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CHEMISTRY EXTENDED ESSAY

BY

STUDENT NO.:

WORD COUNT: 3998 WORDS
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WHAT ARE THE ALTERNATIVE FUELS FOR THE DEPLETING FOSSIL FUELS AND WHICH IS THE BEST FUEL IN ACCORDANCE WITH THE ENERGY OUTPUT?

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ABSTRACT

Since fossil fuels are depleting and causing pollution in the environment, this research was taken to investigate on the alternative fuels for the depleting fossil fuels and determine which of the alternative fuels has the largest energy output. For the success of this research, experiments based on the research question were taken, where different fuels, fossil fuels and non-fossil fuels were burnt to see if they can act as alternatives fuels in future for the depleting fossil fuels by producing a high energy output and not emitting any polluting gases. This was also done to show how other fuels can be alternatives for the depleting non-renewable fuels; as a result, renewable fuels like Methanol and Ethanol were included in the experiment. For the conclusion that was taken into consideration was that, these two fuels; Methanol and Ethanol were found to satisfy what was needed in the research question, because they replenish, produce no emissions, and have a relatively high energy output.

ACKNOWLEDGEMENT

I wish to thank Mrs. Puri, my supervisor and Chemistry teacher, who helped me make it through the end of my extended essay; reviewed all my work; and whose suggestions and comments were of great value, not forgetting my friends who gave me support and encouragement in the process of my work.

3.0 *INTRODUCTION*

The world we live on relies on fuels, mostly the depleting fossils fuels, and without those fuels the world's mobility would cease instantly. Nevertheless, fossil fuels are known as environmentally unfriendly, and not only unfriendly but depleting fuels. Fossil fuels being coal, natural gas and petroleum have been produced from the slow decomposition of plant and animal matter over millions of years. These fossil fuels consist of deposits such as carbon or hydrocarbon of once living organisms. These primary sources have major uses like being the major feedstock (raw material) for the chemicals; and being used in pharmaceutical industries. They can also be used for domestic and industrial heating and cooking; and as fuels for various forms of vehicles. Even though they are of vital use, there are estimated dates for these fossil fuels to run out as suggested by Mark M. Jones (Jones et al, 1987, p172-p177), where for gas the estimated date is 2045 (30 years supply), oil is 2025 (30-50 years supply), and coal is 2338 (300-340 years of supply).

Since the world has realised the depletion of these non-renewable sources, considered to be temporary sources which get depleted when they are used, there had been some alternatives looked into to overcome and solve the problem and these were some of the renewable sources that were thought would be convenient for the fast moving world since they replenish when used. These sources are geothermal energy, wave power, Tidal power, wind power and solar energy, which were proven not to provide enough energy as compared to the mobility of the world nowadays, and they were also found to affect the world economically.

Fossil fuels are hydrocarbons that contain pollutants that are naturally present such as sulphur and nitrogen which cause environmental problems. When burned, they produce a lot of carbon dioxide which is a greenhouse gas that accumulates in the atmosphere, causing acidification, air pollution, water pollution, damage on land surface and ground-level ozone. Because of these terrible effects that fossil fuels have on the environment, scientists are trying to find a solution to this problem by finding alternative fuels that are capable of producing large amounts of energy, available in large quantities, cheap, that are safe to store and transport and easy to ignite and burn, causing no pollution, with a long life cycle.

4.0 *BACKGROUND*

In this section I will be comparing various types of fuels looking at their components, what they contain, their energy output, if the fuel is environmentally friendly and if it is cheap or expensive to be produced and then make a recommendation onto which fuel is to be used.

4.1.0 *Fuels and their characteristics*

4.1.1 *NATURAL GAS*

It is a gas formed from the decomposition that produced crude oil and coal deposits. It is a mixture of gaseous hydrocarbon, mostly Methane (CH_4) 80 to 90% of it, with smaller amounts of other gases which are pollutants such as nitrogen, carbon dioxide, hydrogen sulphide. Again of all fossil fuels, natural gas is said to be in the shortest supply, expected to decline in 30 years to come, and also regarded as the lightest hydrocarbon molecule.

In addition, (Nuffield Coordinated Sciences, 1992, p236) claimed that natural gas is considered to be the clean burning fuel of all the fossil fuels with no solid residue and no smell on its own, which means fewer harmful emissions to the atmosphere, and less greenhouse gases per unit energy released. As for an equivalent amount of heat, when natural gas is burnt, it produces about 20-30% less carbon dioxide than burning petroleum, and about 45% less than burning coal. Natural gas is also found to be easy and cheap to transport, and has high heat output than most fossil fuels and other fuels. Despite that, it is usually associated with coal and oil production and the cost can be that of transportation and extraction of it from coal, which could be expensive even though on its own it is easily transported and cheap. As a result, it can be used more than other fossil fuels, while alternatives are being found, since even in terms of energy output it is required as the best producer of energy; and that impurities in natural gas are easily removed. On the other hand, it does not contain any solid residues which can cause blockages in pipes or exhaust of cars when used. (For more information about natural gas, see appendix 7)

4.1.2 ***ETHANOL (C_2H_5OH)***

It is grain alcohol, an alcohol fuel produced from the fermentation of carbohydrates that have been converted into simple sugars. Ethanol can also be obtained from sugar, root crops, especially cassava and cereals or hydration of ethane (C_2H_4). It is also made from a group of chemical compounds whose molecules contain hydroxyl group (-OH) bonded to a carbon atom. Ethanol is a volatile liquid which does not conduct electricity and burns quite readily with a clean, hot flame. Ethanol can also be safely used for heating and automobiles when combined with gasoline containing 10% by volume maximum ethanol called gasohol.

