.
3) Weigh this spirit lamp using an electronic mass balance. Record this mass reading as well.
4) Then, measure out 100 cm^3 of distilled water using a measuring cylinder.
5) Add this water into the copper beaker of the calorimeter.
6) Record the initial temperature of the water.
7) Insulate the calorimeter by wrapping a fine layer of cotton or wool around it.
8) Cover the calorimeter using a lid, after placing the stirrer and the thermometer inside the beaker.
9) Take a matchstick and light up the spirit lamp. Once the alcohol has started burning, start the stopwatch.
10) Record and Observe the colour of the flame with which the alcohol is burning.
11) Observe any temperature rise in the water.
12) Gently stir the water at all times, during heating.
13) Ensure the fact that minimum heat is lost to the surroundings.
14) Blow out the spirit lamp as soon as the temperature has risen a total of 33˚C.

15) Stop the stopwatch at this instant as well.
16) Take the spirit lamp containing the alcohol and weigh it once again using the mass balance. Record this reading.
17) The experimental set-up should be looking somewhat like this:



18) Wash all the apparatus, and repeat these steps for the other alcohols which are to be tested.

Data Collection:

Qualitative Data:

There was quite a lot of qualitative data in the experiment. However, they were generally the same for all the alcohols being tested. These observations are summarized in the table below:

Before Heating	During Heating	After Heating
1) The alcohol had a very pleasant smell. 2) The alcohol was a colorless liquid 3) It had a very cold feeling when touched.	1) The flame of the alcohol during combustion was divided into two layers; blue and yellow. 2) The flame was odorless. 3) The water in the calorimeter started to bubble. 4) There was water vapour being released out of the calorimeter.	1) The alcohol still had the pleasant smell 2) It remained a colorless liquid.

Quantitative Data:

The data can be divided into five sections, each one for each respective alcohol:

Before Heating:

Methanol:

Mass of spirit lamp = 46.2 g
Mass of spirit lamp with methanol = 85.6 g

Volume of Water = 100 cm^3

Ethanol:

Mass of spirit lamp = 46.2 g
Mass of spirit lamp with butanol = 85.6 g

Volume of Water = 100 cm^3

Propanol:

Mass of spirit lamp = 45.9 g
Mass of spirit lamp with propanol = 83.1 g

Volume of Water = 100 cm^3

Butanol:

Mass of spirit lamp = 46.0 g
Mass of spirit lamp with butanol = 83.1 g

Volume of Water = 100 cm^3

Pentanol:

Mass of spirit lamp = 46.9 g
Mass of spirit lamp with pentanol = 85.6 g

Volume of Water = 100 cm^3

During Heating:

The same procedure was followed for all of the alcohols being investigated. These results are all shown on the table below. Therefore, calculations for these alcohols will not be mentioned further on.

Methanol			Ethanol		
No.	Time (s) (±0.01s)	Temperature (˚C) (±0.5˚C)	No.	Time (s) (±0.01s)	Temperature (˚C) (±0.5˚C)
1	0	22	1	0	22
2	30	24	2	30	24
3	60	26	3	60	27
4	90	30	4	90	31
5	120	35	5	120	35
6	150	39	6	150	40
7	180	43	7	180	44
8	210	47	8	210	48
9	240	51	9	240	52
10	270	55	10	270	55
Propanol			Butanol		
No.	Time (s) (±0.01s)	Temperature (˚C) (±0.5˚C)	No.	Time (s) (±0.01s)	Temperature (˚C) (±0.5˚C)
1	0	26	1	0	26
2	30	29	2	30	28
3	60	33	3	60	31
4	90	37	4	90	35
5	120	40	5	120	39
6	150	43	6	150	44
7	180	47	7	180	48
8	210	51	8	210	52
9	240	55	9	240	56
10	270	59	10	270	59

Pentanol		
No.	Time (s) (±0.01s)	Temperature (˚C) (±0.5˚C)
1	0	26
2	30	28
3	60	32
4	90	36
5	120	41
6	150	45
7	180	51
8	210	55
9	240	58
10	270	59

After Heating:

Methanol:

Mass of spirit lamp and Methanol = 81.8 g

Ethanol:

Mass of spirit lamp and Ethanol = 63.9 g

Propanol:

Mass of spirit lamp and Propanol = 80.9 g

Butanol:

Mass of spirit lamp and Butanol = 81.1 g

Pentanol:

Mass of spirit lamp and Pentanol = 83.6 g

The raw data needs to be processed further to help determine the relationship between the numbers of Carbon atoms in an alcohol and its standard enthalpy of combustion. This is shown on the next page.

