8th International Junior Science Olympiad
Durban, South Africa

Practical Examination: Part 2 - Chemistry

7 December 2011

Duration: 3 hours **Total Marks:** 30

EXAMINATION RULES

1. All competitors must be present at the front of examination room 15 minutes before the examination starts.

2. No competitors are allowed to bring any stationery and tools except his/her personal medicine or any personal medical equipment.

3. Each competitor has to sit at his or her designated desk.

4. Before the examination starts, each competitor has to check the stationery and any tools (pen and calculator) provided by the organiser.

5. Each competitor has to check the question and answer sheets. Raise your hand, if you find any missing sheets. Start after the bell rings.

6. During the examination, competitors are not allowed to leave the examination room.

7. If a competitor needs to use the bathroom he/she must raise his/her hand and an examination supervisor will escort you.

8. The competitors are not allowed to communicate with other competitors and disturb the examination. In case any assistance is needed, a competitor may raise his/her hand and the nearest supervisor will come to help.

9. There will be no questions or discussion about the examination problems. The competitor must stay at his/her desk until the time allocated for the examination is over, although he/she has finished the examination earlier or does not want to continue working.

10. At the end of the examination time there will be a signal (the ringing of a bell). You are not allowed to write anything on the answer sheet, after the allocated time is over. All competitors must leave the room quietly. The answer sheets must be left on your desk.

Read the following instructions carefully:

The three tasks are independent. Students in each team can decide to work cooperatively or separately.

1. The time available is 3 hours.

2. The practical examination paper is in 3 parts. Check that you and each member of your team have a complete set of practical instructions and the corresponding answer sheets. Part 2 of the examination paper consists of 6 pages.

3. Use only the stationery and equipment provided.

4. Write your name, seat number, country and signature on the first page of your answer sheet. You will only need to write your name and seat number on the next pages of your answer sheet. Your team code and student codes must be written on every page of the final answer sheets. Each team member must sign on the front page of the final answer sheets.

5. All results must be written in the designated boxes on the answer sheets. Data written elsewhere will not be graded.

6. While you are in the examination venue, you should wear safety spectacles at all times.

7. Eating of any kind of food is strictly prohibited during the examination. If necessary, you may ask the laboratory assistant and take a snack break nearby outside the venue.

8. Participants are expected to work safely, to behave socially and to keep equipment and work environment clean. When carrying out discussions with your team mates, keep your voice low.

9. Do not leave the examination room until you have permission to do so. Ask the laboratory assistant if you need to use the bathroom and you will be escorted.

10. Work may only begin when the start signal is given.

11. You have 3 hours to complete the experimental tasks, and record your results on the answer sheets. There will be a pre-warning 30 minutes before the end of your time. You must stop your work immediately after the stop command is given. A delay in doing this by 5 minutes will lead to zero points for the task.

12. After completing the task, put all the equipment back in its original place.

13. After the stop command is given, put ONLY the final answer sheets (one copy) on top of the envelope on the desk. Wait for the laboratory assistant to check and collect it. You can take the other papers with you.

CHEMISTRY EXPERIMENT

Energy Content of Fuels

Introduction

Ethanol is an important chemical that is widely used in various industrial sectors. It is a crucial feedstock in the production of various commodities. Examples include pharmaceuticals, paints, inks, detergents, cosmetics, toiletries, speciality chemicals, and beverages to name a few. Ethanol can also be used as an alternative fuel for transport applications. Biodiesel is a mixture of various long chain hydrocarbon molecules, typically methyl, propyl, or ethyl esters. Biodiesel can be used in standard diesel engines, or as a low carbon alternative to heating oil. In some countries, ethanol is used as a gasoline additive (gasohol) or as a petrol (gasoline) substitute, and biodiesel is used with various diesel powered vehicles or engines. Both of these chemicals can be produced from renewable sources. For example, ethanol can be produced from sugar cane, and bio-diesel from high yielding seed oils such as castor, jatropha or palm fruit seeds. The use of renewable resources is one of many proposed strategies to help reduce the effects of climate change and contribute towards sustainable growth and development on a national level.

