Planning

This investigation involves burning alcohol in the air. Key science- Chemistry by Eileen Ramsden says that " an alcohol is a series of organic, homologous compounds, with the general formula Cn H2n+1OH". The alcohol reacts with the oxygen in the air to form the products water and carbon dioxide:

Cn H2n+1OH +(n+n/2)-1O2 ? nH2O + nCO2

The structure of the molecules in this reaction is:

H H | | H - C - C - O- H + 3[O=O] ? 1/2[O=C=O] + 3[H-O-H] | | H H

This reaction is exothermic, as heat is given out. This is because the amount reactant energy is more than the product energy the difference between this is ?H, therefore some energy has been given out in the form of heat.The energy is given out when forming the bonds between the new water and carbon dioxide molecules. This can be shown in an energy level diagram: Reaction co-ordinate ?H is the heat content, which is the enthalpy, which is negative in exothermic reactions as the diagram shows that energy is 'lost' as heat. Enthalpy is defined as the energy of reaction, or the heat energy associated with a chemical change. Chemical Principles By Master & Slowinski says that "For any reaction carried out directly at a constant pressure, the heat flow is exactly equal to the difference between enthalpy of products and that of the reactants", or: Qp = Hp - Hr = ?H Where Qp is the heat flow at constant pressure, Hp is heat energy of products, and Hr is the heat energy of the reactants.

To measure ?H given off, we must use this energy to heat something, this will be water. This is assuming that all the heat produced by combustion of fuel (?H) will equal the amount of heat absorbed by the water (q). So I will measure the amount of energy required to do so. This can be worked out by useing the formula: q = mass X specific heat capacity X temperature rise 1000 Where q is the quantity of heat. The specific heat capacity is the amount of energy required to heat the substance, and is calculated using the formula q = MC?, where q is the enthalpy, is the specific heat capacity and ? is the temperature rise. I chose to use water as it is safe, easily obtainable, and has a constant, reliable specific heat capacity of 4.2J/?C.

The bonds which are made in a exothermic reaction "are forces of attraction between the atoms or ions in a substance" according to Key science- Chemistry by Eileen Ramsden. These can be of two types: covalent, in which the atoms share electrons. Examples of this are water and carbon dioxide, which has a double covalent bond because it shares two pairs of electrons are shared. The other type of bonds are ionic, where a metal is involved. This is where electrons are transferred from one ion to another, so there is an electrostatic force between the ions.

The variables that must be controlled are:

* Mass of water

* Amount of wick on burner

* Type of alcohol

* Height of can above flame

* Type of can

* Time of burning

The alcohols used in this experiment will be from methanol, to hexanol, their formulas and predicted enthalpy changes are:

Substance Formula - Predicted enthalpy change (KJ/mole)

Alcohol CnH2n+1OH

Methanol CH3OH -730

Ethanol C2H5OH -1370

Propanol C3H7OH -2010

Butanol C4H9OH -2670

Pentanol C5H11OH -3320

Hexanol C6H13OH 3980 N.B. The precicted enthalpy changes come form the book of data by Nufield science. As the table shows, each alcohol reaction increases each time by :

CH2 +11/2O 2 ? CO2 + H2O.

Investigating The Combustion Of Alcohols - Method

I did some preliminary results, the results of which are shown in the table below:

Mass water (g) Initial temperature (C) Final temperature (C) Temperature rise (C)

50 19 42 23

100 20 38 18

150 20 31 11

This experiment was done to see which mass of water would be best. The 50g mass was too large a rise as this caused too much heat to be lost to the environment, and 150 was to small. Therefore the 100g value was used, as this temperature was right for the enthalpy calculations. Also the amount of wick was investigated, and I found that if it were too large, there was more heat lost to the environment, and if it were to small, most of the heat given out is lost in the can, so 6mm is the optimum wick length. This will be kept constant throughout, as well as the mass of water, and the temperature will be kept constant, to ensure that only the type of alcohol is being investigated, so that this can be a fair test.

As well as this, methods of reducing heat lost to the environment were investigated. I found that by placing a hardboard draught excluder around the experiment, and a cardboard lid with a hole for the thermometer on top of the can, the heat lost was significantly reduced to make this experiment more accurate. Stirring the water means that there is uniform temperature in the can, and monitoring the temperature rise to ensure uniform heating. The can is copper as copper is a good conductor of heat, so more is transferred to the water. The height of the can above the flame is also a factor, so this needs too be kept constant just touching the can.

I decided to burn the alcohol for three minutes to make sure that enough energy had been transferred for a accurate experiment. The can was kept the same as different cans have different conduction properties The heat is transferred from the flame by vibrating air particles in the flame, caused by the exothermic reaction, which then cause the molecules in the can to vibrate, and so the molecules in the water vibrate.

Method:

* Measure out 100cm3 of water in to copper can using measuring cylinder.