Ethanol is again currently found to be a bit more expensive per litre than gasoline because more energy is required to process as it is obtained from it. Despite this, using ethanol includes renewability, higher octane rating and lower emissions of carbon monoxide and nitrogen oxides that cause acid rain or create greenhouse gases which are very harmful to the atmosphere. It can also be made from the surplus of waste agriculture products like trees. As for transport facilities, it is used in flexible fuel vehicles which are currently offered by most auto manufacturers. This can give an idea that Ethanol can be regarded as an alternative, because Byron W. King (http//www. energy bulletin. net/22997. html) suggested that it can provide more energy content a kilometre per litre for transportation than other fuels. In other countries like Brazil, Ethanol, mixed with petrol, is being used as a fuel for cars and in domestic heating stoves.

4.1.3 ***COAL***

Coal is a solid fossil, readily combustible rock containing between 40 and 98% carbon with varying amounts of volatile materials and some moisture. In this volatile matter, there are oxides of carbon, hydrogen gas, methane and other hydrocarbons, ammonia, and hydrogen sulphide included. Besides carbon, coal is made up of the elements H, O, N, S, which means, it can contain about 3% sulphur, which is much, and as a result, because of that high percentage of sulphur, it is considered as a 'dirty' fuel. Mark M. Jones (Jones op. cit., 1987, p175) also regards coal as a 'dirty' fuel, hence, the world will not be comfortable to use what is referred to as dirty. Even though coal is known to be plenty, coal mines have higher cost of production; and it is also cheaper than petroleum, but also produces pollutants that are greenhouse gases, which also cause acid rain. The World Coal Reserves (1990) also claims that about 20% of the coal is assumed to be difficult to recover which depicts depletion.

Moreover, it looks like more harmful emissions are caused by coal combustion and that coal dust can even explode which is very dangerous, and about 99% can be removed. Again some of the greenhouse gases like carbon dioxide are rapidly emitted during combustion. As for coal, it is cheap to produce and plentiful as compared to other fossil fuels. It also has a comparatively large amount of energy output as it is used in electricity industries and in coal trains. (For more information about coal, also see appendix 7)

4.1.4 ***PARAFFIN***

It is a fuel of which 10-15% of it consists mainly of C_{11} and C_{15} hydrocarbons with boiling points from 160°C to 250°C. Paraffin can be used as a jet fuel as Kerosene, and for domestic heating purposes like being used in heaters and lantern lamps, but because of the hydrocarbons it contains, it is very harmful to the environment by producing greenhouse gases especially carbon dioxide when it is combusted, which cause global warming and acid rain. Again it is quite expensive, and depends on the location to produce paraffin since it is also a fossil fuel; and it is regarded as unattractive to the environment.

4.1.5 ***METHANOL (CH_3OH)***

It is an alcohol fuel. It is methane with one hydrogen molecule replaced by a hydroxyl group (OH). Methanol can be claimed to be a good fuel with similar properties like that of Ethanol. According to the Chinese perspective, it is regarded as an alternative fuel for the future. As for the cost of production, Methanol is quite cheap because a little of the trifluoroacetic acid loss can be afforded. To prove that it is cheap, the Chinese claim that it can be produced under a dollar per gallon from coal, and the technology used for doing so is very mature. Steven S. Zumdahl (Zumdahl, 1993, p112) also suggested that it is among the best fuels, because it can be convenient to use as fuel for racing cars and is a potential replacement for gasoline. It is a non-pollutant, meaning that there are no harmful gases like sulphur oxides, nitrogen oxides or greenhouse gases that can be produced through the racing cars exhaust which when emitted can affect the environment, meaning causing acid rain or affecting the lungs of people that would be watching racing cars, or their respiratory system because those pollutants can even lead to death. As Mark M. Jones (Jones op. cit., 1987, p304) also proposed, Methanol can be used as a jet fuel.

4.1.6 ***HEXANE (C_6H_{14})***

It is a hydrocarbon fuel produced by the refining of crude oil. It contains alkane hydrocarbons of which some of them are greenhouse gases, causing headaches and nausea. The cost of production of hexane is pretty expensive since it is from the refining of crude oil. Hexane because of the hydrocarbon it contains, it can also cause global warming and destroy ~~the ozone layer by the greenhouse gases it emits.~~

In this essay, I will be looking at the alternative fuels for the depleting fossil fuels, and determine which fuel is the best in accordance to the energy output that can sustain the world, and its pollution levels.

4.2 *Hypothesis*

In this investigation, the following results from different fuels are expected:
Ethanol is expected to burn readily, without making any emissions like producing smog while being burned because it does not contain hydrocarbons that cause pollution. In terms of energy output, it is expected to produce a lot of energy because it does not contain a lot of impurities.

Methanol is also expected to burn readily, without producing a lot of smog since it also does not contain hydrocarbons. In terms of energy output, it is expected to produce a relatively high energy but not more than Ethanol because it does not have a long carbon chain.

Hexane is also expected to burn, but not as readily as Ethanol and Methanol, producing a lot of smog because it contains longer hydrocarbon chains. For energy output, it is expected to produce a lot of energy because of a long carbon chain which will produce a lot of energy.

