**VCE Chemistry Unit 3**

**SAC 1: A report on a laboratory Investigation on Synthesis and analysis of Biodiesel**

**Teachers Guide**

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**Rationale behind the design of this SAC**

* This SAC is designed to be in Unit 3, Area of Study 1, Outcome 1:
* Compare fuels quantitatively with reference to combustion products and energy outputs, apply knowledge of the electrochemical series to design, construct and test galvanic cells, and evaluate energy resources based on energy efficiency, renewability and environmental impact
* The SAC for this AOS, is designed to be ‘A report on a laboratory investigation’, worth a total of 50 marks.
* *It should be noted that the Biodiesel SAC and this associated teacher’s guide is a starting point for teachers and may be modified as required.*
* Specific dot points covering this SAC from the study design are:

**Obtaining energy from fuels**

* the definition of a fuel, including the distinction between fossil fuels and biofuels with reference to origin and  renewability (ability of a resource to be replaced by natural processes within a relatively short period of time)
* combustion of fuels as exothermic reactions with reference to the use of the joule as the SI unit of energy, energy transformations and their efficiencies and measurement of enthalpy change including symbol (∆*H*) and common units (kJ mol-1, kJ g-1, MJ/tonne)
* the writing of balanced thermochemical equations, including states, for the complete and incomplete combustion of hydrocarbons, methanol and ethanol, using experimental data and data tables
* calculations related to the combustion of fuels including use of mass-mass, mass-volume and volume-volume stoichiometry in calculations of enthalpy change (excluding solution stoichiometry) to determine heat energy released, reactant and product amounts and net volume of greenhouse gases at a given temperature and pressure (or net mass) released per MJ of energy obtained
* the use of specific heat capacity of water to determine the approximate amount of heat energy released in the combustion of a fuel.

**Fuel choices**

* the comparison of fossil fuels (coal, crude oil, petroleum gas, coal seam gas) and biofuels (biogas, bioethanol, biodiesel) with reference to energy content, renewability and environmental impacts related to sourcing and combustion
* the comparison of the suitability of petrodiesel and biodiesel as transport fuels with reference to sources, chemical structures, combustion products, flow along fuel lines (implications of hygroscopic properties and impact of outside temperature on viscosity) and the environmental impacts associated with their extraction and production.

**Background knowledge**

It is assumed that the students are familiar with the following principles/concepts from year 11:

* Structural formulae of organic molecules
* Polar/non-polar compounds
* Intermolecular forces and their relative strength
* General formula of alkanes, i.e. CnH2n+2
* The source of petrodiesel, i.e. crude oil
* General formula of an ester
* Heat capacity of water

**Hints/Suggestions**

**Part A: Synthesis of Biodiesel**

* Issues surrounding the toxicity of methanol:
* An alternative to methanol might be ethanol, however, separation might be more difficult and this would need to be tried first experimentally.
* To minimise exposure to methanol, students could be provided with 10 mL auto dispensers and dispense the methanol straight into the conical flask.
* A solution of KOH in methanol can be pre-prepared to minimise exposure to methanol, however, this needs to be made *fresh*.
* Instead of shaking the jar for 10 minutes a magnetic stirrer bar/stirrer can be used to stir the mixture vigourously in a conical flask.
* Possibly a safer way of handling the methanol in case the lid does not seal properly and the contents leak out of the glass jar
* A separating funnel could be used to separate the layers if they were available at the school and the bottom layer could be easily drained.
* The separation of the layers can take a while (around 30 mins) and better if left over night to separate each time, thus the synthesis might have to occur over a couple of classes:
* Rather than synthesise the biodiesel, the lab technician could make it (*use ratio in prac of KOH: methanol: oil*) and then the students could Part B
* As biodiesel is hygroscopic, it will absorb water over time, so this may affect the results
* Apparently any type of vegetable oil can be used to make Biodiesel, but some are better than others, e.g. canola or grape-seed oil.

