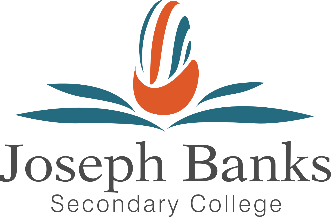
**Yr12 Integrated Science General 2020**

TASK 06: SIS

Chemistry– Comparing the heat energy produced by combustion of various alcohols

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

**Topic**

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, fibers, rubbers, solvents, explosives, and other industrial chemicals.

**Task Detail**

Your task is to complete this booklet to produce a scientific report that details the findings of your investigation.

Periods 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.

Class allocated time: Term 3, Week 6 (4 lessons)

Task Due Date: 4th September Friday (Term 3, Week 7)

Weighting: 10%

**Useful Documents**

Use your notes from prior classwork, lessons and the following internet resources to answer the knowledge questions in this booklet.

Weblinks:

The Chemistry of Petrol and Diesel: <https://www.compoundchem.com/2016/05/17/petrol/>

Fuel Properties Comparison: <https://afdc.energy.gov/fuels/properties>

Hydrocarbons in Fossil Fuels: <http://chemistry.elmhurst.edu/vchembook/509fossilfuel.html>

<https://www.intechopen.com/books/diesel-and-gasoline-engines/fuels-of-the-diesel-gasoline-engines-and-their-properties>

Liquified Petroleum Gases (LPG): <https://sibur-int.com/product/hydrocarbons/catalog/item373.php#:~:text=It%20is%20produced%20by%20mixing,after%20fractionation%20of%20NGL%2DSHFLU.&text=Propane%20is%20a%20three%2Dcarbon,compressible%20to%20a%20transportable%20liquid.>

**MARKING GUIDE**

|  |  |  |
| --- | --- | --- |
| **DESCRIPTION** | **MARKS AVAILABLE** | **MARKS RECEIVED** |
| **Background**  Balanced Equations.  Physical Properties of fuels. | 4  6 |  |
| **Introduction**  Provide information about the structure and composition of hydrocarbons.  Explain the aim of the investigation.  Describe the reactants and products of combustion reactions.  Describe why it is important to understand the amount of energy in fuels. | 2  1  2  2 |  |
| **Variables**  Correctly identify the independent, dependent and at least 3 control variables (and how they will be controlled), including any relevant units. | 6 |  |
| **Hypothesis**  Provide a hypothesis statement that incorporates the independent and dependent variables. | 2 |  |
| **Method**  Safe and appropriate laboratory behaviour explained  Labelled diagram of setup.  List of equipment | 2  2  1 |  |
| **Results: Table**  Record results in a table.  Incorporating a relevant title.  Determine average data. | 3 |  |
| **Results: Graph**  Draw a graph of your results in an appropriate format for the data type, ensure everything is labelled, including correct units and an incremental scale is used.  Graph should be in pencil (use a ruler)  Includes an appropriate title incorporating both variables. | 6 |  |
| **Discussion**  Question 1  Question 2  Question 3  Question 4  Question 5  Question 6  Question 7 | 4  4  3  6  4  4  6 |  |
| **Conclusion**  Summarise overall finding from the investigation.  Link to the hypothesis. | 2 |  |
| **TOTAL MARKS** | 72 | **%** |

**TITLE**

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**BACKGROUND**

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.

Write down the balanced chemical equations, showing the reactants and products for the ***combustion*** ***reactions*** of Methanol, Ethanol, Propanol, and Butanol in the presence of Oxygen. (4 marks)

Methanol:

Ethanol:

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

Propanol:

Butanol:

Unleaded:

2C8H18 + 25 O2 🡪 16 H2O + 2CO2

Diesel:

4C12H23 +71 O2 –> 48 CO2 + 46 H2O

Determine the following chemical properties for Methanol, Ethanol, Propanol, Butanol, Unleaded and Diesel: (6 marks)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Property** | **Methanol** | **Ethanol** | **Propanol** | **Butanol** | **Unleaded** | **Diesel** |
| Image |  |  |  |  |  |  |
| Chemical Formula |  | **C2H5OH** |  |  | **Octane: C8H18** | **The average chemical formula for common diesel fuel is C12H24,**  **Ranges from C9 to C20.** |
| Density (kg/m3) |  | **789** |  |  | **715-780** | **849** |
| Boiling Temperature (°C) |  | **78.3** |  |  | **85** | **163-360** |
| Autoignition Temperature (°C) |  | **365** |  |  | **280** | **210** |
| Flashpoint (°C) |  | **16.6** |  |  |  | **52 - 96** |

**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)

**INTRODUCTION**

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**VARIABLES:**

**Independent Variable:**

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**Dependent Variable:**

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**Controlled Variables:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**HYPOTHESIS:**

How does the number of hydrocarbons affect the amount of energy needed to heat the fuel?

