Chemistry Three,

Assessable Prac

Semester One

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AIM

To experimentally determine the heats of combustion of three alcohols, methanol, 1-propanol and 1-butanol.

CONCLUSION

The experimentally determined values for the heats of combustion for three alcohols, methanol, 1-propanol and 1-butanol were 1026 $KJmol^{-1}$, 3341 $KJmol^{-1}$ and 2924 $KJmol^{-1}$ respectively.

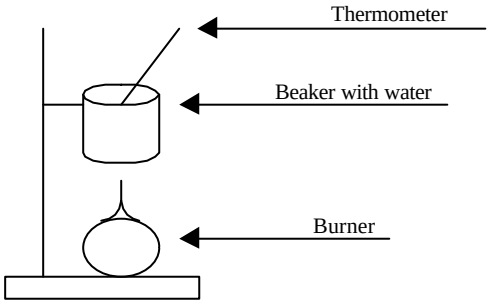
BACKGROUND

When any substance is combusted, heat is released. When 1 mole of any substance is combusted, the amount of heat released is called the molar heat of combustion of that substance, it is the amount of heat energy that is released when 1 mole of that substance is burned. The molar heat of combustion is measured in Joules (J).

In this experiment, the amount of alcohol which will yield, on combustion, a certain quantity of heat is determined. Then using published data for the heat of combustion of ethanol the heats of combustion of the three other alcohols are calculated. The alcohols to be tested are burnt in a small spirit burner. Heat produced is then absorbed in 200mL of water contained within a flask above the burner. Because of the simple nature of the equipment, it is not possible for the water to absorb all of the heat form the burner, only a fraction of it. The success of the experiment lies with taking as much care as possible to ensure that the fraction of the heat is the same for all the alcohols tested. The conditions must be kept as constant as possible. That is why this particular method has been chosen for this experiment, because it allows you to get a fairly accurate result, even with basic and simple equipment.

METHOD

- The apparatus was set up as in the diagram below.



- Approximately 20 mLs of ethanol was added to the burner.
- The burner and its contents were weighed to at least 0.01g accuracy.
- The initial temperature of the water was recorded.
- The burner was lit and shielding it from draughts the temperature of the water was allowed to rise 10K before the flame was extinguished.
- The maximum temperature that was reached was recorded.
- The burner and contents were reweighed.
- The experiment was redone using methanol, 1 propanol and 1 butanol.

DATA

Methanol

Start mass methanol:	125.50g
End mass methanol:	124.70g

Total methanol burned: 0.80g

Water start temperature: 23.10ºC
Water finish temperature: 34.05ºC
ÄT of water: 10.95ºC

Ethanol
Start mass ethanol: 193.85g
End mass ethanol: 192.90g
Total ethanol burned: 0.95g

Water start temperature: 27.10ºC
Water finish temperature: 39.20ºC
ÄT of water: 12.10ºC

1-Propanol
Start mass 1-propanol: 177.40g
End mass 1-propanol: 176.95g
Total 1-propanol burned: 0.45g

Water start temperature: 23.10ºC
Water finish temperature: 33.80ºC
ÄT of water: 10.70ºC

1-Butanol
Start mass 1-butanol: 218.19g
End mass 1-butanol: 217.55g
Total 1-butanol burned: 0.64g

Water start temperature: 23.20ºC
Water finish temperature: 34.00ºC
ÄT of water: 10.80ºC

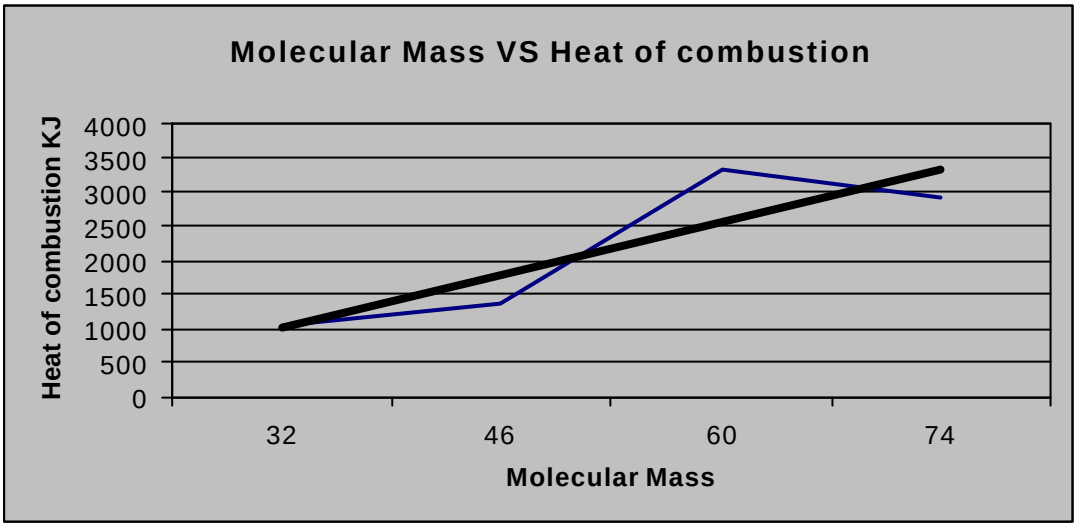
ANALASIS

Alcohol	Molecular formula	Relative molecular mass	Mass required to raise temperature by 1k	Fraction of the molar mass	Molar heat of combustion
Methanol	CH_3OH	32	0.07305936g	0.002283105	$1026KJmol^{-1}$
Ethanol	C_2H_5OH	46	0.07851239g	0.001706791	$1372KJmol^{-1}$