Data Processing:

The data was collected and analyzed for each alcohol as given below:

METHANOL:

Before Heating:

Mass of spirit lamp = 46.2 g **(a)**

Mass of spirit lamp with methanol = 85.6 g **(b)**

∴ Mass of methanol = 85.6 g – 46.2 g **(b-a)**

= 39.4 g

Volume of Water = 100 cm^3

∴ **Mass of Water (m)** = Volume x Density

= 100 cm^3 x 1g/cm^3

= 100 g

Initial Temperature = 22˚C

After Heating:

Final Temperature = 55 ˚C

Temperature Change (ΔT) = Final Temperature - Initial Temperature

= 55 ˚C - 22˚C

= 33 ˚C

Temperature Change (ΔT) = 33 K

Mass of spirit lamp and Methanol = 81.8 g **(f)**

∴ Mass of Methanol burnt = 85.6 g - 81.8 g **(f-b)**

= 3.8 g

Molar Mass of Methanol = (12.01) + (4 x 1.01) + (16)

= 32.05 g/mol

$\therefore$ Moles of Methanol burnt = $\dfrac{\text{Mass of Methanol}}{\text{Molar Mass of Methanol}}$

$= \dfrac{3.8 \text{ g}}{32.05 \text{ g/mol}}$

= 0.1186 mol

Specific Heat Capacity of Water (c) = 4.18 J g^{-1} K^{-1}

Enthalpy Change during combustion = Mass of Water x Specific Heat Capacity x Temperature Rise of Water

Enthalpy Change during combustion (Δ*H*) = $mc\Delta T$

= 100 g x 4.18 J g^{-1} K^{-1} x 33 K

= 13794 J

= 13.794 kJ

$\therefore$ **Standard Enthalpy of Combustion of Methanol (ΔH°_{comb})**

$= \dfrac{\text{Enthalpy Change during combustion } (\Delta H)}{\text{Number of Moles of Methanol}}$

$= \dfrac{13.794 \text{ kJ}}{0.1186 \text{ mol}}$

= 116.3 kJ/mol

Number of Carbon atoms in methanol = 1

From the following experimental data, it can be calculated that the **standard enthalpy of combustion of methanol (ΔH°_{comb}) is 116.3 kJ/mol.**