In this experiment, you will compare the energy content of ethanol and bio-diesel by measuring their heats of combustion in kJ g^{-1} of fuel. In order to find the heat of combustion, you will first use the energy from burning ethanol or bio-diesel to heat a known quantity of water. By monitoring the temperature of the water, you can find the amount of heat transferred to it, using the formula

$$q = C_p \bullet m \bullet \Delta t$$

where q is the heat transferred, C_p is the specific heat capacity of water, m is the mass of water and Δt is the change in temperature of the water. Finally, the amount of fuel burned will be taken into account by calculating the heat per gram of fuel consumed in the combustion.

Objectives

In this experiment, you will

- Compare the heat of combustion for biodiesel and ethanol.
- Calculate the heat of combustion and per cent efficiency for both fuels.

Materials

Small oil lamp

Glass stirring rods

Digital thermometer

100 mL graduated cylinder

Small stainless steel cup

An iron tripod

Utility clamps

Lighter

Ethanol

Biodiesel

Procedure

1. Ensure you and your partners are wearing a laboratory coat and safety glasses.
2. Check that your work station has a digital thermometer, lighter, an oil lamp and supports as in the image.

Part 1: Ethanol

3. Weigh the empty oil lamp on the mass balance provided, and record the value on your data sheet.
4. Using a firm grip, turn the top half of the oil lamp and separate it from the base chamber. See Figure 1.

