CHEMISTRY COURSEWORK

RESULTS

ALCOHOL	AVERAGE MASS BURNT (G)
METHANOL	1.54
ETHANOL	1.02
PROPAN-1-OL	0.77
BUTAN-1-OL	0.69
PENTAN-1-OL	0.55
HEXAN-1-OL	0.52

Following the gathering of results, the enthalpy change of combustion of the alcohols was calculated using the equation from page 2:

Energy Transferred = Mass of water x Temperature rise x specific heat capacity (4.17)

Now to calculate the enthalpy change of combustion, the following steps are taken:

1.) Energy per gram = Energy Transferred ÷ Average mass change of alcohol

2.) Energy per mole = Energy per gram x Molecular mass

The Energy Transferred from each alcohol is constant as the variables, volume of water (200ml) and temperature rise (15°C) were kept constant. Therefore the calculation of energy transferred from each alcohol is:

Energy Transferred = $cm\Delta T$
  = 4.17 x 200 x 15
  = 12510 J

To convert this into KJ, we divide it by 1000 = 12510 ÷ 1000 = 12.510 KJ.
Hence 12.510 KJ of energy is transferred by each alcohol to raise 200ml of water by 15°C.
The calculations of the enthalpy change of combustion for each alcohol can be seen on the following page.

1.) **Methanol – CH$_3$OH : molecular mass = 32g**

Energy per gram = Energy Released ÷ Average mass change
  = 12.510   ÷ 1.54
  = 8.10 KJ

Energy per mole = Energy per gram x molecular mass
  = 8.10   x 32
  = 259 KJ mol $^{-1}$

2.) Ethanol – CH3CH$_2$OH : molecular mass = 46g

Energy per gram = Energy Released ÷ Average mass change
= 12.510   ÷ 1.02
= 12.3 KJ

Energy per mole = Energy per gram x molecular mass
= 12.3   x 46
= 566 KJ mol $^{-1}$

3.) Propan-1-ol – CH$_3$CH$_2$CH$_2$OH : molecular mass = 60g

Energy per gram = Energy Released ÷ Average mass change
= 12.510   ÷ 0.77
= 16.3 KJ

Energy per mole = Energy per gram x molecular mass
= 16.3   x 60
= 978 KJ mol $^{-1}$

4.) Butan-1-ol– CH$_3$CH$_2$CH$_2$CH$_2$OH : molecular mass = 74g

Energy per gram = Energy Released ÷ Average mass change
= 12.510   ÷ 0.69
= 18.1 KJ

Energy per mole = Energy per gram x molecular mass
= 18.1   x 74
= 1339 KJ mol $^{-1}$

5.) Pentan-1-ol – CH$_3$CH$_2$CH$_2$CH$_2$CH$_2$OH: molecular mass = 88g

Energy per gram = Energy Released ÷ Average mass change
= 12.510   ÷ 0.55
= 22.8 KJ

Energy per mole = Energy per gram x molecular mass
= 22.8   x 88
= 2006 KJ mol $^{-1}$

6.) Pentan-1-ol – CH₃CH₂CH₂CH₂CH₂CH₂OH: molecular mass = 102g

Energy per gram = Energy Released ÷ Average mass change
= 12.510   ÷ 0.52
= 24.1 KJ

Energy per mole = Energy per gram x molecular mass
= 24.1   x 102
= **2458 KJ mol⁻¹**

The table below summarises the enthalpy change of combustion of each alcohol.

ALCOHOL	ENTHAPLPY CHNAHE OF COMBUSTION (KJ mol⁻¹)
METHANOL	-259
ETHANOL	-566
PROPAN-1-OL	-978
BUTAN-1-OL	-1339
PENTAN-1-OL	-2006
HEXAN-1-OL	-2458