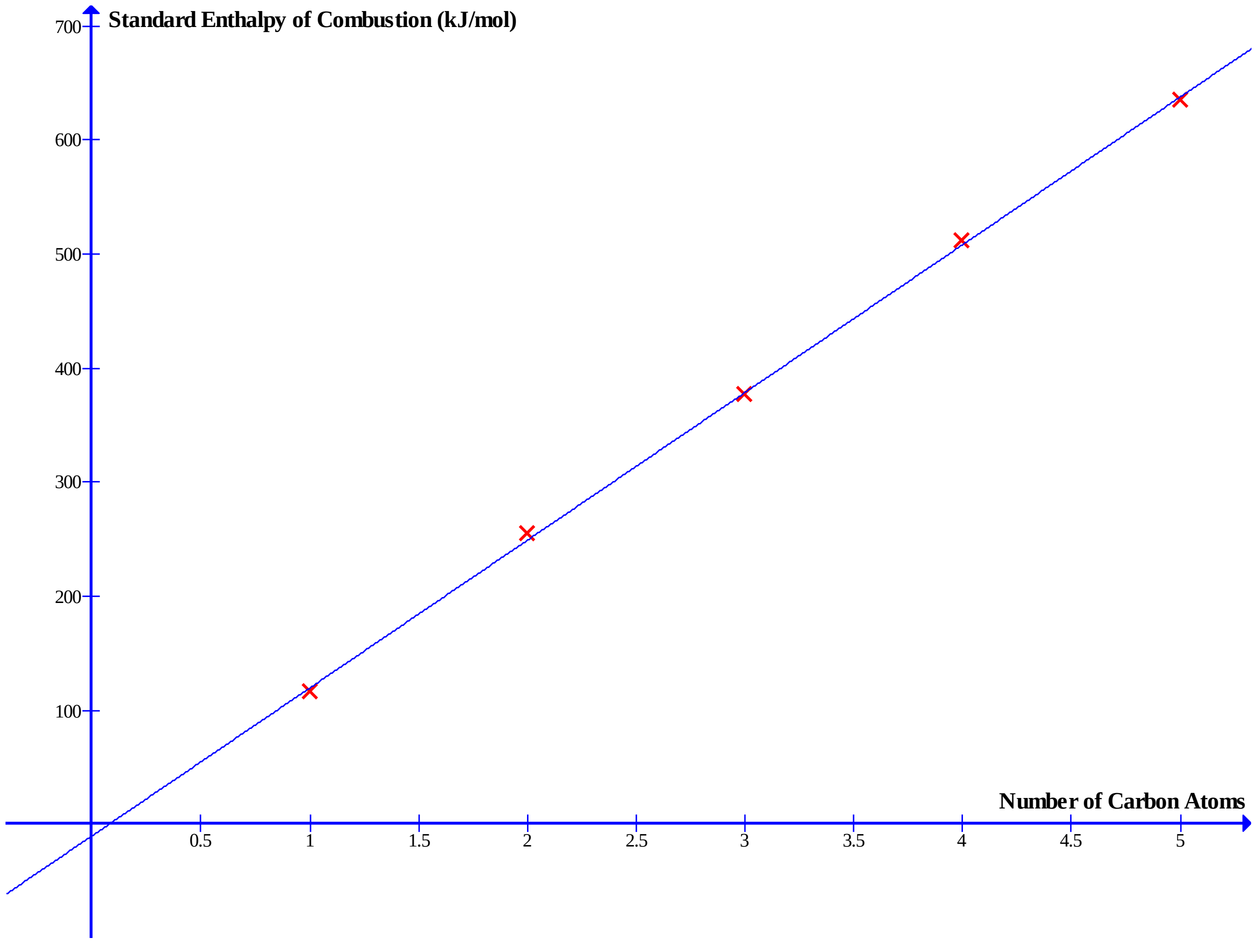
Similar procedures are followed to determine the standard enthalpy of combustion of the rest of the alcohols. The results are tabulated in the next page.

Thus, all the 4 alcohols have been tested for their standard enthalpy of combustions. The overall results are as shown in a tabular form below:

No.	Alcohol	Number of Carbon Atoms	Standard Enthalpy Of Combustion (ΔH°_{comb}) (kJ/mol)
1	Methanol	1	-116.3
2	Ethanol	2	-254.3
3	Propanol	3	-376.9
4	Butanol	4	-511.3
5	Pentanol	5	-635.3

The above table of results can also be explained graphically. The graph relating the number of carbon atoms in an alcohol and its Standard Enthalpy of Combustion is shown below:

Number of carbon atoms in an alcohol vs. Standard Enthalpy of Combustion ΔH°_{comb}



Please note that the actual values of the enthalpy of combustion are negative. For graphical purposes, only the magnitudes of these results are taken.

