

Enthalpy Experiment

I will be trying to obtain reliable results which tell me the relationship between the number of carbon atoms, in particular alcohols: Methanol, Ethanol, Propan-1-ol and Butan-1-ol, and the amount of heat energy given out, known as the enthalpy of combustion. The combustion process is the making and breaking of bonds. In my experiment heat will be given out (it will be an exothermic reaction) In an exothermic reaction the products are at a lower energy level than the reactants, the difference is the heat energy. The complete combustion of an alcohol is when it reacts with oxygen in the air to form water and CO_2 . Fuel is a substance that is generally burned to produce thermal energy. Using these 4 alcohol fuels I aim to find out how much heat energy each alcohol produces. I am going to investigate this energy release by burning alcohol- "enthalpy of combustion" and how the number of carbon atoms in each of the alcohols affects the enthalpy change occurring during combustion.

Once my results have been obtained I will compare them against the theoretical enthalpy values. If they don't match up I will suggest some factors which conclude why.

Hypothesis

My hypothesis is that the more carbon atoms, the more heat will be produced. Alcohols produce heat when they burn in oxygen or air. Full combustion should generate only two products: CO_2 and H_2O . I predict that the alcohol with the greatest relative molecular mass will be the most efficient. Therefore, it will be Butan-1-ol as it has the greatest mass-per-mole of each of the four alcohols.

ALCOHOL	FORMULA OF ALCOHOL	AVERAGE TEMP
	THEORETICAL ENTHALPY	RISE

VALUES

12.33	Methanol	- 726	CH ₃ OH
11.83	Ethanol	-1367	C ₂ H ₅ OH
12.15	Propan-1-ol	-2021	C ₃ H ₇ OH
12.00	Butan-1-ol	-2676	C ₄ H ₉ OH

To work out the energy transferred to water I could use the above table, and the following calculation:

$$\text{Energy Transferred to Water} = \text{Specific Heat Capacity (4.2JgC}^{-1}\text{)} \\ \times \text{Mass of Water} \times \text{Change in Temp}$$

- Methanol: $4.2 \times 100 \times 12.33 = 5178.6 \text{ J}$
- Ethanol: $4.2 \times 100 \times 11.83 = 4968.6 \text{ J}$
- Propan-1-ol: $4.2 \times 100 \times 12.15 = 5103 \text{ J}$
- Butan-1-ol: $4.2 \times 100 \times 12.00 = 5040 \text{ J}$

The Relative Molecular Mass can be calculated by substituting the appropriate values in the formula of each alcohol, the RMM needs to be known to calculate how many moles are in each alcohol. All of these calculations needed to be performed to obtain my final results.

$$\text{No. of Moles} = \text{Mass Burnt} / \text{RMM}$$

- Methanol: Mass used- $0.81\text{g} / 32 = 0.025 \text{ moles}$
- Ethanol: Mass used- $0.56\text{g} / 46 = 0.012 \text{ moles}$
- Propan-1-ol: Mass used- $0.5\text{g} / 60 = 0.0083 \text{ moles}$
- Butan-1-ol: Mass used- $0.47\text{g} / 72 = 0.0064 \text{ moles}$

Now i can work out the enthalpy by using the results from the previous two calculations.

$$\text{Enthalpy} = \text{Energy Transferred to Water (J)} / \text{Moles of Fuel Burnt (mol)}$$

- Methanol: $5178.6 / 0.025 = 207.144 \text{ kJmol}^{-1}$
- Ethanol: $4968 / 0.012 = 414.05 \text{ kJmol}^{-1}$
- Propan-1-ol: $5103 / 0.0083 = 614.82 \text{ kJmol}^{-1}$
- Butan-1-ol: $5040 / 0.0064 = 787.5 \text{ kJmol}^{-1}$

Now each of these values can be plotted on a graph, against the number of carbon atoms. Below is the table of these results.

My Final Results Table

ALCOHOL NUMBER OF MOLES	ENERGY TRANSFERRED ENTHALPY CHANGE TO WATER
Methanol 0.025	5178.6 J -207.144 kJ/mol ₁
Ethanol 0.012	4868.6 J -414.05 kJ/mol ₁
Propan-1-ol 0.0083	5103 J -615.83 kJ/mol ₁
Butan-1-ol 0.0066	5040 J -763.63 kJ/mol ₁

Analysis

My prediction states that the amount of heat produced per gram of alcohol will increase as the number of carbon atoms per molecule increases. This was true, further proving that Butan-1-ol to be the most efficient, as it produced the most heat. Methanol, with the lowest

relative molecular mass, was the least efficient of the four alcohols. Carbon atoms in alcohols do have an effect on the heat of combustion. As the number of carbon atoms increases the heat of combustion also increases, this is because every time a carbon atom is added, 12 is being added onto its' RMM

Evaluation

Although my own enthalpy values do not match up with the theoretical enthalpy values, they are of a similar order, giving, roughly, straight-line graphs. It is likely that the heat loss from my apparatus was constant throughout my whole experiment, therefore, the trends I discovered were correct but my apparatus was crude. My results could never have been as accurate as the theoretical values because of the experimental errors that occurred. My results are much lower than the theoretical values, the theoretical values most likely calculated all energy release, my experiments' calculation was heat energy alone. Other factors affecting the accuracy of my results could be that, sound and light energy will have been lost in the room. The beaker itself will have absorbed some of the energy. The alcohol containers had different amounts of alcohol and varying wick sizes, these factors contributed to the varying size of the flame; which sometimes never even touched the beaker.

Also the environment in which my experiment was conducted could have contributed to my low enthalpy values. A lack of oxygen could have caused incomplete combustion, this is, however, unlikely. The room temperature may have acted as a cooling agent.

I conclude that the classroom was a difficult environment in which to perform this experiment, there are so many potential ways of losing energy, as everything likes to gain heat energy. Apart from sufficient heat insulation and, no gusts of air to take heat away from the experiment there are no ways to obtain results close to the theoretical enthalpy values. From my graph I notice the obvious anomalous result is in the combustion of Butan-1-ol, however it wasn't abnormally anomalous and I think it will be due to natural error, I could repeat that part of the experiment again, to gain an average and re-plot it on the graph.