**Part B: Properties of Biodiesel**

**(a) Density**

* This is pretty much straight forward
* To limit the students exposure to petrodiesel, it is *not recommended* that the students measure the density of petrodiesel, due to the following safety risks:
* Petrodiesel is highly flammable and has a rather strong smell. It thus, must be kept away from sources of ignition, PPE worn and also handled in a fumehood. Thus, the density measurement would need to occur in the fumehood also.
* Petrodiesel depending on the supply has a range of densities they must conform to within the Australia Standard for Fuels i.e., 0.820 to 0.850 g mL-1. There is a question in the SAC that deals with this comparison, based on this second hand data, thus eliminating the need to measure the density of a sample of petrodiesel.

**(b) Effect of temperature on flow rates**

* *See safety issues in Part B (b), above*
* To limit the students exposure to petrodiesel, it is highly recommended that the lab technician pre-prepares 3-4 test tubes with stoppers prior to the class to share around. If they are *well sealed*, then this minimises the safety risk and limits any vapours from the test tube.
* Students would then need to fill an identical test tube to the same level as the petrodiesel for this to work.
* The longer and thinner, the test tubes, the better this part will work.
* It is *not recommended* that the test tubes be heated above 35˚C in a beaker of hot water. However, 30˚C might be a better limit to lower any safety risks.

**(c) Energy content of Biodiesel**

* Burning of petrodiesel as a comparison is *not recommended*:
* Too many safety issues
* Petrodiesel usually contains a tiny amount of sulphur based compounds
* Gives off a fair amount of smoke
* The average Energy content of petrodiesel is given in an analysis question for comparison to second hand data
* The biodiesel produced, burns in a controlled manner, so it is fine to burn this, however a *fume hood must be used* and it is highly recommended that only around 1.0 mL of the biodiesel is burned:
* ignition of the biodiesel is not easy and either use a candle wick (of some description) or insert a bit of paper towel into the crucible and light that
* An aluminium case of those little tea tree candles might be able to be used instead of a crucible. This will give better heat transfer to the water.
* Insulating the evaporating dish with aluminium foil will help insulate against heat loss to the environment from the water
* Any suitable container can be used to hold the water, a small ceramic bowl would work also

**Extension Activities**

* A variety of vegetable oils could be used to make biodiesel in the class.
* Groups can compare the properties of the different Biodiesels (i.e. density, flow rate compared to petrodiesel, energy content, etc.) to each other for further analysis
* Students could also measure the density and fluid flow of the vegetable oil used to make their biodiesel
* If the densities and/or fluid flows are different, then this would indicate that Biodiesel has been made and it’s not just the vegetable oil

**Materials:** These numbers assume a group of 20 students working in pairs

|  |  |  |
| --- | --- | --- |
| **Chemicals** | **Amount per group** | **Total amount** |
| Methanol | 10 mL | 100 mL |
| Petrodiesel | N/A (share test tubes) | 30 mL |
| Potassium hydroxide | 0.4 g | 4 g |
| Saturated NaCl solution | 5 mL | 50 mL |
| Vegetable Oil | 50 mL | 500 mL |

|  |  |  |
| --- | --- | --- |
| **Equipment** | **Amount per group** | **Total amount** |
| Candle wick | 1 | 10 |
| Conical Flasks with stoppers (at least 100 mL) | 1 | 10 |
| Crucible | 1 | 10 |
| Evaporating Dish | 1 | 10 |
| Glass Rod | 1 | 10 |
| Mass balances | 1 | a few to share |
| Matches or Lighter | 1 | 2 or 3 to share |
| Measuring cylinders: | 2 x 10 mL; 1 x 50 mL; 1 x 100 mL | 20 x 10 mL; 10 x 50 mL; 10 x 100 mL |
| Plastic Container (small) for ice/water bath | 1 | 10 |
| Plastic Pasteur Pipettes | 6 | 60 |
| Spatulas | 1 | 10 |
| Stop Watch | 1 | 10 |
| Test tubes with stoppers | 1 | 10 |
| Thermometer | 1 | 10 |