Error Propagation:

Methanol:

Uncertainty in the mass balance = 0.001 g

∴Mass of methanol burnt = 3.8 g ± 0.002g (calculated twice and uncertainties are always added)

Percentage Uncertainty = $\frac{0.002\ g}{3.80\ g} \times 100\ \%$

= **0.053 %**

Uncertainty in the thermometer = 0. 5˚C

∴ Temperature Difference = 33˚C ± 1˚C

Percentage Uncertainty = $\frac{1^\circ C}{33^\circ C} \times 100\ \%$

= **3.03 %**

Uncertainty in the measuring cylinder = 0.5 cm^3

Volume of Water taken = 100 cm^3

∴Percentage Uncertainty = $\frac{0.5\ cm^3}{100\ cm^3} \times 100\%$

= **0.5 %**

Uncertainty in Stopwatch = 0.01 s

However, the time does not affect the readings. Thus, its uncertainty can be neglected or ignored.

∴Total uncertainty = Sum of Percentage Uncertainties

= 0.053% + 3.03 % + 0.5%

= **3.583 %**

Uncertainty in kJ/mol = 3.583 % of 116.3 kJ/mol

= ± 4.167 kJ/mol

∴ The **standard enthalpy of combustion of methanol** (with uncertainty) is

116.3 kJ/mol ± 4.167 kJ/mol.

The following steps can be followed to determine the uncertainties in the data values of the other four alcohols.

∴ The **standard enthalpy of combustion of ethanol** (with uncertainty) is

254.3 kJ/mol ± 9.18 kJ/mol.

∴ The **standard enthalpy of combustion of Propanol** (with uncertainty) is

376.9 kJ/mol ± 13.65 kJ/mol.

∴ The **standard enthalpy of combustion of butanol** (with uncertainty) is

511.3 kJ/mol ± 18.56 kJ/mol.

∴ The **standard enthalpy of combustion of pentanol** (with uncertainty) is

635.3 kJ/mol ± 23.89 kJ/mol.

Thus, the result of error analysis is as shown below:

No.	Alcohol	Standard Enthalpy Of Combustion (ΔH°_{comb})
1	Methanol	**116.3 kJ/mol ± 4.167 kJ/mol**
2	Ethanol	**254.3 kJ/mol ± 9.18 kJ/mol**
3	Propanol	**376.9 kJ/mol ± 13.65 kJ/mol**
4	Butanol	**511.3 kJ/mol ± 18.56 kJ/mol**
5	Pentanol	**635.3 kJ/mol ± 23.89 kJ/mol**

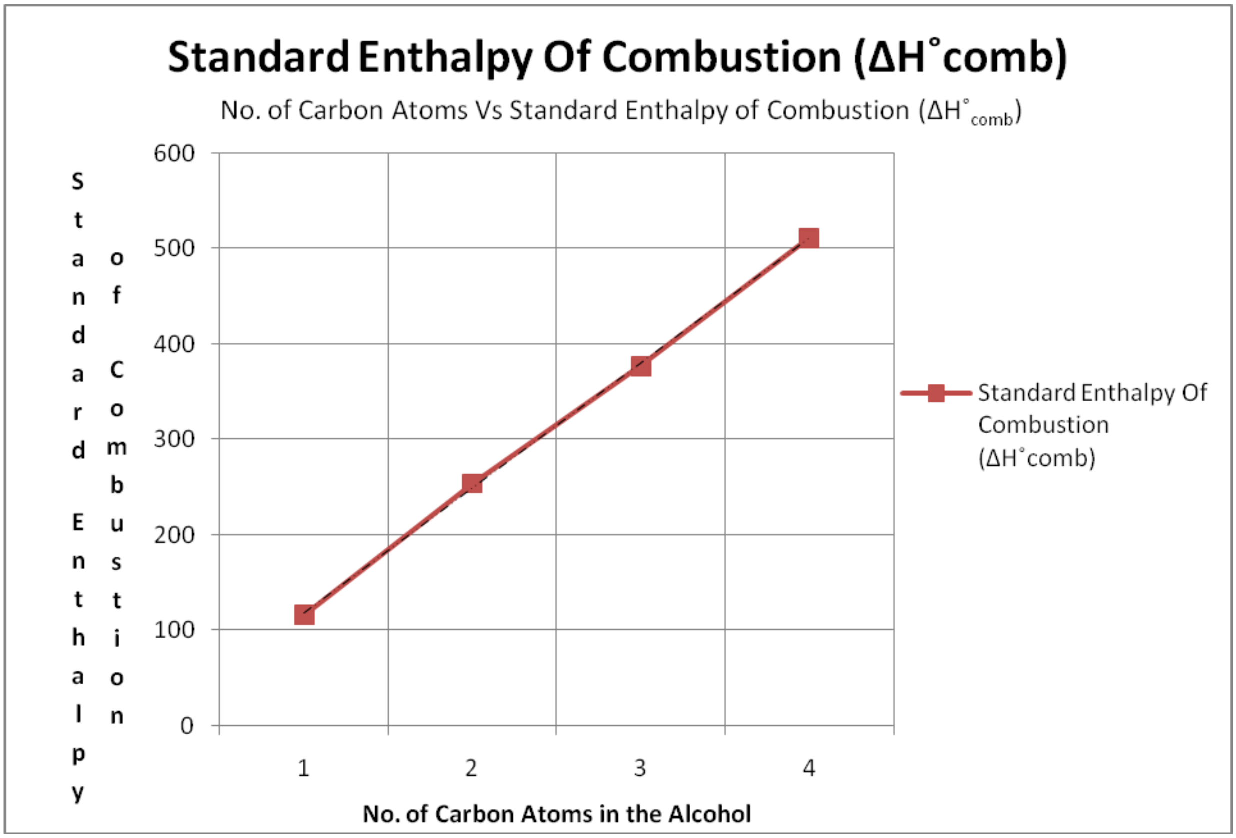
Conclusion:

The experiments carried out were quite successful, and yielded valid results. It has helped determine the relationship between the number of carbon atoms in an alcohol chain and its respective standard enthalpy change of combustion. The final results of the experiment are given as follows:

No.	No. Of Carbon Atoms In The Molecule	Alcohol	Standard Enthalpy Of Combustion (ΔH°_{comb}) (kJ/mol)
1	1	Methanol	-116.3
2	2	Ethanol	-254.3
3	3	Propanol	-376.9
4	4	Butanol	-511.3

Thus, the hypothesis has been proved correct. As the number of carbon atoms in an alcohol chain increases, its respective standard enthalpy change of combustion also increases. As it can be seen, the standard enthalpy combustion values increase as the number of carbon atoms increase. This can be explained by each successive member of the series contains one more methylene group ($-CH_2-$) than the previous one. When it is burnt, there will be one extra C-C bond and two extra C-H bonds to be broken. Therefore, much more energy is required for combustion. This is proven by the readings obtained in the table above.

A graph can be made from these set of readings above. This graph is presented on the next page:



The graph represents the trend in the experimental results. As the number of Carbon atoms in an alcohol molecule increases, the following standard enthalpy of combustion also increases. The red line plots the experimental data, whereas the black dotted line is the best fit line. The best fit line is a linear line. As a result, it can be concluded that the standard enthalpy of combustion of alcohols is proportionate to the number of carbon atoms the alcohol chain contains.