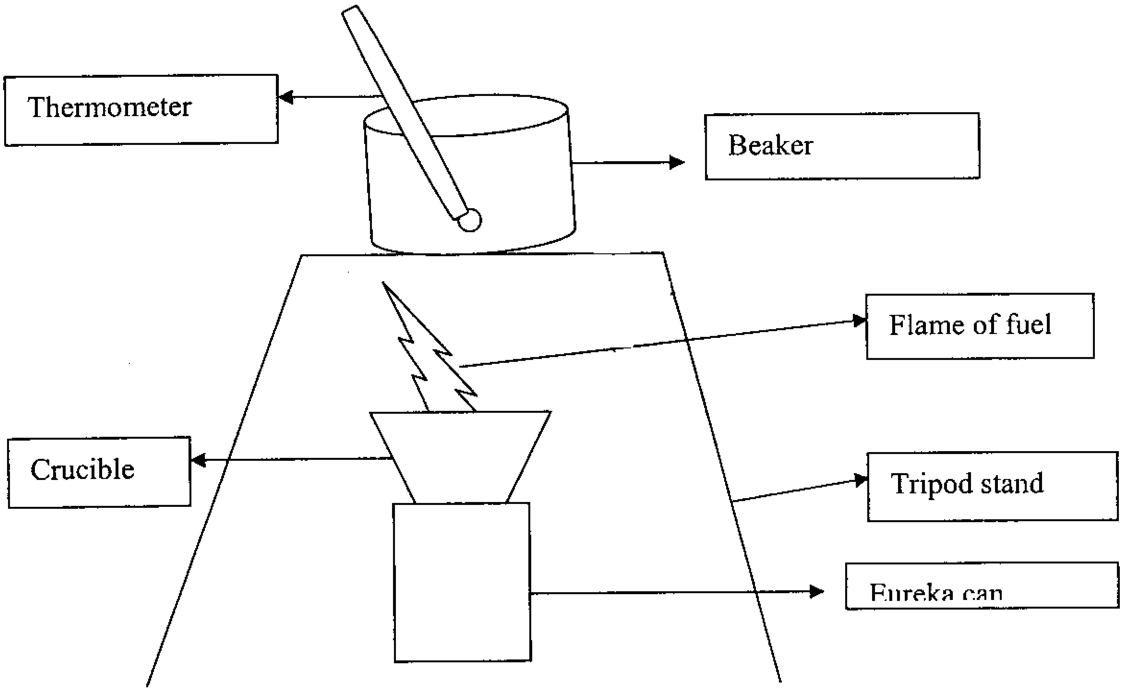
Paraffin is not expected to burn readily because of the impurities it contains. As for energy output, it is expected produce a lot of energy because of a very long carbon chain which will produce a lot of energy when the bonds are broken.

5.0 ***BODY(In this section of the essay, I wanted to outline the steps in carrying out experiments for energy output calculations)***

5.1 ***METHOD (How the experiment was undertaken)***

1. Collect all the apparatus and materials needed for the experiment.
2. Set up a tripod stand, wire gauze, and a Bunsen burner.
3. Place the eureka can under the tripod stand.
4. Fill the beaker with $40cm^3$ of water tap and place the beaker on the tripod stand
5. Using a graduated measuring cylinder, measure the volume of $6cm^3$ of the fuel, and pour it in the crucible.
6. Place the crucible containing the fuel on eureka can.
7. Use the thermometer to take the initial temperature of water before heating it.
8. Light up the wooden splint from a lighted Bunsen burner and carefully burn the fuel.
9. The fuel will immediately catch the flame and then it will burn on its own. At this stage safety spectacles should be used.
10. Immediately after burning the fuel, record the temperature change of water every ½ minute until the fuel completely burns out from the initial temperature at 0 minutes. (Note; using the thermometer stir the water while recording the temperature of water evenly all around the beaker)
11. The same procedure should be taken for all the fuels, ethanol, Methanol, Hexane and paraffin
12. Repeats should be done for each fuel to get more accurate and precise results, to see which fuel is the best. For more illustration refer to figure 5.1.1

FIGURE 5.1.1



5.2 ***DATA PROCESSING AND PRESENTATION***

For temperature (°C) refer to appendix 2 (DATA COLLECTION)

Calculating the enthalpy change (ΔH) of water when it was heated by burning the fuel ETHANOL.

ΔT = highest temperature – lowest temperature
(93.0±0.1°C) – (17.0±0.1°C)
= 76.0±0.2°C (refer to appendix 3)

Finding the enthalpy change

Heat energy (KJ) = mass (kg) × specific heat capacity (KJ/Kg) × ΔT (°C)

Since we used the fuel to heat water, and got the ΔT of water, we use the specific heat capacity of water which is 4.18J/g °C

Considering the density of water as 1g/cm^3 and it occupies the volume of 40cm^3, then the mass would be:

Mass = density × volume
1g/ cm^3 × 40.0 cm^3
= 40g

Mass of water = 40g
ΔT of water = (76.0±0.2°C)
Specific heat capacity of water = 4.18J/g °C

Substituting these new values in our equation we get:

Heat energy = mass × specific heat capacity × ΔT
40g × 4.18J/g °C × 76.0 °C
= 12707.20Jmol^{-1}
= 12.7027KJmol^{-1}

Calculating the mass of Ethanol
Mass = density × volume
0.789 × 6.0
= 4.734g
Finding the number of moles of Ethanol

$$\text{Moles} = \frac{\text{known mass}}{\text{Molar mass}} = \frac{4.734}{46.08} = 0.102734375 \text{ moles}$$

$$\Delta H = \frac{-Q}{n} = \frac{-12.7072}{0.102734375} = -120.4348593 = -123.69 KJmol^{-1}$$

Calculating the enthalpy change (ΔH) of water when it was heated by burning the fuel METHANOL.

ΔT = highest temperature – lowest temperature
(85.0±0.1°C) – (18.0±0.1°C)
= 67.0±0.2°C (refer to appendix 4)
Finding the enthalpy change
Heat energy (KJ) = mass (kg) × specific heat capacity (KJ/Kg) × ΔT (°C)
Since we used the fuel to heat water, and got the ΔT of water, we use the specific heat capacity of water which is 4.18J/g °C
Considering the density of water as $1 g/cm^3$ and it occupies the volume of $40 cm^3$, then the mass would be:
Mass = density × volume
$1 g/cm^3 \times 40.0 cm^3$
= 40g
Mass of water = 40g
ΔT of water = (67.0±0.2°C)
Specific heat capacity of water = 4.18J/g °C
Substituting these new values in our equation we get:

Heat energy = mass × specific heat capacity × ΔT
40g × 4.18J/g °C × 67.0 °C
= $11202.4 Jmol^{-1}$
= $11.2024 KJmol^{-1}$

Calculating the mass of METHANOL
Mass = density × volume
= 0.7918 × 6.0
= 4.7508g
Finding the number of moles of METHANOL

$$\text{Moles} = \frac{\text{known mass}}{\text{Molar mass}}$$

$= \frac{4.7508}{32.05}$

$= 0.1482308892$ moles

$\Delta H = \frac{-Q}{n}$

$= \frac{-11.2024}{0.1482308892}$

$= -75.57399175$

$= -75.57KJmol^{-1}$

Calculating the enthalpy change (ΔH) of water when it was heated by burning the fuel HEXANE.