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**METHOD:**

**Safety:**

* Wear eye protection
* Do not open the spirit burner

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**Materials:**

|  |  |
| --- | --- |
| **Apparatus** | **Chemicals** |
| * Safety Glasses * Retort stand and clamp * Conical flask * Measuring cylinder * Thermometer * Electronic balances * Spirit burners with wicks and caps, containing the alcohols listed. | Methanol (HIGHLY FLAMMABLE, TOXIC)  Ethanol (HIGHLY FLAMMABLE)  Propan-1-ol (HIGHLY FLAMMABLE, IRRITANT)  Butan-1-ol (FLAMMABLE, IRRITANT, HARMFUL) |

**Note:** 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.

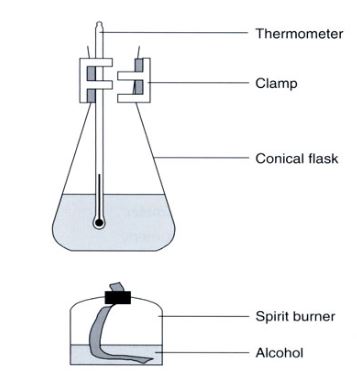
**Diagram:**

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

**Procedure:**

1. Measure 100 mL 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 alcohol and record this mass and the name of the alcohol.
4. Record the initial temperature of the water in the flask.
5. Place the spirit burner under the flask and light the wick.
6. Start the timer the moment the lit spirit burner is under the flask.
7. Allow the alcohol to heat the water so the temperature rises by about 40oC (starts at 20oC ) and reaches a final temperature of 60oC.
8. Replace the cap to extinguish the flame.
9. Re-weigh the spirit burner and cap and record this mass. Work out the mass of alcohol used.
10. Using a fresh 100 mL of cold tap water, repeat the experiment with another alcohol.
11. Repeat the experiment 3 times for each alcohol so an average can be determined.

**RESULTS Table 1:**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Fuel** | Initial Temp/°C | Final Temp/°C | **Temp Change/**°C | Initial mass/g | Final mass/g | **Mass used/g** | **Time Taken(min)** |
| **Methanol** |  |  |  |  |  |  |  |
| Trial 1 |  |  |  |  |  |  |  |
| Trial 2 |  |  |  |  |  |  |  |
| Trial 3 |  |  |  |  |  |  |  |
| Average |  |  |  |  |  |  |  |
| **Ethanol** |  |  |  |  |  |  |  |
| Trial 1 |  |  |  |  |  |  |  |
| Trial 2 |  |  |  |  |  |  |  |
| Trial 3 |  |  |  |  |  |  |  |
| Average |  |  |  |  |  |  |  |
| **Propanol** |  |  |  |  |  |  |  |
| Trial 1 |  |  |  |  |  |  |  |
| Trial 2 |  |  |  |  |  |  |  |
| Trial 3 |  |  |  |  |  |  |  |
| Average |  |  |  |  |  |  |  |
| **Butanol** |  |  |  |  |  |  |  |
| Trial 1 |  |  |  |  |  |  |  |
| Trial 2 |  |  |  |  |  |  |  |
| Trial 3 |  |  |  |  |  |  |  |
| Average |  |  |  |  |  |  |  |

**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)

C=

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

**Table 2:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Fuel** | **C** | **=** | **q** | **÷** | **m** |  |
| **Methanol** |  | **=** |  | **÷** |  |  |
| **Ethanol** |  | **=** |  | **÷** |  |  |
| **Propanol** |  | **=** |  | **÷** |  |  |
| **Butanol** |  | **=** |  | **÷** |  |  |

**Graph:** Graph the specific heat capacity (C) for all three fuels using the graph paper provided below.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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**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.

* **Justifies diesel calculation – 1 mark**
* **Justifies ethanol calculation – 1 mark**
* **Justifies unleaded calculation – 1 mark**
* **Ranked in correct order – 1 mark**

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, Kerosene, Octane.

* **Fuels ranked in order of least energy to most energy (natural gas (LPG), octane, kerosene) – 1 mark**
* **Correct chemical formula for each fuel – 1 mark per fuel (3 marks)**

**LPG using contains propane and butane.**

**Octane is 8 carbons in length.**

**Kerosene contain hydrocarbons of chains 6-16 carbons in length.**

* **Statement about length of carbon chain determining the amount of energy-longer the carbon chain the more energy (2 marks)**

**CONCLUSION**

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**REFERENCES**

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**Extra Space:**

**END OF ASSESSMENT**