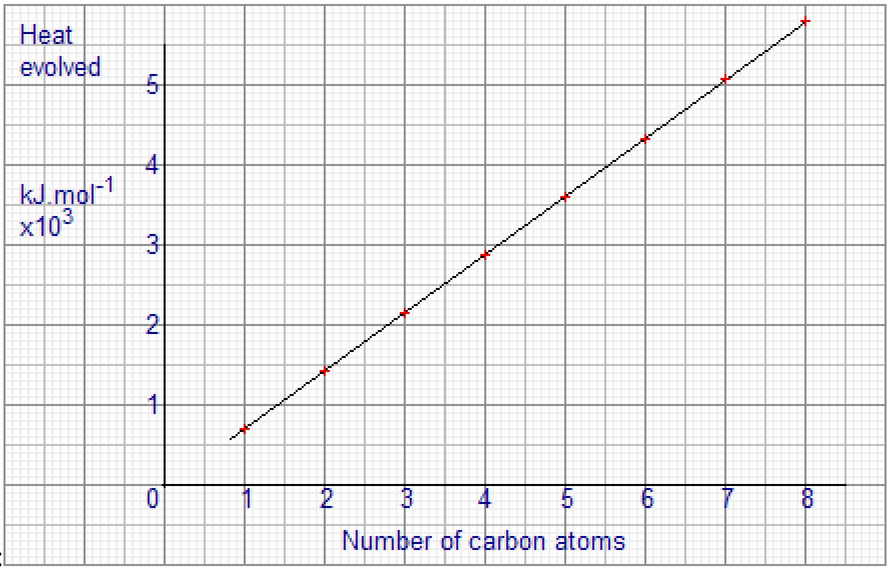
<u>Error Analysis:</u>

However, the literature values for the combustion of these four alcohols are given as:

Alcohol	C atoms	kJ mol^{-1}
Methanol	1	–726
Ethanol	2	–1367
Propanol	3	–2021
Butanol	4	–2676
Pentanol	5	-3329

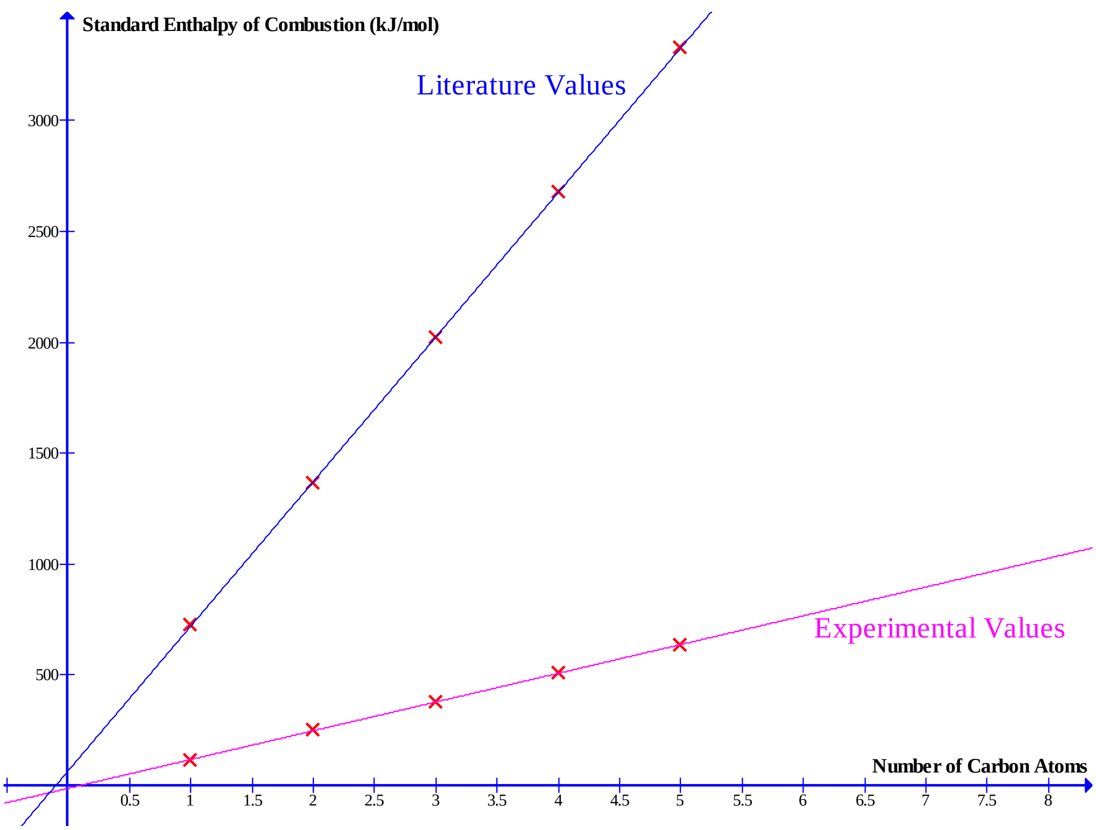
(Taken from: http://www.creative-chemistry.org.uk/alevel/module2/documents/N-ch2-09.pdf and http://www.creative-chemistry.org.uk/gcse/documents/Module7/N-m07-24.pd)

The graph of the literature vales looks somewhat like

this: 

(Taken from: http://www.succeedingwithscience.com/labmouse/chemistry_as/images/1310a.png)

When the literature values and the actual values obtained are combined on a graph, it looks somewhat like this:



Compared to the theoretical values, the experimental values are way off. There is a large error rate. As a result, the error percentage for each alcohol was found.