ΔT = highest temperature – lowest temperature

(81.0±0.1°C) – (18.0±0.1°C)

= 63.0±0.2°C (refer to appendix 5)

Finding the enthalpy change

Heat energy (KJ) = mass (kg) × specific heat capacity (KJ/Kg) × ΔT (°C)

Since we used the fuel to heat water, and got the ΔT of water, we use the specific heat capacity of water which is 4.18J/g °C

Considering the density of water as $1g/cm^3$ and it occupies the volume of $40cm^3$, then the mass would be:

Mass = density × volume

$1g/\ cm^3 \times 40.0\ cm^3$

= 40g

Mass of water = 40g

ΔT of water = (63.0±0.2°C)

Specific heat capacity of water = 4.18J/g °C

Substituting these new values in our equation we get:

Heat energy = mass × specific heat capacity × ΔT

40g × 4.18J/g °C × 63.0 °C

$= 10533.6Jmol^{-1}$

$= 10.5336KJmol^{-1}$

Calculating the mass of HEXANE

Mass = density × volume

= 0.659 × 6.0

= 3.954g

Finding the number of moles of HEXANE

Moles = $\frac{\text{known mass}}{\text{Molar mass}}$

$= \frac{3.954}{86.2}$

$= 0.04587006961$ moles

$\Delta H = \frac{-Q}{n}$

$= \frac{-10.5336}{0.04587006961}$

= -229.6399393
= $-229.64KJmol^{-1}$

Calculating the enthalpy change (ΔH) of water when it was heated by burning the fuel PARAFFIN

ΔT = highest temperature – lowest temperature
(84.5±0.1°C) – (18.0±0.1°C)
= 66.5±0.2°C (refer to appendix 6)

Finding the enthalpy change
Heat energy (KJ) = mass (kg) × specific heat capacity (KJ/Kg) × ΔT (°C)
Since we used the fuel to heat water, and got the ΔT of water, we use the specific heat capacity of water which is 4.18J/g °C
Considering the density of water as $1g/cm^3$ and it occupies the volume of $40cm^3$, then the mass would be:
Mass = density × volume
$1g/\ cm^3 \times 40.0\ cm^3$
= 40g
Mass of water = 40g
ΔT of water = (66.5±0.2°C)
Specific heat capacity of water = 4.18J/g °C
Substituting these new values in our equation we get:
Heat energy = mass × specific heat capacity × ΔT
40g × 4.18J/g °C × 66.5 °C
= $11118.8Jmol^{-1}$
= $11.1188KJmol^{-1}$

Calculating the mass of PARAFFIN
Mass = density × volume
= 0.93000 × 6.0
= 5.58g
Finding the number of moles of PARAFFIN

$$\text{Moles} = \frac{\text{known mass}}{\text{Molar mass}} = \frac{5.58}{172.4} = 0.032367 \text{ moles}$$

$$\Delta H = \frac{-Q}{n} = \frac{-11.1188}{0.032367}$$

= -343.522724
= $-343.52KJmol^{-1}$

SUMMARY TABLE FOR ENTHALPY CHANGE/OF THE FUELS

FUEL	ENTHALPY CHANGE (ΔHc)$KJMol^{-1}$
Paraffin	$-343.52KJmol^{-1}$
Hexane	$-229.64KJmol^{-1}$
Ethanol	$-123.69KJmol^{-1}$
Methanol	$-75.57KJmol^{-1}$

5.3 ***DISCUSSION***

Natural gas and coal were not used in the experiment because they were not available but others were included in the experiment and the following were obtained as a result:

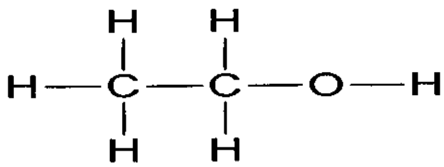
Ethanol, burned quite readily with a clean, hot flame for 7.5 minutes, and the water that was heated rose to the maximum temperature of 93°C. Besides that, there was no black smoke and a choking smell when it was burned, and the beaker was not covered with black soot, but it stayed clean and clear. The results showed that Ethanol produces large energy output (enthalpy change) of $-123.69KJMol^{-1}$.

Combustion of Ethanol:

$C_2H_5OH_{(aq)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(l)}$

$\Delta Hc = -123.69KJmol^{-1}$

STRUCTURE OF ETHANOL



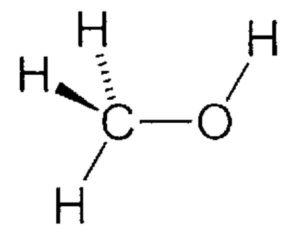
(http\\www. sciencegeek. net/.../taters/O. Biochem. Htm)

As for methanol it also burnt readily once a flaming splint was brought next to it. It also burnt with a clean hot flame like Ethanol since they have similar properties, and as a result it did not produce any black soot and choking smell. This was further proved by having the beaker clear, without any soot on it. One other good factor about Methanol is that, it burns quite for a long time producing a relatively large energy output because during the experiment it took 8.5 minutes for it to burn out, also heating the water in the beaker to 85°C. It produced relatively a lot of energy, where the enthalpy change was $-75.57KJMol^{-1}$.