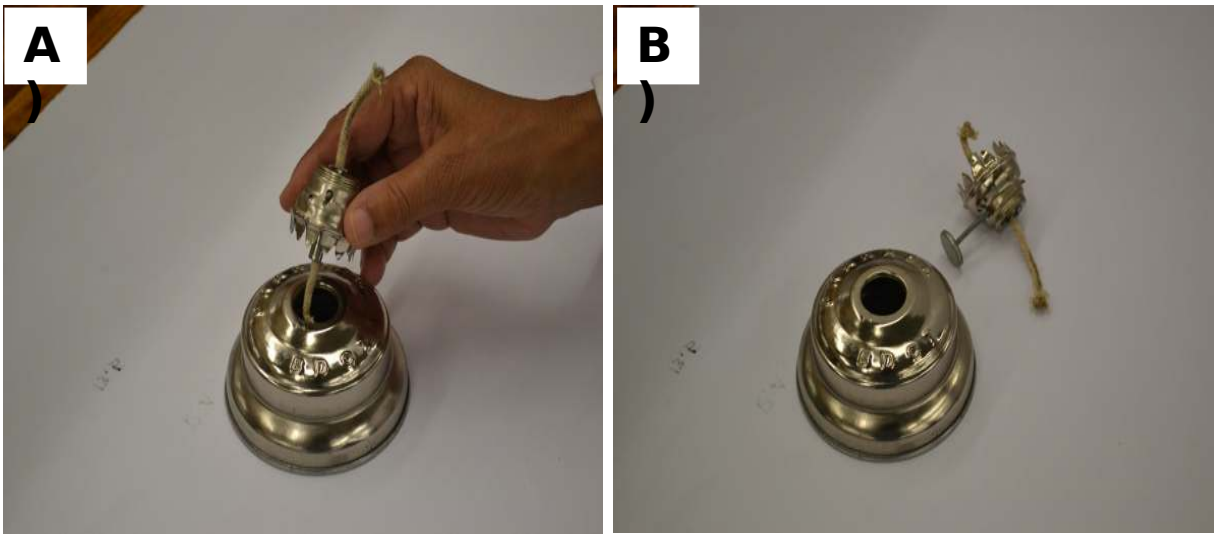


Figure 1

5. Use the measuring cylinder provided to add approximately 100 mL of ethanol into the open chamber of the oil lamp.
6. Place the top half of the oil lamp back onto the open chamber of the lamp and re-weigh (do not close the lamp tightly).
7. Record the mass of the oil lamp fully assembled and with ethanol.
8. Weigh the empty stainless steel cup on the mass balance provided, and record the value on your data sheet.
9. Use a measuring cylinder to add approximately 200 mL of chilled (icy) water to the empty stainless steel cup.
10. Weigh the stainless steel cup + water, and record the value.
11. Condition the top half of the wick with the ethanol, by simply removing the top half of the lamp, invert, dip the wick into the ethanol for 15 – 25 seconds, and then return to its original position and firmly rotate closed.

12. Set up the apparatus as shown in Figure 2. Ensure the stainless steel cup is 5 cm above the oil lamp. Use a utility clamp to suspend the digital thermometer in the water. The digital thermometer should not touch the bottom of the cup.

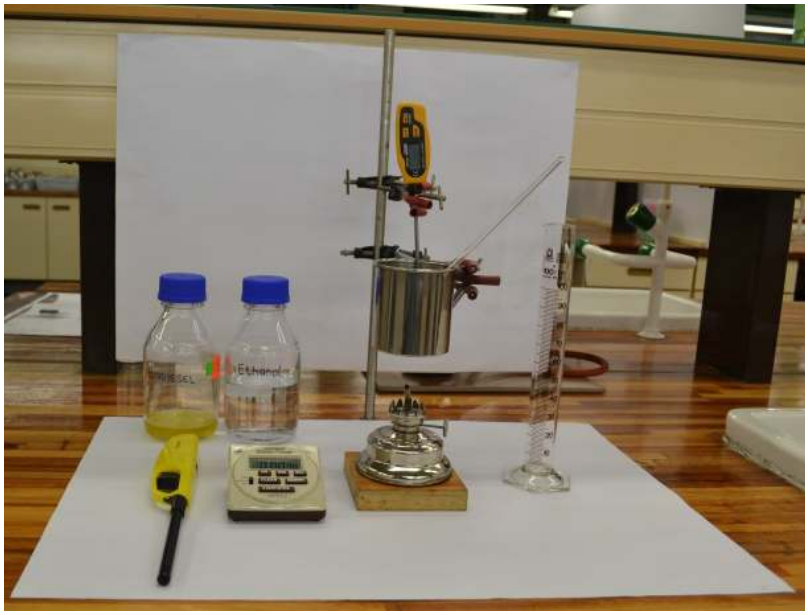


Figure 2

13. Start data collection. Record the initial temperature of the water, t_1, in your data table. Then light the oil lamp. Heat the water in the stainless steel cup until the temperature reaches approximately 30 °C, and then extinguish the flame using a beaker/dowser provided. CAUTION: Keep hair and clothing away from an open flame.
14. Continue stirring the water and record the temperature every 30 seconds until the temperature stops rising. Record the maximum temperature, t_2.
15. Wait 5 – 10 minutes, and then determine and record the final mass of the cooled oil lamp and contents.

Part 2: Biodiesel

1. Repeat Steps 3-15 this time with biodiesel.

Processing the data

1. Find the mass of water heated.
2. Find the change in temperature of the water, Δt.

3. Calculate the heat absorbed by the water, q, using the formula in the introduction of this experiment. For water, C_p is 4.18 J g^{-1} °C^{-1}. Change your final answer to kJ.
4. Find the mass of fuel (ethanol or biodiesel) burned.
5. Calculate the heat of combustion for ethanol and biodiesel, in kJ g^{-1}.
6. Calculate the % efficiency in both trials of the experiment. Divide your experimental value (in kJ g^{-1}) by the accepted value, and multiply the answer by 100. The accepted value for the heat of combustion of ethanol is 30.0 kJ g^{-1}, and for biodiesel it is 41.2 kJ g^{-1}.