**Suggested Marking Rubric**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **5 marks** | **4 marks** | **3 marks** | **2 marks** | **1 mark** | **0 marks** |
| **Comprehensive** knowledge and understanding of the principles of comparing fuels quantitatively and qualitatively in reference to the scope of this investigation | **Detailed** knowledge and understanding of the principles of comparing fuels quantitatively and qualitatively in reference to the scope of this investigation | **Sound** knowledge and understanding of the principles of comparing fuels quantitatively and qualitatively in reference to the scope of this investigation | **Some** knowledge and understanding of the principles of comparing fuels quantitatively and qualitatively in reference to the scope of this investigation | **Limited** knowledge and understanding of the principles of comparing fuels quantitatively and qualitatively in reference to the scope of this investigation | Not  shown |
| Accurate application of ideas and concepts to familiar and new contexts. | Accurate application of **most** ideas and concepts to familiar and new contexts. | Accurate application of **many** ideas and concepts to familiar and new contexts. | Accurate application of **some** ideas and concepts to familiar contexts. | Applies **few** ideas or concepts accurately to familiar contexts. | Not  shown |
| **Accurate and appropriate** application to recording and **insightful** and **detailed** quantitative and/or qualitative observations with correct units including the use of tables. | **Accurate and clear, detailed** recording of quantitative and/or qualitative observations with correct units including the use of tables. | **Accurate** recording of relevant quantitative and/or qualitative observations with correct units including the use of tables. | Records quantitative and/or qualitative observations with **some** correct units including **some** use of tables. | Records **few** quantitative and/or qualitative observations. | Not  shown |
| Manipulates data **accurately and in detail** | Manipulates **most** data accurately and clearly | Manipulates **most** data accurately | Manipulates **some** data accurately. | **Minimum** accurate use of data, if any. | Not  shown |
| Identifies and addresses **most** possible sources of uncertainty accurately | Identifies and addresses **many** possible sources of uncertainty accurately | Identifies **many** and addresses **some** possible sources of uncertainty | Identifies and addresses **some** possible sources of uncertainty | Identifies **few, if any** possible sources of uncertainty | Not  shown |
| Draws **clear and concise** conclusions consistent with the question under investigation and the information collected. | Draws **clear** conclusions consistent with the question under investigation and the information collected | Draws conclusions **mostly** consistent with the question under investigation and the information collected | Draws **some** conclusions consistent with the question under investigation or the information collected | Draws **few, if any**, conclusions consistent with the question under investigation and the information collected | Not  shown |
| Evaluates the procedure effectively and discusses the reliability of data **accurately and in detail** | Evaluates the procedure and discusses the reliability of data **accurately**. | Evaluates **some** of the procedure and discusses **some** aspects of the reliability of data. | Evaluates **some** of the procedure and/or discusses **some** aspects of the reliability of data. | **Limited** evaluation of the procedure and/or discussion of the reliability of data. | Not  shown |
| **Comprehensive and accurate** use of scientific language and conventions | **Detailed and accurate** use of scientific language and conventions | **Accurate** use of scientific language and conventions | **Some** accurate use of scientific language and conventions | **Limited** use of scientific language and conventions | Not  shown |
| Demonstrates **Comprehensive** knowledge and understanding of risk assessment, risk management and work practices in the laboratory. | Demonstrates **detailed** knowledge and understanding of risk assessment, risk management and work practices in the laboratory. | Demonstrates **sound** knowledge and understanding of risk assessment, risk management and work practices in the laboratory. | Demonstrates **some** knowledge and understanding of risk assessment, risk management and work practices in the laboratory. | Demonstrates **very little** knowledge and understanding of risk assessment, risk management and work practices in the laboratory. | Not  shown |
| Communicates findings from the investigation **accurately, concisely and effectively.** | Communicates findings from the investigation **accurately and effectively**. | Communicates **most** findings from the investigation **accurately.** | Communicates **some** of the findings from the investigation **accurately.** | Communicates **few**, if any, findings from the investigation **accurately.** | Not  shown |