Combustion of Methanol:

$2CH_3OH_{(aq)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 4H_2O_{(l)}$

$\Delta Hc = -75.57KJmol^{-1}$

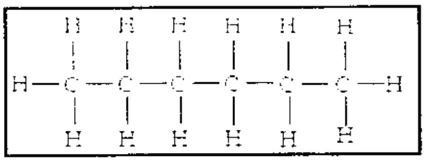


Methanol

(http\\www. sciencegeek. net/.../Unit 3 lewiStructures. htm)

Hexane did not take a long time to burn; it took 5.5 minutes to burn, heating water in the beaker to a temperature of 81°C. It produced a lot of energy of -229.64KJMol^{-1} (enthalpy change). Even though it produced a lot of energy, a lot of smog was also produced, which resulted into a beaker being completely covered with soot.

Combustion of Hexane
$C_6H_{14} + 9\frac{1}{2}O_2 \rightarrow 6CO_2 + 7H_2O$
$\Delta Hc = -229.64KJmol^{-1}$
Hexane, (C_6H_{14}) by the structural formula

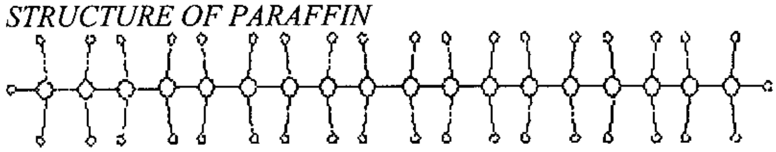


(http//www. gcse chemistry.com/o/2. htm)

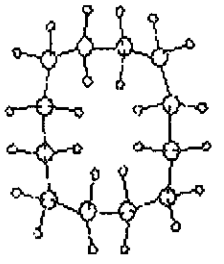
Paraffin produced a very bad choking odour and produced black soot that covered the beaker completely. Besides that, paraffin took a long time to ignite because during the experiment, a long time was spent trying to make it catch fire. Even though, paraffin took a long time to burn, because it burnt for 9.5 minutes, heating water to a temperature of 84°c; it produced a lot of energy, the enthalpy change of -343.52KJMol^{-1}.

Combustion of paraffin
$C_{18}H_{38} + 27\frac{1}{2} O_2 \rightarrow 18 CO_2 + 19H_2O$
$\Delta Hc = -343.52KJmol^{-1}$

STRUCTURE OF PARAFFIN



a) $C_{18}H_{38}$



b) c-$(CH_2)_{12}$

(http\\www. Virtualexplorer.com. au-special-means volume, contribs-hafner. Fig4 jpg file)

6.0 *CONCLUSION*

For the conclusion, according to the hypothesis that was made before, the research was found to be successful. Ethanol did not produce any smog when it was burnt as predicted, and the energy output is -123.69KJmol^{-1} which is a lot of energy. For Methanol, it also did not produce any choking smog when it was burned, and produced the energy output of -75.57KJmol^{-1}. For Hexane, when it was burned, it produced a lot of smog and as a result the beaker was fully covered with soot, and as for energy output, it was -229.64 KJmol^{-1} that was produced which is much. As for Paraffin, it produced a lot of smog than any other fuel that was burned, and produced the energy output of -343.52KJmol^{-1}.

Ethanol did not produce a lot of smog because it does not contain hydrocarbons which are gases that cause pollution.. To prove that Ethanol does not contain a lot of pollutants, it burnt with a clean, hot flame. This depicts that Ethanol does not contain greenhouse gases that can lead to global warming or cause acidic rain.

Moreover, Ethanol, especially, was chosen because it does not conduct electricity which gives us the idea that it is safe to use it together with electric devices, but as long as is done carefully Again is safe to use it for domestic heating purposes like using it in cooking stoves and heaters. Again it can be easily used in cars as a perfect fuel because when it is used; cars will not emit that black smog they always produce, which affects the environment very badly, because of containing greenhouse gases like carbon dioxide, nitrogen oxides and sulphur. Consequently all these can cause acid rain that damages fertile soil for agriculture.

Once more, because Ethanol easily ignites and burns without polluting, it is another motive why it is preferred as an alternative fuel, since when fossil fuels are burned, especially coal, it undergoes combustion, which means it does not burn readily; but its burning becomes incomplete, which is something that is not preferred when taking into account humans' health.

On the other hand, Ethanol is safe to store and transport, though it is said to be expensive per litre gasoline. Yet again since it is a fuel, it still has some disadvantages, but it is not as appalling as fossil fuels; which are still harmful even if the environment is trying by all means to avoid them. In terms of energy output, Ethanol can beat many fossil fuels because even in the experiment, it proved out to have great amount of energy output by burning for 6 minutes, making water attain the temperature of 93°C, which is relatively a lot of energy.

For Methanol it also did not produce a lot of smog, and this also shows that it does not contain polluting gases like sulphur, nitrogen oxides and carbon dioxide that can be environmentally unfriendly by causing global warming and acidic rain. Moreover, Methanol produced a relatively larger energy output as it heated water up to the maximum temperature of 85°C, taking 8.5 minutes. This proves that it takes a long time to burn, meaning not much of it will be consumed.

What also makes it a good fuel is that it can be easily stored and transported without spilling and polluting the environment by damaging the land surface, killing the water creatures and plants.

From the results obtained, Ethanol and Methanol were found to satisfy what the investigation was about by being chosen as alternatives for the depleting fossil fuels in accordance with their energy output which is relatively high, and the fact that they are renewable, and do not emit polluting gases.

In this investigation, there were some unresolved questions, like measuring the amount of pollutant emitted by each fuel, and also having to measure the energy output of other fossil fuels like coal and natural gas was difficult because they were not available. In addition, having to test for every gas that was suspected to be present in each fuel used in this investigation. For these unsolved questions, suggestions can be considered where possible, and for some unsolved questions, answers could not be reached because the investigation was limited, but for further investigations, what could be looked onto more is; the amount of pollutants being emitted; test for gases that are said to be present in every fuel, to really verify that they are present; more collection of fuels should be used to make the investigation even more successful and challenging.

