9/9/2016



Teacher: Mrs Hall

dUE date: 9/09/16

Chemistry Vehicle Emissions Assignment

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The purpose of this report is to make a justified evaluation regarding the statement by Ian Johnson (2008) that “According to many spokespeople, businessmen, Governments and Scientists the cost of doing anything effective about chemicals which causes global warming is prohibitive; we simply cannot afford the sorts of measures that will significantly affect the problem for the better.” This statement is unjust, as there are measures that can be applied to reduce the amount of vehicle emissions.

Global warming is a phenomenon in which weather patterns and temperatures are changing rapidly and unpredictably on a global scale resulting in an increase in the temperature of the earth’s surface. Global warming is primarily caused by the growing concentration of heat-trapping gases in the atmosphere, commonly known as greenhouse gases. The results of global warming are rising sea levels, species being forced to migrate and an increase in precipitation. If this problem persists, hurricanes and other storms are likely to become stronger, floods and droughts will become more common and less fresh water will be available.

The greenhouse effect is a natural process that warms the Earth’s surface. When the sun’s energy reaches the Earth’s atmosphere, some of it is reflected back to space and the rest is absorbed and re-radiated by greenhouse gases. Many greenhouse gases including water vapour, carbon dioxide, methane, nitrous oxide, ozone and some artificial chemicals such as chlorofluorocarbons (CFCs) are naturally present in the atmosphere.

However, in vehicles, the principle greenhouse gas is carbon dioxide (CO2), but they also produce the greenhouse gases nitrous oxide and methane. In 2012, road transport is estimated to have produced 76mega tonnes of carbon dioxide emissions, which accounted for 84 per cent of emissions from the transport sector and over 12% of all greenhouse gas emissions produced in Australia.

The absorbed energy warms the atmosphere and the surface of the Earth. The primary cause of global warming is human activity, most significantly the burning of fossil fuels to drive cars and generate electricity. However, human activities including burning fossil fuels, agriculture and land clearing are increasing the concentrations of greenhouse gases. This is the enhanced greenhouse effect which is contributing to the warming of the earth.

As of October 2014, motor vehicles registered in Australia travelled an average of 13,800 kilometres per vehicle. The average rate of fuel consumption for all motor vehicle was 13.3 litres per 100 kilometres (Australian Bureau of Statistics, 2015).

The amount of petrol and gas that this equates to is stated below (refer to appendix I for calculations):

There were 17.7 million registered motor vehicles in Australia as of 31 December 2014. Therefore, the total mass of gases released per year by Australians through vehicle emissions is:

It is demonstrated by the significantly high value above that the amount of gases released through vehicle emissions needs to be reduced to assist in the solution of minimising global warming. In order to achieve this, e85 (up to 85% of ethanol and the remaining petrol) will be compared to petrol to determine whether ethanol would be more beneficial to Australia’s economy.

The major fuel source that Australian consumers utilise is petrol. Petrol is comprised of octane which undergoes combustion to produce energy, shown below;

C8H18 + 12.5O2 -> 8CO2 + 9H2O  
Octane + Oxygen -> Carbon Dioxide + Water Vapour

When 1L of petrol is burned, 3.169 kilograms of gas is produced (carbon dioxide and water vapor). The combustion of petrol (octane) is a representation of an exothermic reaction that releases   
-5262.5 kJ/mol which is used to power a car (refer to appendix II for calculations).

Internationally, ethanol has a long history of use as a petrol extender, octane improver and alternative fuel which has been put forward as a means of reducing greenhouse gas emissions and alleviating adverse economic conditions in the sugar industry. At present it is being widely promoted as a clean and renewable fuel that could reduce global warming, air pollution and reliance on diminishing reserves of fossil fuel. Ethanol (ethyl alcohol) is a clear, colourless liquid, generally manufactured from grain or sugar. Currently around 90% of Australia’s ethanol is produced from wheat.

However, ethanol is corrosive to car engines and fuel line and using ethanol above 10% would require certain modifications and design specifications to vehicles. Flexible-fuel vehicles (FFVs) can operate on neat petrol or fuel that contains 85 per cent ethanol by volume. The main differences between FFVs and petrol vehicles are the materials used in the fuel management system and modifications to the engine calibration system. Misfuelling with E85 may occur in the marketplace due to a lack of consumer awareness and primarily because the price of Bio E-Flex and other E85 automotive fuel products are expected to be significantly below that of regular unleaded petrol by approximately 20 cents per litre. Misfuelling could lead to engine damage, inconvenience to consumers and potentially, risks to consumer safety.

In addition to this, ethanol has a significantly lower heat of combustion. This means that more ethanol would be required to travel the same distance as when using petrol. A greater temperature is also required for combustion to occur because ethanol has a higher flash point than that of normal petrol. Furthermore, ethanol is more expensive to produce than hydrocarbons used for fuel such as octane and large areas of land would be needed to grow the biomass needed to produce the ethanol. This can cause environmental problems such as soil erosion, land clearing and deforestation as well as result in losses of large amounts of arable land.

Regardless of this, there are various advantages to incorporating ethanol (e85) as Australia’s new alternative fuel to reduce vehicle emissions. Using ethanol as a vehicle fuel has measurable greenhouse gas emissions benefits compared with using petrol. Carbon dioxide (CO2) released when ethanol is used in vehicles is offset by the CO2 captured when crops used to make the ethanol are grown. As a result, FFV’s running on ethanol produce less net CO2 than conventional vehicles per kilometer travelled.

Also, ethanol can be produced by the fermentation of glucose, making it a more desirable fuel source as it can be produced from renewable glucose. The presence of oxygen in the molecule means that combustion is almost always complete and therefore there is a reduction in polluting forms such as CO2 and soot. It also means that toxic additives which help petrol burn evenly by providing oxygen do not need to be added to the fuel.

