**Joseph Banks Secondary College**

Year 12 Integrated Science: General

****Unit 4 - Task 8

**Assessment type:** Practical Report – Chemical Reactions (fuels and combustion reactions)

**Conditions**

Period allowed for completion of the task:

* Four Lessons of class time dedicated to completing the practical report
* A device (ipad/laptop) may be used to access research material on Seqta and on the internet.

Use your prior knowledge from classwork, prior lessons and internet resources to answer the knowledge questions in this booklet. Use the marking guide on the following page as a guide to constructing your response.

**Task Weighting:**

8% of the school mark for this pair of units

**NAME:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Introduction:**

The combustion of alcohol produces energy. This experiment compares the amount of heat produced by the combustion of various fuels.

Hydrocarbons comprise a class of organic chemical compounds composed only of the elements carbon (C and hydrogen (H). The carbon atoms join together to form the framework of the compound, and the hydrogen atoms attach to them in many different configurations. Hydrocarbons are the principal constituents of petroleum and natural gas. They serve as fuels and lubricants as well as raw materials for the production of plastics, fibres, rubbers, solvents, explosives, and industrial chemicals.

A combustion reaction is a type of exothermic reaction, this means that there is more energy given out then there is taken in. Different fuels will therefore transfer different amounts of energy when they burn because of the different numbers of Carbon atoms in the different fuel molecules.

Determine the following chemical properties for Diesel, Ethanol and Unleaded Petrol:

|  |  |  |  |
| --- | --- | --- | --- |
| **Property** | **Diesel** | **Ethanol** | **Unleaded** |
| Chemical Formula | C12H24 | C2H5OH | C8H18 |
| Density | 849kg/m3 | 789 | 715-780 |
| Boiling Temperature | 180-360 | 78.3 | 85 |
| Autoignition Temperature | 210 | 365 | 280 |
| Flashpoint | 52-96 | 16.60 | -40 |

Write down the balanced chemical equations, showing the reactants and products for the ***combustion*** ***reactions*** of Diesel, Ethanol and Unleaded Petrol in the presence of Oxygen.

Diesel:

4C12H23 +71 O2 –> 48 CO2 + 46 H2O

Ethanol:

C2H5OH + 3O2 -----> 2CO2 + 3H2O

Unleaded Petrol:

2C8H18 + 25 O2 🡪 16 H2O + 2CO2

**Specific Heat Capacity**

A common way to measure energy changes in the laboratory is to measure the change in temperature of water. The specific heat capacity of water is 4.186 joules/gram °C. This means that 4.18 Joules of energy is needed to increase the temperature of 1 g of water by 1 °C. The total amount of energy needed to heat a substance can be found from the following equation:

Where,

q = the quantity of heat involved, measured in joules (J)

m = the mass of the water, measured in grams (g)

C = the specific heat capacity of the substance, measured in (J/g °C)

= the change in temperature (final temp. – initial temp.) measured in Celsius (°C)

**METHOD:**

|  |  |
| --- | --- |
| Apparatus | Chemicals |
| Eye protection  Each group requires:   * Retort stand and clamp * Conical flask (250ml) * Measuring Cylinder (50ml) * Thermometer * Digital balance   Spirit burners are provided and labelled at the front of the room. Take one spirit burner to your bench to complete the first round of experimentation.  Spirit burners containing Diesel are located in the fume hood and must be used under the supervision of a teacher | **Unleaded Petrol (HIGHLY FLAMMABLE)**  **Ethanol (HIGHLY FLAMMABLE)**  **Diesel (HIGHLY FLAMMABLE)** |

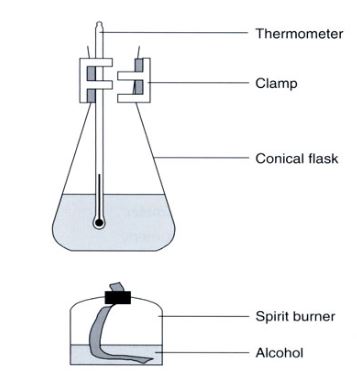


Figure 1: Experimental setup to test the combustion of different fuels.

1. Measure 10ml of cold tap water into a conical flask.
2. Clamp the flask at a suitable height so that a spirit burner can easily be placed below.
3. Weigh the spirit burner (and cap) containing the fuel and record this mass and the name of the fuel.
4. Record the initial temperature of the water in the flask.
5. Place the spirit burner under the flask and light the wick.
6. Allow the fuel to heat the water so the temperature rises by about 40oC.
7. Replace the cap to extinguish the flame.
8. Re-weigh the spirit burner and cap, and record this mass.
9. Work out the mass of alcohol used.
10. Using a fresh 10ml of cold tap water, repeat the experiment with another fuel.