7.0 APPENDICES

7.1 (Appendix 1) THE PRACTICAL

In the experiment I am comparing the different fuels and finding out which one of them is the best.

NOTE: FOR NATURAL GAS AND COAL, THEY CANNOT BE USED IN THE LABORATORY, HENCE NO EXPERIMENTAL DATA FOR THEM.

APPARATUS:

- Safety spectacles
- Stop watch
- Thermometer
- Graduated measuring cylinder
- Eureka can
- Crucible
- Wire gauze
- Tripod stand
- Bunsen burner
- Matches
- 100cm^3 beakers (4)

MATERIALS:

- 6cm^3 Ethanol
- 6cm^3 Methanol
- 6cm^3 Hexane
- 6cm^3 paraffin
- Wooden splint
- 40cm^3 water

7.2 (Appendix 2) DATA COLLECTION

ERROR ANALYSIS
Error uncertainty of the stopwatch = ½ × 0.1 = ±0.05min
Error uncertainty of the thermometer = ½ × 0.1 = ±0.05°C

TABLE 1

MATERIAL	TIME (Minutes) ±0.05	1st reading Temperature (°C) ±0.05	2nd reading Temperature (°C) ±0.05	AVERAGE Temperature (°C) ±0.1
ETHANOL	0.00	17.00	17.00	17.0
	0.50	23.00	23.00	23.0
	1.00	30.00	30.00	30.0
	1.50	39.00	39.00	39.0
	2.00	46.00	46.00	46.0
	2.50	55.00	55.00	55.0
	3.00	64.00	64.00	64.0
	3.50	74.00	74.00	74.0
	4.00	79.00	79.00	79.0
	4.50	85.00	85.00	85.0
	5.00	89.00	89.00	89.0
	5.50	91.00	91.00	91.0
	6.00	93.00	93.00	93.0
	6.50	93.00	93.00	93.0

TABLE 2

MATERIAL	TIME (Minutes) ±0.05	1st reading Temperature (°c) ±0.05	2nd reading Temperature (°c) ±0.05	AVERAGE Temperature (°c) ±0.1
METHANOL	0.00	18.00	18.00	18.0
	0.50	21.00	21.00	21.0
	1.00	25.00	25.00	25.0
	1.50	37.00	37.00	37.0
	2.00	39.00	39.00	39.0
	2.50	41.00	41.00	41.0
	3.00	55.00	55.00	55.0
	3.50	58.00	58.00	58.0
	4.00	65.00	65.00	65.0
	4.50	70.00	70.00	70.0
	5.00	75.00	75.00	75.0
	5.50	79.00	79.00	79.0
	6.00	81.00	81.00	81.0
	6.50	83.00	83.00	83.0
	7.00	84.00	84.00	84.0
	7.50	84.00	84.00	84.0
	8.00	84.00	84.00	84.0
	8.50	85.00	85.00	85.0

TABLE 3

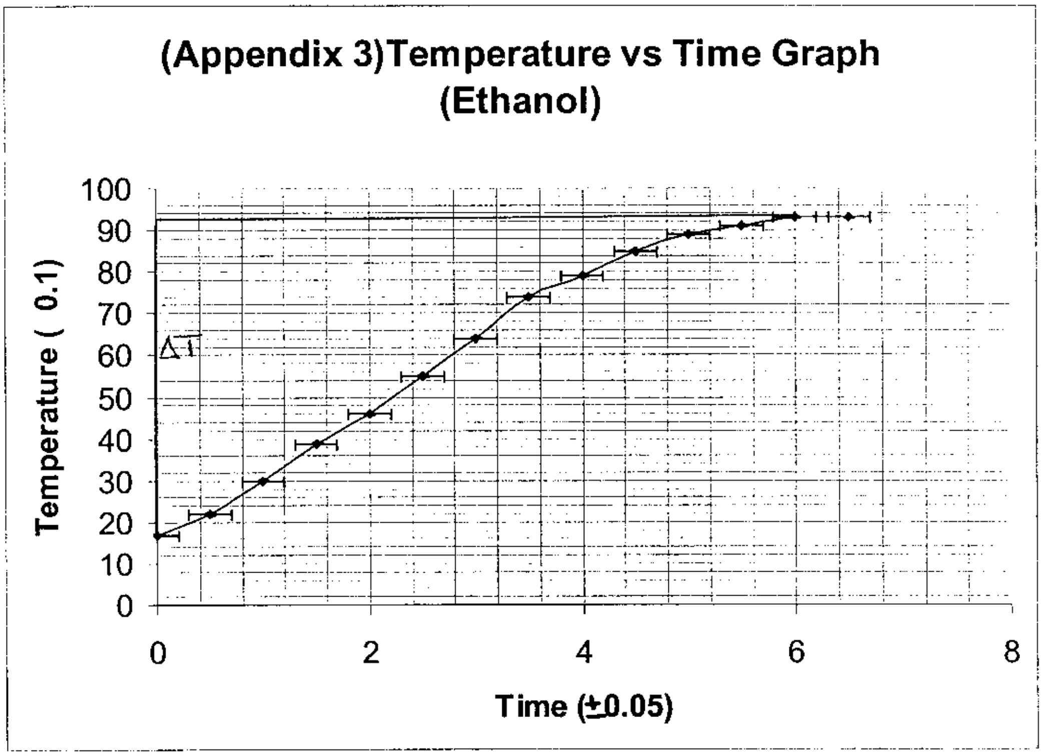
MATERIAL	TIME (Minutes) ±0.05	1st reading Temperature (°C) ±0.05	2nd reading Temperature (°C) ±0.05	Average Temperature (°C) ±0.1
HEXANE	0.00	18.00	18.00	18.0
	0.50	23.00	23.00	23.0
	1.00	31.00	31.00	31.0
	1.50	42.00	42.00	42.0
	2.00	53.00	53.00	53.0
	2.50	64.00	64.00	64.0
	3.00	73.00	72.00	72.5
	3.50	81.00	81.00	81.0

