Candidate 8 evidence

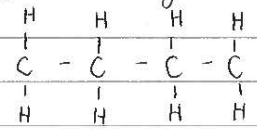
Enthalpy of Combustion

Aim

- To investigate the effect of increasing alcohol size on the enthalpy of combustion [redacted].

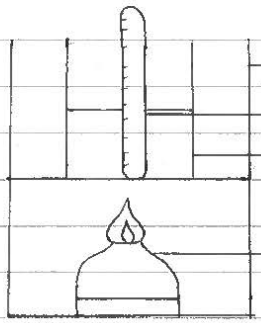
Underlying Chemistry

- The enthalpy of combustion is the energy released when a substance burns completely in oxygen.
- Values for enthalpy of combustion are always negative since the reaction is exothermic.
- In enthalpy of combustion equations there is always only one mole of the feul in the mole to mole ratio. e.g...
- $CH_3OH + \frac{3}{2}O_2 \rightarrow CO_2 + 2H_2O$
  ↑ 1 mole
- A feul is a substance which contains energy, some feuls contain more energy than others. In my experiment the alcohols were the feuls. [redacted]
- All the alcohols I used were primary alcohols which means the hydroxyl functional group [OH] was on an end carbon. e.g...



- [this is butanol / butan-1-ol]
- There are also secondary and tertiary alcohols but these were not used in my experiment.
- After the experement was carried out $E_H = mc\Delta T$ can be used to calculate the energy released for the mass burned. When m is the mass of water heated, c is the specific heat capacity (which for water is always 4.18) and ΔT is the change in temperature of the water. Cross multiplying can then be used to factor up for one mole. e.g...
- mass burned (of feul) ⟶ energy released (KJ)
  gfm ⟶ enthalpy of combustion. ($KJmol^{-1}$)

Method



- Spirit burner was weighed, spirit burner was lit and placed under can containing water. Water was allowed to increase in temperature by 10 °C (around). Flame on spirit burner was put out and was then weighed again. The previous was then carried out with 3 other alcohols. No extra safty precations were taken.

Data

Alcohol	Start temperature of water (°C)			End temperature of water (°C)			ΔT (°C)			
	1	2	3	1	2	3	1	2	3	Av
methanol	20	20	20	31	30	31	11	10	11	10.7
ethanol	20	20	20	30	30	30	10	10	10	10.0
butanol	20	20	20	30	30	30	10	10	10	10.0
pentanol	20	20	20	30	30	30	10	10	10	10.0

Alcohol	Start mass of spirit burner (g)			End mass of spirit burer (g)			change in mass (g)			
	1	2	3	1	2	3	1	2	3	Av
methanol	261.11	260.09	259.20	260.09	259.20	258.24	1.02	0.89	0.96	0.96
ethanol	235.48	234.92	234.29	234.92	234.29	233.79	0.56	0.63	0.50	0.56
butanol	267.54	267.02	266.54	267.02	266.54	265.96	0.52	0.48	0.58	0.53
pentanol	234.06	233.57	233.11	233.57	233.11	232.61	0.49	0.46	0.50	0.48

- [100ml of water was used]

Calculations

Methanol

- $Eh = mc\Delta t$
  $= 0.1 \times 4.18 \times 10.7$
  $= 4.4726$ KJ

$0.96g \longrightarrow 4.4726$ KJ
$32g \longrightarrow 149.086\ldots$
$= -149$ KJmol^{-1} [to nearest whole number]

Ethanol

- $Eh = mc\Delta t$
  $= 0.1 \times 4.18 \times 10$
  $= 4.18$ KJ

$0.56g \longrightarrow 4.18$ KJ
$46g \longrightarrow 343.357\ldots$
$= -343$ KJmol^{-1}

Butanol

- $Eh = 4.18$KJ

~~$0.83g \rightarrow 4.18$KJ~~
~~$60g \rightarrow 473.201\ldots$~~
~~$= 473$KJmol^{-1}~~