* Place can so flame just touches bottom of can

* Stir and record initial temperature of water

* Record initial mass of alcohol plus burner

* Start clock and light burner at the same time

* Stir water

* Burn for three minutes, then extinguish flame

* Record final temperature of water

* Record final mass of burner and alcohol

Investigating The Combustion Of Alcohols - Results

Initial temp (C) Max Temp (C) Temp rise (C) Initial burner (g) Finish burner (g) No. C atoms

Methanol 1 17 37 20 48 47 1

Methanol 2 18 38 20 55 73 1

Ethanol 1 18 40 22 47 46 2

Ethanol 2 18 41 23 73 92 2

Propanol 1 19 39 20 43 44 3

Propanol 2 20 40 20 35 65 3

Butanol 1 20 42 22 44 43 4

Butanol 2 20 42 22 65 98 4

Hexanol 1 19 42 17 52 52 5

Hexanol 2 19 42 17 88 38 5

Pentanol 1 19 34 15 38 51 6

Pentanol 2 20 35 15 51 87 6 The controlled variables are the same can, the 100g of water throughout, 6mm of wick, and the flame just touching the can, to ensure this is a fair test, and that only the alcohol.

Investigating The Combustion Of Alcohols - Analysis

The graph shows two lines. The top line is the results predicted by the chemistry data book- by Nufield Advanced Science. The lower line is the line of best fit for the results that I obtained. The line is a straight line that does not go through the origin. This is because when y = 0, x = 1 carbon atom. The actual results graph is not directly proportional, only proportional, as the graph was a straight line. The predicted graph is directly proportional, as was predicted it should be, this is shown as the number of carbon atoms is one, the enthalpy change is -730, and when the number of carbon atoms doubles to two, the enthalpy change nearly doubles to -1370, and when the number of carbon atoms doubles again to 4, the enthalpy change, again nearly doubles to -2670.

This is because earlier in the planning section, I predicted that the number of carbon atoms would be proportional to the number the enthalpy change. This is because when the number of carbon atoms increases by 1, the reaction increases then number of molecules used as follows: CH_2 + 11/2O2 ? CO_2 + H_2O This shows that the number of molecules increases by the same amount each time, and so should the enthalpy change, if the all other variables were kept constant, and so the predicted graph would look like this, showing that No. carbon atoms ? enthalpy change. This is assuming that all the heat given off by the burner is absorbed by the water: This graph is a straight line, like my actual results, so my results support this part of the prediction, but they are not directly proportional as predicted, therefore my results do not support this part of the

Investigating The Combustion Of Alcohols - Evaluation

This experiment has many sources of error as the results were not what were predicted. The real results, predicted results and % error, had no ananomalous results.

My results are highly inaccurate as they are all nearly half the predicted results. This is not due to the inaccuracy of not carrying out the experiment properly as the error bars on the graph were too small to be drawn accurately, as the two readings are almost the same.

These small inaccuracies are caused by slight differences in the values of the fixed variables, like the mass of water not being exactly 100g, due to incorrect reading of the measuring cylinder caused by a paralax error, caused when the scale is read at an angle to the eye, as the light is reflacted through the glass, causing the reading to appear somewhere else . The same error could have been meant an error in the reading of the thermometer, causing there to be wrong temperature readings. The amount of wick on the burner will not have been exactly the same (6mm) on each burner as this was difficult to measure. This would have caused differences in the amount of alcohol burnt. The flame was not always just touching the can, as this again was difficult to measure accurately, and would have caused differences in the amount of heat given off as the temperature of the flame is different and different heights. The can might not have been the same as this experiment was done over two lessons, and different cans have different conduction properties. Also the time for each burn might not have been three minutes exactly each time as it takes time for the final reading to be read and the flame to be extinguished after the time is up. The thermometer was not in the same place at each temperature recording, as even though the water was stirred, there would be differences in the temperature of the water at different depths.

To make the results slightly more accurate, I would use more accurate, maybe electronic ways of measuring temperature and volume, also measure the wick length and height of can above the flame. I would also have marked the can used, so that it could be used again, and had a more accurate timing system As these errors were only small, they could not have made the massive differences between the predicted results, so there must have been other factors that caused the heat from the burner not to reach the water, and cause these errors.

The whole experiment was surrounded in mats to stop a draught taking heat from the flame, however there were still gaps at the tops of the experiment where a draught could have caused heat to be lost. Also the can, although copper, would not have transferred all the heat across, some would be lost heating up the can. The can being copper meant that as well as heat being added easily, heat is lost just as easily, as the water heats up. There was a card board lid to prevent some of this heat lost, but the sides of the can were not insulated, so huge amounts of heat were given of by the can. The clamp, which is metal, and was touching the can will have meant some of the heat was transferred into the clamp and stand, causing more heat loss form the experiment. In order for this experiment to be more accurate, I would have to insulate the can and the clamps, completely exclude all draughts use a better conductor other than water to heat, and use a thinner can, made of a better heat conducting material.

Given that the range of the experiment was only 6 alcohols from methanol to hexanol and that the experiment was only 3 minutes, and the inaccuracies of the experiment, I would say that the evidence is not strong enough to draw firm conclusions from. If this experiment was to be done again, then all the possible sources of error mentioned would have to be counteracted and controlled, as well as using a much wider range of readings of many more alcohols, burn them for different periods of time, heat different substances other that water, investigate the other variables. I would also take many more readings so a that a much more accurate average could be taken. Other experiments could have been done investigating other organic compounds, such as hydrocarbons, to see if they behave similarly, and investigate them under different conditions, such as at extremes of temperature and pressure.