ANALYSIS

In general looking at graph 2, a clear trend can be seen in which as the number of atoms in the chain increases, the enthalpy change of combustion becomes increasingly negative as the reaction becomes more exothermic. Theoretically the reason for this is as the number of C-H bonds increase with each alcohol; more energy is required to break each bond. This is also the same case with breaking the O=O and C-C bonds as the number of these increases with each alcohol. Making new bonds also increases with each alcohol as making the number of CO_2 and H_2O molecules increase. Observing graph 1, you can see that in general the average mass burnt of each fuel decreases as the alcohol increases, however the difference in mass burnt also decreases (with the exception of propan-1-ol and butan-1-ol) which suggests that a lot less mass is needed to combust an alcohol as the alcohol increases in size. The reason behind this is the reactivity of the alcohols depend on there carbon atoms, where the more carbon atoms, the more reactive the alcohol would be, therefore it would use less fuel to heat the water. For example by looking at graph 1 you can see that ethanol which has two carbon atoms uses 1.02g of fuel to burn where as hean-1-ol has six carbon atoms and only uses 0.52g of fuel to heat the water up by 15°C.

By observing graph 3 you can clearly see that energy density is proportionate to the increase in alcohol size, where methanol produces the least amount of energy per gram (8.1KJ) and hexan-1-ol produces the most amount of energy per gram (24.1g).

Observing graph 2 we can see that two sets of results are plotted:
1. Enthalpy change of combustion of my own results
2. Enthalpy change of combustion of average bond enthalpies

The graph shows a strong positive correlation between the molecular mass of each alcohol and the enthalpy change of combustion. Looking at calculations made in my prediction, more energy is needed to break the bonds as the molecular mass increases. As each alcohol increases an extra carbon and two hydrogen atoms are added on and therefore each alcohol's molecular mass rises by 14.

Analysing the average bong enthalpy results you can clearly see that there is a perfect correlation where the enthalpy change of combustion changes by -618 KJ mol^{-1}, as each alcohol increases. Theoretically this occurs under standard conditions where the combustion difference is the same as each time an extra carbon and two hydrogen atoms are added on. The graph shows a very constant gradient where no anomalous results are present as the results are based on standard conditions where no energy is loss to the surroundings.

Looking at the line showing my results, again there is a fairly strong positive correlation between the enthalpy change of combustion and the molecular mass. The line of best fit shows a steady increase in the enthalpy change of combustion although not all points tend to fit the line however there is a general increase in the change where the molecules become larger. Here again the rise in mass of these alcohols means more bonds between theses alcohols, more energy is needed to break the increasing amount of bonds. The gradient for this graph is also constant where the energy difference is similar between the alcohols from the line of best fit. The high difference in the results obtained and calculated earlier in the prediction can be seen from both lines of the graph in which the average bond enthalpy line is much steeper where it suggests that for the experiment results a lot of energy disposed away. The difference in the enthalpy change increases more as the molecular mass increases mainly because a lot more energy is released to the surroundings as the alcohol size increases. For example the theoretical enthalpy change for butan-1-ol is -2512 KJ mol^{-1}, where as for the results which I obtained is 1339 KJ mol^{-1}, showing a difference of nearly -1200 KJ.

EVALUATION

Overall the method used to measure the enthalpy change of combustion provided me with reliable results in which a successful conclusion can be made. Comparing the results which I obtained and that of the average bond enthalpies, we can see that the heavier alcohols produce more energy. However, I did find an anomalous result in methanol where the point on graph 1 did not match that of the best fit line and therefore was seen as an anomaly. The reasons behind why such a result was obtained could have being to the fact that methanol was the first alcohol used and therefore the surrounding conditions could have affected the outcome, in which a lot of mass was

needed to raise the temperature by 15°C. There were a number of limitations which could have affected the final outcome which are listed below with explanation.

I. Whilst the alcohols were combusting there was a significant amount of heat being lost to the surroundings and therefore not heating the water efficiently. This would have affected the outcome of the results as if no heat was to be lost, the water could have heated by 15°C far quicker and therefore only a small amount of the alcohol would have being used.

II. Human error also affected the final outcome in which factors such as weighing, measuring and reading off measurements. The measuring of exactly 200ml of water could have being read off incorrectly on the measuring cylinder, in which the amount of energy released would have being affected.

III. Even though I stirred the water through out the experiment, I did not stir each trial equally with the same amount of effort and therefore heat being spread over the copper calorimeter would have being different for each trial.