1 propanol	C_3H_7OH	60	0.04205607g	0.000700934	3341KJmol^{-1}
1 butanol	C_4H_9OH	74	0.05925926g	0.0008008	2924KJmol^{-1}

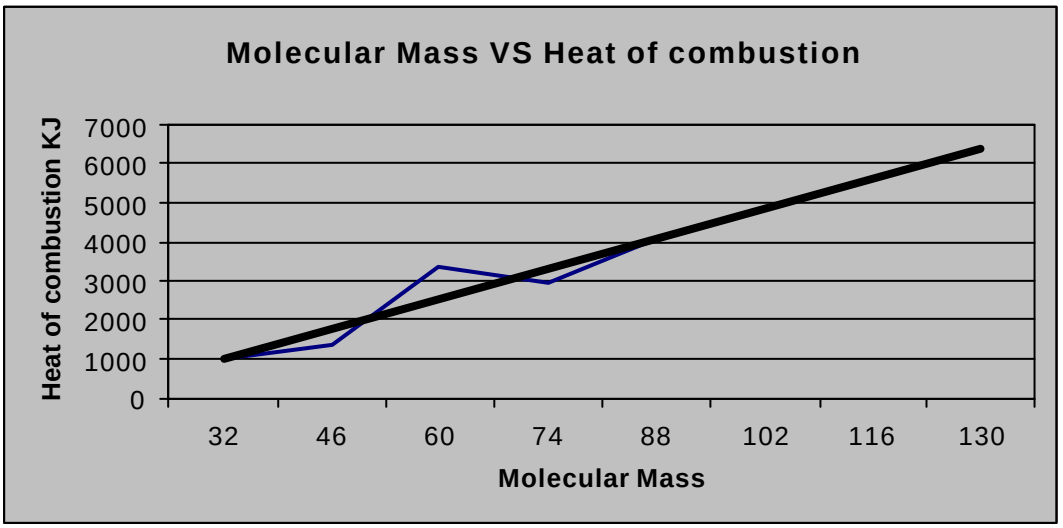
1. Molecular mass VS Molar Heat of Combustion

32	46	60	74
1026	1372	3341	2924



2.

N-octanol, $C_8H_{17}OH$, molecular mass = 130



Estimated value for the molar heat of combustion for n-octanol is 6380kJmol^{-1}.

3.

Methanol – 32, CH_3OH , 1026 KJmol^{-1}
CH_3-mass is 15, OH-mass is17
CH_3-heat = 480KJ , OH-heat = 545KJ

Ethanol – 46, C_2H_5OH, 1372 KJmol^{-1}
CH_3-mass is 15, CH_2-mass is 14, OH mass is 17
CH_3-heat =447KJ, CH_2-heat is 417KJ, OH-heat is 507KJ

1-Propanol – 60, C_3H_7OH, 3341KJmol^{-1}
CH_3-mass is 15, 2xCH_2-mass is 28, OH mass is 17
CH_3-heat=835.2KJ, CH_2-heat=779KJ, OH-heat=946

1-Butanol – 74, C_4H_9OH 2924KJmol^{-1}
CH_3-mass is 15, 3xCH_2-mass is 42, OH-mass is 17
CH_3-heat=592, CH_2-heat=553, OH-heat=617

Average CH_3 heat=589KJ
Average CH_2 heat =583KJ
Average OH heat = 653KJ

Estimated value for the combustion energy involved in each CH_2 is 583KJmol^{-1}, and for each alcohol substituent 653KJmol^{-1}.

4. This experimental method avoids many of the uncertainties involved with heat losses because of the fact that we have a known value for the heat of combustion of one of the alcohols. This means that we don't have to make sure that all the heat gets absorbed into the water (which it won't) for an accurate result. We only have to make sure that the fraction of heat being absorbed by the water is close to the same fraction of heat being absorbed by the water when the other alcohols are combusted. This makes it far easier to get an accurate result for the other alcohols, than trying to measure the heat received directly by the water as some of the heat will go into the air, beaker etc.

ERRORS

Due to the fluctuating conditions in any area it is impossible to get exactly the same fraction of heat being absorbed by the water with every single alcohol. Therefore every time the experiment is repeated there are slightly different results for the amount burned and the change in temperature. This leads to incorrect numbers being entered into equations and results which may be quite different from the actual values. These errors can be reduced by subjecting the experiment

to a more controlled environment so that the changes in the environment around the experiment are minimized and therefore the errors also minimized.

Incorrectly weighing the alcohols before and after the burning can result in an incorrect value for the number of moles of that substance and therefore can seriously affect the end results of the experiment. These errors can be minimized by using a more accurate balance of an electronic balance for extra accurate measurement.
Another error that may lead to the results of the experiment being incorrect is not correctly measuring the temperature. If the temperature is higher or lower than the actual value of the temperature, the resultant heat of combustion will be either too high or too low, and not as close as possible to the desired correct value. To avoid errors such as this, the thermometer must always be checked with the eyes perpendicular to the thermometer to avoid parallax error. All care must be taken to avoid letting the thermometer touch the side of the beaker because this can result in the temperature of the beaker being measured and not the temperature of the water.