Similarly, ethanol has the potential to be carbon neutral as the products of its use are exactly those required for its production by photosynthesis, it has already been successfully applied as a fuel extender without engine damage and it has a higher octane rating then petrol meaning it burns smoother in high compression performance engines. Finally, this particular fuel contains no impurities such as sulphur and so produces no polluting SO2 and is easily transportable and can be easily incorporated into fuel blends.

*Figure 1* is an illustration of a comparison table for ethanol and natural gas.

*Figure 1*

|  |  |  |
| --- | --- | --- |
|  | Ethanol (e85) | Petrol (octane) |
| Combustion reaction chemical formula | C2H5OH + 3O2 -> 2CO2 + 3H2O | C8H18 + 12.5O2 -> 8CO2 + 9H2O |
| Kilograms of greenhouse gases produced when 1L of petrol is burned | 2.436 kg (1.51 kg CO2) | 3.169 kg (2.17 kg CO2) |
| Enthalpy | -1289 kJ/mol | -5242 kJ/mol |

Overall, the comparison of ethanol and petrol provides difficulty in determining which source will assist in reducing the amount of vehicle emissions and therefore global warming. There are various advantages and disadvantages that ethanol accompanies with regard to costs, fuel efficiency, vehicle modifications, kilograms of gases produced when 1L of each fuel is burned and enthalpy. Although, the amount of carbon dioxide (greenhouse gas) produced when 1L of fuel is burned is the defining factor in coming to a conclusion about an alternative fuel. According to *figure 1*, ethanol and petrol result in 1.51 and 2.17 kg of CO2 produced respectively. Ethanol produces less greenhouse gas when it is released which means it is assisting in eradicating global warming.

In conclusion, it can be identified that Ian Johnson statement regarding global warming is incorrect because there is an alternative source of fuel that can assist in reducing vehicle emissions. This alternative fuel is ethanol, and this produces 0.66 kg/L less greenhouse gas (CO2) than our current fuel source petrol. Thereby, this will reduce greenhouse gas emissions which in the long term will help combat global warming. All disadvantages aside; this is the first step to winning the fight against global warming.

Appendix:

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Appendix I

There were 17.7 million registered motor vehicles in Australia as of October 2014. Therefore, the total mass of gases released per year by Australians through vehicle emissions is:

Appendix II

Moles of octane used when 1L of petrol is burned

Density of octane = 703 kg/m3  
 = 0.703 g/cm3

Volume of petrol = 1L  
 = 1000ml

Find moles of octane

Relative molecular mass:

Mass of carbon = 12  
Mass of hydrogen = 1

Moles of carbon dioxide produced

Relative molecular mass:

Mass of carbon = 12  
Mass of oxygen = 16

The moles for octane will be multiplied by 8 because 1 mole of octane produces 8 moles of carbon dioxide.

Convert to grams

Moles of water vapor produced

Relative molecular mass:

Mass of hydrogen = 1  
Mass of oxygen = 16

The moles for octane will be multiplied by 9 because 1 mole of octane produces 9 moles of water vapor.

Convert to grams

Change in enthalpy:

Reactants

1 mole of C8H18 and 12½ moles of O2 contain:

4 moles of C-C bonds = 4 x 347 = 1388 kJ/mol  
18 moles of C-H bonds = 18 x 413 = 7434 kJ/mol  
12½ moles of O=O bonds = 12.5 x 495 = 6187.5 kJ/mol

Energy required to break bonds = 1388 + 7434 + 6187.5  
 = 15009.5 kJ/mol

Products

8 moles of CO2 and 9 moles of H2O

16 moles of C=O bonds = 16 x 745 = 11920 kJ/mol  
18 moles of H-O bonds = 18 x 464 = 8352 kJ/mol

Energy released when new bonds form = 11920 + 8352  
 = 20272 kJ/mol

Combustion of ethanol

C2H5OH + 3O2 -> 2CO2 + 3H2O

Moles of ethanol used

Density of ethanol = 789 kg/m3  
 = 0.789 g/cm3

Volume of ethanol = 1L  
 = 1000ml

Find moles of ethanol

Relative molecular mass:

Mass of carbon = 12  
Mass of hydrogen = 1  
Mass of oxygen = 16

Moles of carbon dioxide produced

Relative molecular mass:

Mass of carbon = 12  
Mass of oxygen = 16

The moles for ethanol will be multiplied by 2 because 1 mole of ethanol produces 2 moles of carbon dioxide.

Convert to grams

Moles of water vapor produced

Relative molecular mass:

Mass of hydrogen = 1  
Mass of oxygen = 16

The moles for ethanol will be multiplied by 3 because 1 mole of ethanol produces 3 moles of water vapor.

Convert to grams

Change in enthalpy for ethanol:

Reactants

1 mole of C2H5OH and 3 moles of O2 contain:

1 mole of C-C bonds = 1 x 347 = 347 kJ/mol  
5 moles of C-H bonds = 5 x 413 = 2065 kJ/mol  
1 mole of O-O bonds = 1 x 146 = 146 kJ/mol  
1 mole of H-H bonds = 1 x 432 = 432 kJ/mol  
3 moles of O=O bonds = 3 x 495 = 1485 kJ/mol

Energy required to break bonds = 347 + 2065 + 146 + 432 + 1485  
 = 4475 kJ/mol

Products

2 moles of CO2 and 9 moles of H2O

4 moles of C=O bonds = 4 x 745 = 2980 kJ/mol  
6 moles of H-O bonds = 6 x 464 = 2784 kJ/mol

Energy released when new bonds form = 2980 + 2784  
 = 5764 kJ/mol

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