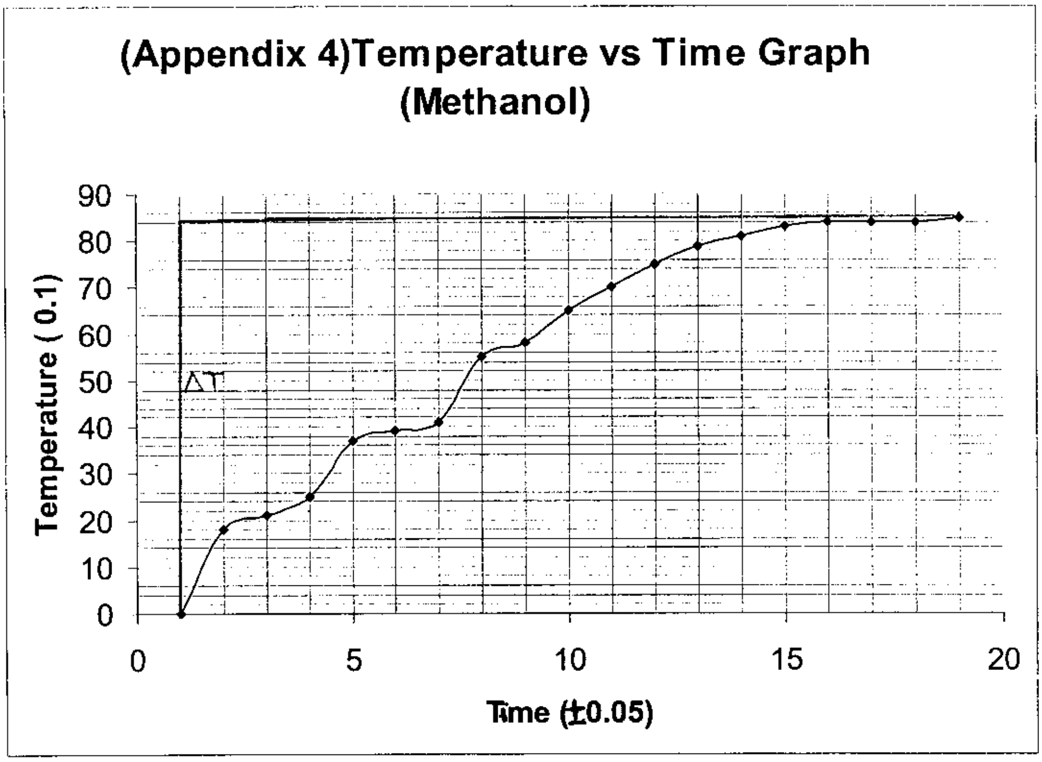
TABLE 4

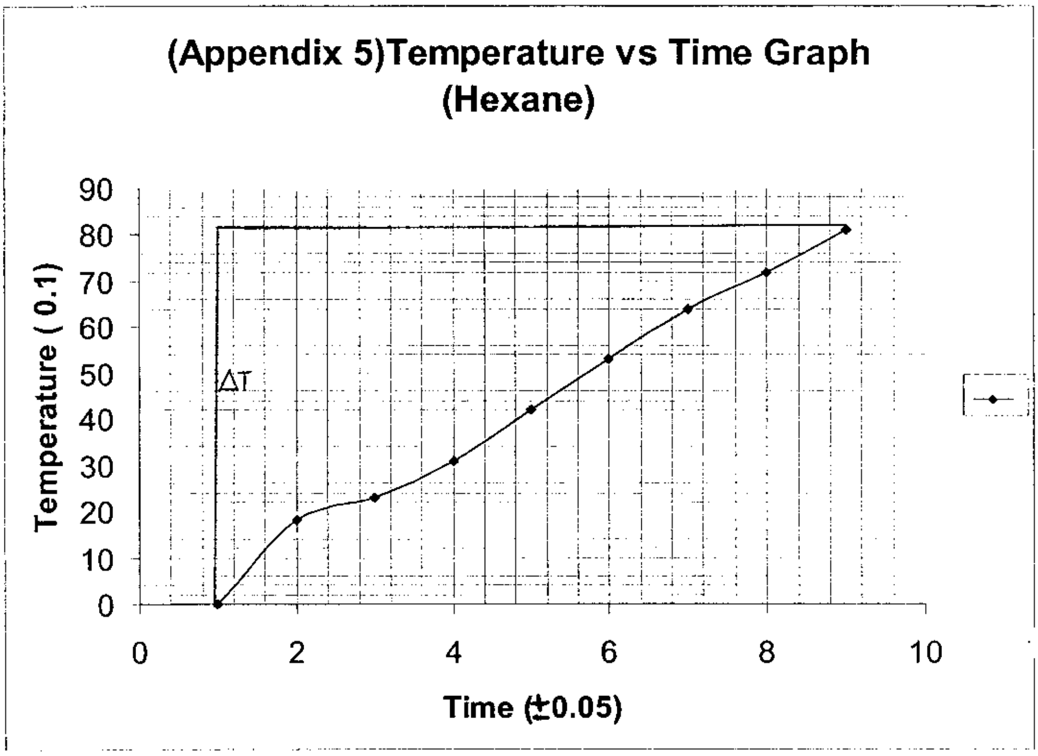
MATERIAL	TIME (Minutes) ±0.05	1st reading Temperature (°C) ±0.05	2nd reading Temperature (°C) ±0.05	Average Temperature (°C) ±0.1
PARAFFIN	0.00	18.00	18.00	18.0
	0.50	24.00	24.00	24.0
	1.00	30.00	30.00	30.0
	1.50	35.00	35.00	35.0
	2.00	43.00	43.00	43.0
	2.50	46.00	46.00	46.0
	3.00	52.00	52.00	52.0
	3.50	59.00	59.00	59.0
	4.00	65.00	65.00	65.0
	4.50	69.00	69.00	69.0
	5.00	74.00	74.00	74.0
	5.50	78.00	78.00	78.0
	6.00	81.00	81.00	81.0
	6.50	83.00	83.00	83.0
	7.00	84.00	84.00	84.0
	7.50	84.00	84.00	84.0
	8.00	84.00	84.00	84.0
	8.50	84.00	84.00	84.0
	9.00	84.00	85.00	84.5
	9.50	84.00	85.00	84.5

