Combustion of Alkanols

Aim: To find the molar heat of combustion for three different alkanols.

Theory: Specific Heat Capacities:

Water – 4.18

Aluminium – 0.89

*Courtesy of Conquering Chemistry, Roland Smith, 2005.

Published values of Molar Heat of Combustions

Ethanol	1364 kJ mol^{-1}
1-Propanol	2016 kJ mol^{-1}
1-Butanol	2677 kJ mol^{-1}

*Courtesy of SI Chemical Data, Alward, GH & Findlay, TJV, 1974, Jacaranda.

Molar Weight of Alkanols:

Ethanol	46.06844
1 – Propanol	60.09501
1 – Butanol	74.12158

*Courtesy of KRW's Solutions Assistant Software, Version 2.0.8

Equipment:

- Ethanol Spirit Burner
- 1-Propanol Spirit Burner
- 1-Butanol Spirit Burner
- Electronic Balance
- Aluminium can insulated with cardboard and tin.
- Retort stand
- Boss head x 2
- Clamp x 2
- Thermometer
- Water
- Matches

Method:

1. Recorded mass of empty aluminium can.
2. Set up retort stand.
3. Attached one set of boss head and clamp to retort stand and hung thermometer to it.
4. Attached other set of boss head and clamp to retort stand slightly lower.
5. Added Approx 200ml of water to aluminium can and re-weighed.
6. Hung aluminium can and insulation from second clamp.
7. Recorded temperature of water.
8. Recorded mass of the ethanol spirit burner.
9. Lit ethanol spirit burner and placed under aluminium can.
10. Allowed temperature of the water to rise by approximately 15 degrees celcius.
11. Recorded temperature.
12. Extinguished flame and re-weighed ethanol spirit burner.
13. Determined mass of ethanol combusted.
14. Used mass and specific heat capacity of both water and aluminium to calculate combined specific heat capacity.

15. Used ?H = -mC?t formula to calculate heat produced.
16. Converted value to energy per mole.

Results:

Test	Mass of Can (g)	Mass of Can + Water (g)	Mass of Spirit Burner (g)			Temperature (°C)		
			At Start	At End	Difference	At Start	At End	Difference
Ethanol #1	11.85	194.21	207.60	206.61	0.99	23.0	40.0	17.0
Ethanol #2	11.85	260.77	175.27	174.04	1.23	26.0	40.0	14.0
1-Propanol #1	11.85	221.46	218.43	217.34	1.09	22.5	40.0	17.5
1-Propanol #2	11.85	213.44	207.50	206.61	0.89	26.0	40.0	14.0
1-Butanol #1	11.85	230.70	208.13	207.28	0.85	26.0	40.0	14.0
1-Butanol #2	11.85	226.87	206.51	205.75	0.76	28.5	40.0	11.5

Calculations:

Calculations for combined specific heat capacity:

$C = ((Mass_{can} * 0.89) + (Mass_{water} * 4.18)) / Mass_{can + water}$

Test	Mass of Can (g)	Mass of Can + Water (g)	Mass of Water (g)	Combined Specific Heat Capacity
Ethanol #1	11.85	194.21	182.36	3.979
Ethanol #2	11.85	260.77	248.92	4.030
1-Propanol #1	11.85	221.46	209.61	4.004
1-Propanol #2	11.85	213.44	201.59	3.997
1-Butanol #1	11.85	230.70	218.85	4.011
1-Butanol #2	11.85	226.87	215.02	4.008

?H = -mC?t

Test	Mass of Can + Water (g)	Combined Specific Heat Capacity	Temp Difference (°C)	?H (J)
Ethanol #1	194.21	3.979	17.0	-13137.8
Ethanol #2	260.77	4.030	14.0	-14714.4
1-Propanol #1	221.46	4.004	17.5	-15517.5
1-Propanol #2	213.44	3.997	14.0	-11944.7
1-Butanol #1	230.70	4.011	14.0	-12954.8
1-Butanol #2	226.87	4.008	11.5	-10457.3

kJ per mole Calculations

MHC = ?H * (Molar Mass / Mass burnt) / 1000

Test	?H (J)	Mass Combusted (g)	Molar Mass	Molar Heat of Combustion (kJ mol^{-1})
Ethanol #1	-13137.79	0.99	46.068	611.4
Ethanol #2	-14714.45	1.23	46.068	551.1
1-Propanol #1	-15517.54	1.09	60.095	855.5
1-Propanol #2	-11944.70	0.89	60.095	806.5
1-Butanol #1	-12954.75	0.85	74.122	1129.7
1-Butanol #2	-10457.30	0.76	74.122	1019.9

Final Values:

Alkanol	Molar Heat of Combustion (kJ mol^{-1})

	Test #1	Test #2	Average
Ethanol	611.4	551.1	581.2
1-Propanol	855.5	806.5	831.0
1-Butanol	1129.7	1019.9	1074.8

Conclusion: The molar heat of combustion for ethanol is 581 kJ mol^{-1}, for 1-Propanol is 831 kJ mol^{-1} and for 1-Butanol 1075 kJ mol^{-1}.

Evaluation:

Alkanol	Molar Heat of Combustion (kJ mol^{-1})				% Correct
	Test #1	Test #2	Average	Pub Value	
Ethanol	611.4	551.1	581.2	1364	42.6
1-Propanol	855.5	806.5	831.0	2016	41.2
1-Butanol	1129.7	1019.9	1074.8	2677	40.1

As the above table shows, when the experimentally determined values were compared against the known published values, there were large differences. However, the margin for error on each test was similar therefore suggesting the same variables were causing the differences each time.

One such possible cause of error was simply the loss of energy to the surroundings such as the air, boiling some of the water, the cardboard and can insulation and glass & metal parts of the spirit burner. All these possible sources of error were noticed during the experiments. Bubbles appeared in the water, suggesting boiling; heat was felt in the surrounding air, the cardboard singed and the metal part of the spirit burner heated up significantly. All these errors could have accounted for part of the percentage error.

Another source of error is the equipment used. The electronic balance had an error margin of ±0.005 grams and the thermometer had and error margin of ±0.5 °C.

A way to improve the accuracy of the results would be to use a calorimeter. However, one consolation is that at least the results were consistant.