**RESULTS:** Possible example of a correct results table below

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Fuel** | **Initial Temp/**°C | **Final Temp/**°C | **Temp Change/**°C | **Initial mass/g** | **Final mass/g** | **Mass used/g** |
| **Ethanol** | 20 | 60 | 40 | 239.9g | 239g | 0.9g |
| **Unleaded** | 20 | 60 | 40 | 224.7g | 224g | 0.7g |
| **Diesel** | 21 | 61 | 40 | 224.3g | 223.9g | 0.4g |

**Calculating the energy gained by the water:**

Using the data from your table above, substitute the values into the following equation in order to determine the quantity of heat energy absorbed by the water.

Where,

q = the quantity of heat involved, measured in joules (J)

m = the mass of the water, measured in grams (g) (\*hint: 1ml of water = 1g of mass)

C = the specific heat capacity of the substance, measured in (J/g °C)

= the change in temperature (final temp. – initial temp.) measured in Celsius (°C)

Use the table below to assist you with your calculations for each fuel.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **q** | **=** | **m** | **C** |  |
| **Fuel** |  |  |  |  |  |
| **Ethanol** | 3348.8J | **=** | 20 | 4.186 | Matches the temp change from previous table |
| **Unleaded** | 3348.8J | **=** | 20 | 4.816 |  |
| **Diesel** | 3348.8J | **=** | 20 | 4.186 |  |

Graph the quantity of heat energy gained by the water from all three fuels using the graph paper provided below.

**Graph – 7 marks**

* Correct labels
* Units
* Scale
* Title
* Diesel plotted correctly (heat gained vs amount of fuel used)
* Unleaded plotted correctly
* Ethanol plotted correctly.

**Discussion questions**

1. Rank the fuels in order from highest to lowest in terms of the amount of energy produced per gram of fuel? Justify your answer with calculations.

1st – Diesel

2nd – Unleaded

3rd – Ethanol

Justifies answers by showing calculations. Needs to divide “q” by the amount of fuel used for each of the 3 fuel types. This will give an answer in joules of energy per gram of fuel.

1. Does all the heat produced by combustion go into raising the temperature of the water? If not, where is energy lost?

* *Statement that heat is lost from the system – 1 mark*
* *Describes 3 ways in which energy can be lost from the system – 3 marks*

1. What effect does the size of the molecule have on the energy of combustion in terms of energy per gram?

* *States the general relationship that the larger the molecule, the more energy that is released from its combustion – 1 mark*
* *Describes the amount of energy per gram and relates it to the number of atoms in the chemical formula – 1 mark*
* *Refers to the number of hydrogen-carbon bonds in the formula – 1 mark*

1. From your results, discuss the reasons why trucks and four-wheel drives use Diesel and family cars tend to use unleaded fuels. Your response should include benefits and deficits of using each fuel type.

* *Because trucks carry heavier loads, diesel enables them to carry less fuel as it produces more energy per gram than unleaded – 1 mark*
* *Family cars tend to not require the high amount of torque produced by diesel fuel, instead faster acceleration for stop-start journey – 1 mark*
* *Lists one benefit and one deficit for each fuel type – 4 marks*

1. Compare the amount of carbon dioxide produced from complete combustion of each of the three fuels. Be specific with your response.

* *Compares carbon dioxide produced from each fuel – 3 marks (1 per fuel)*
* *Provides figures for fuel comparison*

1. Describe the differences between incomplete and complete combustion in terms of the reactants and products in the chemical reaction.

* *Defines complete combustion – 1 mark*
* *Defines incomplete combustion – 1 mark*
* *Describes production of carbon dioxide in complete combustion – 1 mark*
* *Describes production of carbon monoxide and soot in incomplete combustion – 1 mark*

1. The following alcohols are often used as fuels in different combustion reactions. Using your knowledge of how the number of Carbon atoms can be used to predict which fuel will release the most energy, rank the fuels left to right in order from least energy to most energy. Be sure to include the chemical formula and balanced combustion reactions for each of the listed fuels.
   1. Natural Gas, Propane, Butane, Kerosene, Octane.

* *Fuels ranked in order of least energy to most energy (methane, propane, butane, octane) – 1 mark*
* *Correct chemical formula for each fuel – 1 mark per fuel (4 marks)*
* *Balanced combustion reaction of each fuel – 1 mark per fuel (4 marks)*

***BONUS MARKS AS KEROSENE REMOVED FROM FINAL ASSESSMENT (2)***