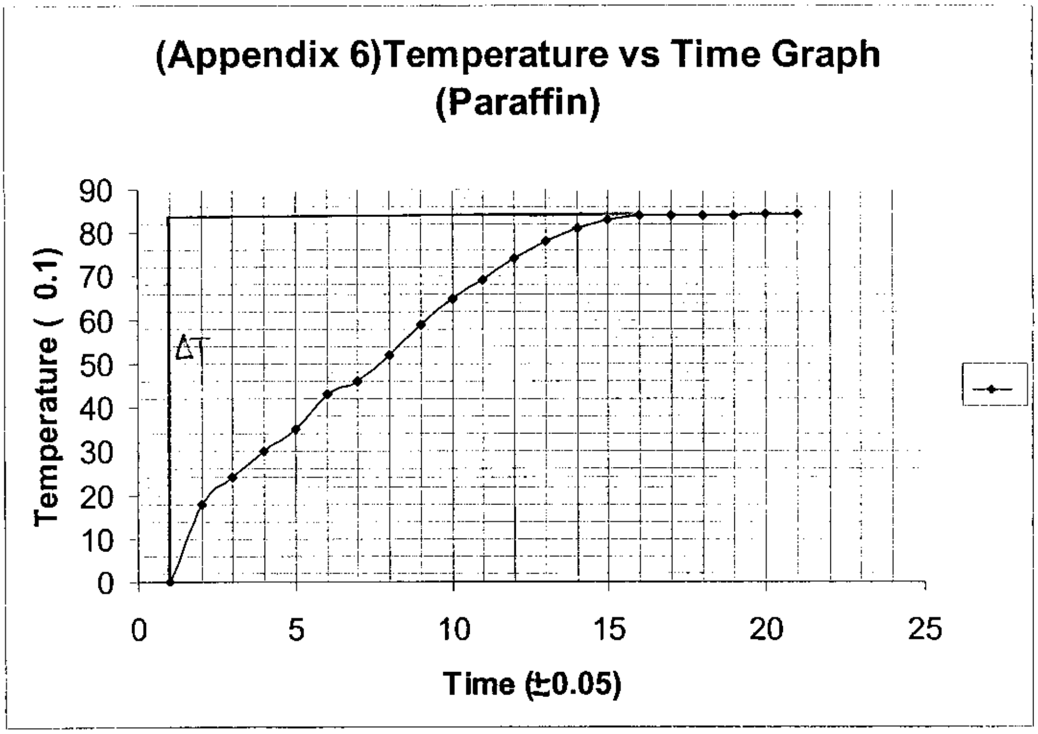
Name of the fuel	Volume of fuel taken ±0.1cm^3
Ethanol	6.0
Methanol	6.0
Hexane	6.0
Paraffin	6.0
Volume of water taken to be heated by each fuel ±0.1cm^3	
40.0	

7.3 TEMPERATURE VS TIME GRAPHS






(Appendix 5)Temperature vs Time Graph
(Hexane)
Temperature (0.1)
Time (±0.05)
ΔT
0
10
20
30
40
50
60
70
80
90
0
2
4
6
8
10


(Appendix 6)Temperature vs Time Graph
(Paraffin)
Temperature (0.1)
Time (±0.05)
ΔT
0
10
20
30
40
50
60
70
80
90
0
5
10
15
20
25

7.4 OBSERVATIONS

FOR ETHANOL : The beaker was not covered with any soot
FOR METHANOL: There was also no soot observed on the beaker
FOR HEXANE : The beaker was all cover with black soot
FOR PARAFFIN : The beaker was also covered with black soot

7.5 (Appendix 7) Additional Theories

Even though natural gas is a clean burning fuel among the fossil fuels, the fact remains the same, because it is a fossil fuel. As a result, it cannot be continued to be used since it is also one of the depleting fuels which are non-renewable. Natural gas has to be replaced because its availability is about 30 years supply in this world; and the world has to find an alternative for natural gas since it cannot be available forever or be replenished. The world could still compromise because of it being a clean burning fuel, but because it contains some greenhouse gases like carbon dioxide and nitrogen oxides, also causing thermal pollution and because of having limited supplies it cannot be continued to be used since it is going to make the world suffer as time goes on.

Coal is a fossil fuel that is already running out of time, even though is not so soon; but its availability is about 300-340 years supply as stated by Mark M. Jones (Jones et al, 1987, p177), which is also not forever; and it is a non-renewable source of energy. Despite that, Mark M. Jones (Jones, Ibidi, 1987, p175) regards coal as a 'dirty' fuel, hence, the world will not be comfortable to use what is referred to as dirty. Even though coal is known to be plenty, because coal mines have higher cost of production; and it is cheap than petroleum, with a plenty of ash that can be used to make roads, coal is a dirty fuel that contains greenhouse gases like carbon dioxide together with sulphur dioxide that causes acid rain, which damages soil, and particulates (fly ash), and all these cause thermal pollution. As a result, coal has to be replaced as quickly as possible before it can completely destroy the environment; since it is also difficult and expensive for it to recover, since it is depleting. Also because when it is combusted it produces harmful emissions; and one thing is that it produces a dreadfully dangerous dust that is extremely explosive which needs very stringent safety measures to be taken before being used.

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