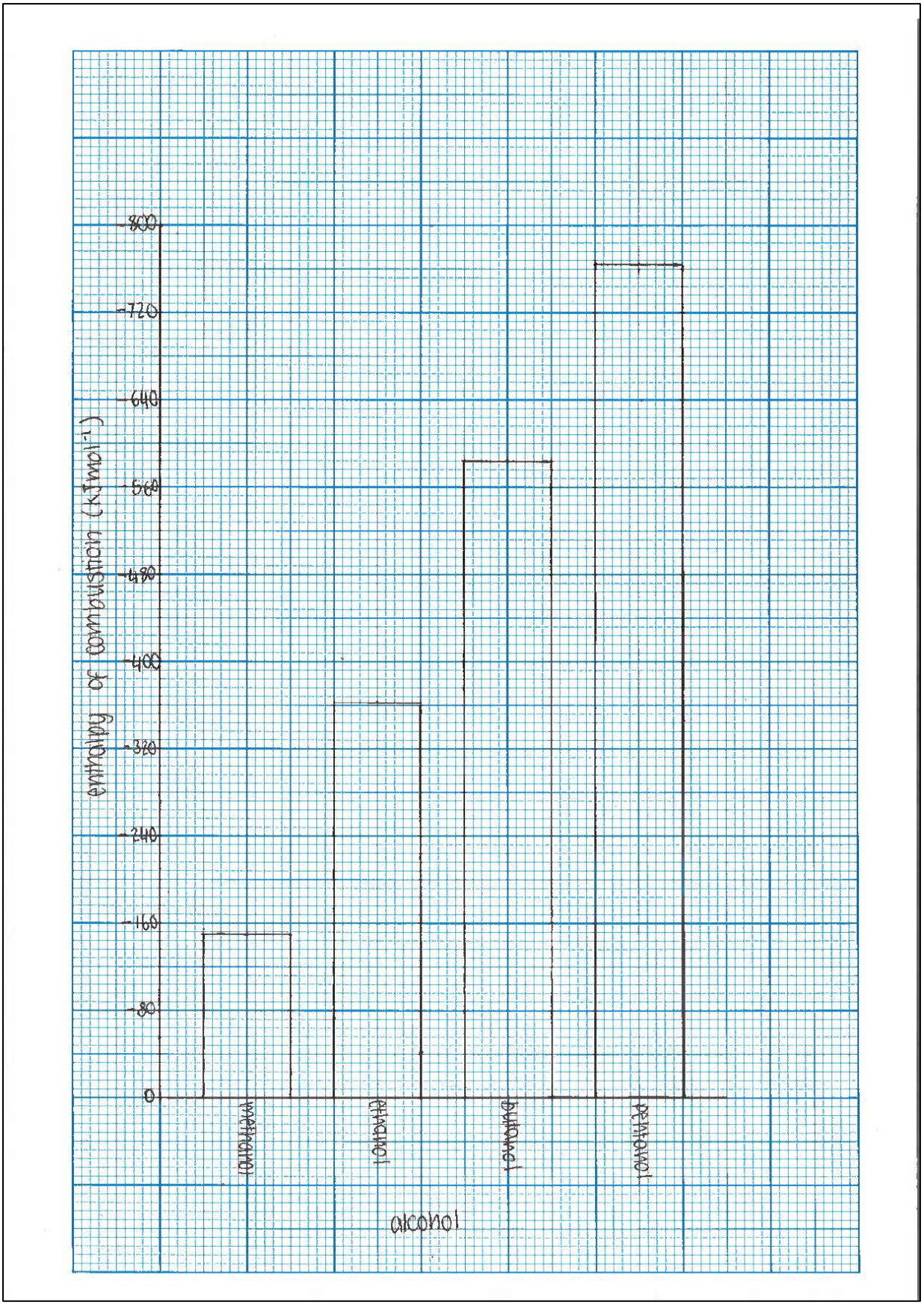
$0.53g \rightarrow 4.18$KJ
$74g \rightarrow 583.62\ldots$
$= -584$ KJmol^{-1}

Pentanol

- $Eh = 4.18$KJ

$0.48g \rightarrow 4.18$KJ
$88g \rightarrow 766.33\ldots$
$= -766$ KJmol^{-1}

Alcohol	Enthalpy of Combustion (KJmol^{-1})
methanol	-149
ethanol	-343
butanol	-584
pentanol	-766


enthalpy of combustion (kJmol⁻¹)
800
720
640
560
480
400
320
240
160
80
0
methanol
ethanol
butanol
pentanol
alcohol

Internet Data

C. no.	alcohol	formula of '1-ol' primary alcohols	ΔH^{θ}_{comb} in kJ/mol
1	methanol	CH_3OH	–726
2	ethanol	CH_3CH_2OH	–1367
3	propan–1–ol	$CH_3(CH_2)_2OH$	–2021
4	butan–1–ol	$CH_3(CH_2)_3OH$	–2676
5	pentan–1–ol	$CH_3(CH_2)_4OH$	–3329

(1)

Analysis

- The internet data is significantly higher than my data with the source saying the enthalpy of combustion for methanol is $-726 kJmol^{-1}$ which is 4.87 times larger than my result, $-149 kJmol^{-1}$. My result for ethanol, $-343 kJmol^{-1}$, is 3.99 times smaller than the sources, $-1367 kJmol^{-1}$. The internet sources value for butanol which is $-2676 kJmol^{-1}$ is 4.58 times bigger than my result of $-584 kJmol^{-1}$. My result for pentanol, $-766 kJmol^{-1}$ is 4.35 times smaller than the sources result of $-3329 kJmol^{-1}$.
- My results are consistantly smaller than the internet source. This shows that there are factors which bring my result value down consistantly. these factors will be discussed in my evaluation.

Referance / Citation

https://www.docbrown.info/page06/alcohols4.htm (1)

- Accessed 12th March 2024.

Conclusion

- As you increase alcohol size, the enthalpy of combustion of the alcohol also increases.

Evaluation

- The results I got were consistantly much lower than the internet sources results. A possible reason for this could be:
  - With the aperatace which I had access to, there will have definantly been some heat loss to the surroundings, due to the heat sheild not being able to trap all of the heat energy released and transfer it into the water. A way this could have been prevented to give more accurate results could be to use more advanced apperatice such as a bomb calorimeter.
- My results were all around the same times smaller than the internet results. This shows that I carried out the proceaure well, with the aperatace I had, since the results were consistantly lower and not random.
- My results were quite reliable since I repeated my experiment 3 times for each alcohol and took an average of the ΔT and the change in mass. For my experiment to be more reliable I could have carried out more repeates.