Methanol:

Standard Enthalpy of Combustion (ΔH°_{comb}):

Literature or Theoretical Value = –726 kJ/mol

Experimental Value = -116.3 kJ/mol

∴ Error = 726 kJ/mol - 116.3 kJ/mol (Eliminating Negative signs for calculations)

= 609.7 kJ/mol

$$\textbf{Percentage Error} = \frac{\text{Error}}{\text{Theoretical Value}} \times 100\%$$

$$= \frac{609.7 \text{ kJ/mol}}{726 \text{ kJ/mol}} \times 100\ \%$$

$$= \mathbf{84.0\%}$$

In this manner, the percentage errors for other alcohols were also found and the results are summed up in the table below:

No.	Alcohol	No. of Carbon Atoms	Percentage Error (%)
1	Methanol	1	84.00
2	Ethanol	2	81.40
3	Propanol	3	77.50
4	Butanol	4	80.80
5	Pentanol	5	82.30

As a result, despite the magnitude of errors, the experiment was completed in a perfect manner and satisfactory results have been obtained.

Evaluation:

There is no doubt that the experiment could have yielded better results, as high error percentages were prevalent. However, this magnitude of error does have its sources. Some of the sources are given below:

1) Around 90% of the heat from the spirit lamp did not reach the base of the tripod stand itself. This was the main reason of error. Heat was lost very easily. A lot of heat was lost in this manner and contributed to a lower than expected temperature change in the water. This was undoubtedly, the main source of experimental error.
2) Although, the copper calorimeter was properly insulated, heat loss was prevalent. The lid had a hole to allow the thermometer to be placed inside. This meant heat could be lost in this manner as well.
3) The mass of water might not have been constant throughout the heating process. Some of the water might have evaporated off, suggesting a mass loss. This would then give different results.
4) It was observed that during the combustion of alcohols, a yellow flame was obtained at times. This is the sign of the incomplete combustion of alcohols. As a result, carbon monoxide is formed instead of carbon dioxide. Therefore, this incomplete combustion results in low standard enthalpy of combustion values as the reaction is not complete.
5) During calculations, the specific heat capacity of the copper calorimeter was not included. This is wrong. The copper beaker did absorb some heat from the spirit lamp. This should have been added onto the heat energy absorbed by the water. Due its absence, a lot of heat was absorbed through the copper calorimeter itself, and this was not calibrated.

These sources of error could have been prevented at the first place. The random errors can be prevented in that manner. However, the systematic errors need to be corrected as well. Therefore, the method of the experiment can be evaluated further.

1) This experiment could have been carried out at a place of constant temperature.
2) The calorimeter could have been insulated more. A thick cotton wool could have been added.
3) The presence of draught shields would have helped reduce heat loss.
4) Use a digital thermometer to improve the accuracy of measurement.
5) Minimize the heat lost by ensuring no gas (vapour) is lost during the heating process, by adding more cotton for insulation or covering the calorimeter with a thick lid.
6) Black coloured cardboard can also be used for preventing heat loss.
7) Stir the water at all times to distribute heat evenly.
8) Blow out the spirit lamp as soon as possible. A delay here means that there is more loss of alcohol.
9) Make sure, no alcohol spills out during the burning process.
10) Carry out the experiment in the presence of excess oxygen to ensure that no incomplete combustion takes place.
11) Increase the number of trials for each alcohol and take the average of the results.
12) Repeat with a much larger variety of alcohols. ($C_6H_{13}OH$, $C_7H_{15}OH$, $C_8H_{17}OH$, etc).

Keeping these things in mind, the experiment can yield much better results.