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Experiment #3 – Bomb Calorimeter: Heat of Combustion of 1-Butanol

Calorimetry can be used to study the chemical potential energy stored in substances. One of the most important types of reactions studied using calorimetry is combustion, in which a compound reacts completely with excess oxygen. In particular, this lab involves measuring the heat accompanying the combustion of 1-butanol (C_4H_9OH) using a bomb calorimeter at constant volume.

This organic alcohol is placed in a small cup within a sealed vessel called a *bomb*. The bomb, which is designed to withstand high pressures, has an inlet valve for adding oxygen and electrical contacts to initiate the combustion. After the sample has been placed in the bomb, the bomb is sealed and pressurized with oxygen. It is then placed in the calorimeter and covered with an accurately measured quantity of water. When all the components within the calorimeter have come to the same temperature, the combustion reaction is initiated by passing an electrical current through a fine wire that is just above the sample. When the wire gets sufficiently hot, the sample ignites.

Procedure

1. Clean and dry all equipment: bucket, bomb and sample cup.

2. Add 2000 mL of D.I. water to the metal bucket and place it in the calorimeter paying attention to the guides.

3. Attach a 10 cm length of fuse wire to the sample holder terminals. Place the wire through the holes and wrap it once or twice around each terminal.

4. Place the sample cup in the sample holder and adjust the fuse wire loop so that it hangs approximately halfway into the cup.

5. Pipet 1.00 mL of D.I. water into the bottom of the bomb chamber (not into sample cup).

6. Pipet 1.00 mL of 1-butanol into the cup; make sure to perform this after step 5 so that the sample does not evaporate.

7. Place the cup containing the 1-butanol into the bomb and secure the cover a gentle hand-tight.

8. Pressurize the bomb with approximately 20 atm of oxygen gas. <u>Your instructor MUST be present during this portion of the procedure</u>.

9. Place the bomb in the calorimeter, attach the ignition wires to the top of bomb, cover the calorimeter by aligning the pilot hole and screw, and turn on the stirrer.

10. Wait 5 minutes and observe the temperature at 30 second intervals until a constant equilibrium temperature is achieved (4 constant values). Record this temperature.

11. Plug in the wires onto the ignition unit and press the button to ignite your sample.

12. Continue to observe the temperature until a constant equilibrium temperature is achieved. Record this temperature.

13. Carefully remove the cover and place it in the holder.

14. Remove the bomb, equalize the pressure, disassemble and completely dry all parts of the bomb.

15. If successive trials are to be run, add a new 2000 mL supply of D.I. water to the bucket and repeat steps 3–14.

Data and Calculations

Volume of sample _____   Density of sample _____

Initial temperature _____   Final temperature _____

1. Write a balanced equation for the combustion reaction of one mole of 1-butanol.

2. Calculate the mass (in g) of the 1-butanol sample.

3. Calculate the heat of reaction per mole of 1-butanol. ***Our calorimeter constant (Heat Capacity) = 10.3 kJ / °C***

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4. Does question #3 solve for ΔE (internal energy) or ΔH (enthalpy)? Circle your choice and briefly explain.

5. Calculate the **ideal** work per mole of alcohol for the combustion reaction at 1 atm and 25 °C.

6. Give the following values in kJ/mol for $CH_3(CH_2)_2CH_2OH$ at 1 atm and 25°C: Show your work below for full credit.

   $\Delta E =$ _____ $\Delta H =$ _____ $w =$ _____

7. Use literature values of enthalpy of formation to calculate ΔH_{rxn} for the balanced combustion reaction in question #1. Use this as the theoretical value.

8. Calculate a % error for this experiment using ΔH_{rxn} values from problems 6 and 7 above.

9. Why is 1 mL of D.I. water added to the bottom of the bomb chamber?