Experiment 1: Specific Heat of Ethanol

Procedure

CHE 347 TA: Alec Beaton

In this experiment, we will measure the heat capacity of ethanol using a calorimeter.

Introduction

The heat capacity of a substance is the amount of heat required to raise the temperature of that substance by 1°C. It is an extensive property. The corresponding intensive property is the specific heat (or "specific heat capacity"), which is the amount of heat required to raise the temperature of 1 g of that substance by 1°C. The objective of this lab is to measure this intensive property for ethanol.

In order to measure the specific heat of ethanol, we will use the first law of thermodynamics and observe the transfer of heat from an ethanol sample to its surroundings. The surroundings in this case consist of primarily water (whose specific heat is 4.184 $Jg^{-1}°C^{-1}$). By using a familiar equation from general chemistry,

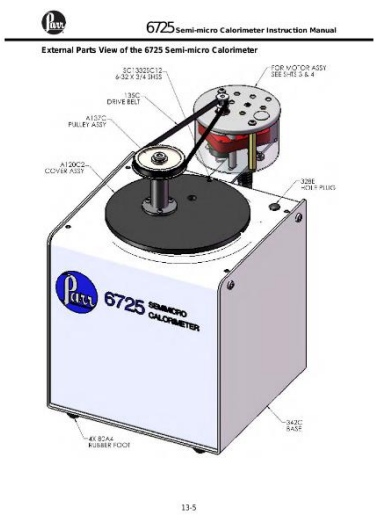
$$Q = m\ C\ \Delta T \quad [1]$$

we can determine the heat, Q in Joules (J), associated with a temperature change, ΔT in°C, of a substance with specific heat capacity C in J $g^{-1}°C^{-1}$ and mass m in g.

A key component of this lab is that a temperature correction of 0.63 must be applied to values obtained from the Parr calorimeter.

You will carry out this measurement a few times and compare against the literature value of 2.460 J $g^{-1}°C^{-1}$. You will also use Dixon's Q-test to identify any outliers in the series of measurements. For more details on Dixon's Q-test, please refer to the original paper by Dean and Dixon (1951), along with the supplemental material provided by the TA.

Objectives



- Apply the first law of thermodynamics to an experiment.

- Calculate heat flow based on change in temperature and heat capacity.

- Employ Dixon's Q-test to identify an outlier.

Equipment

- Parr 6772 Calorimetric Thermometer
- Parr 6755 Solution Calorimeter
    a. Bucket (Dewer)
    b. Lid
    c. Belt
    d. Pulley
    e. Glass stir rod

Procedure

1. Add 90 mL of DI water to the calorimeter bucket
2. Insert stirrer and lid assembly and begin stirring
3. Record the temperature after reading appears to stabilize (about 5 minutes)
4. (While preparing for the lab) Use the literature density of ethanol, 0.789 g/mL, to estimate the volume of ethanol that you will need. (Trial 1: 5 g ethanol, Trial 2: 7 g ethanol, Trial 3: 9 g ethanol)
5. Measure appropriate mass of ethanol into a test tube (Trial 1: 5 g ethanol, Trial 2: 7 g ethanol, Trial 3: 9 g ethanol)
6. Lower ethanol test tube into water bath using a clamp and rod, insert the thermometer into the ethanol
7. Allow the ethanol to reach about 78°C (record the exact final temperature)
8. Turn off stirring on the calorimeter and remove lid

9. Carefully transfer HOT ethanol to calorimeter bucket
10. Replace lid and begin stirring
11. Record the temperature after reading stabilizes
12. Once all values have been recorded, empty bucket into waste container

Repeat all steps for two more trials, varying mass of ethanol as specified in step 4.

Be sure to report the results of your measurements on the blackboard, since the rest of your class section needs this information to complete the post-lab.

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Post-Lab Questions

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Please note (general for this and all future lab reports): The answer to each question must be clearly numbered and include a copy of the original question.

If you chose to write your answers, you must do so very neatly/legibly on non-spiral bound paper.

If you choose to type out your answers, you must use accepted formatting for all units and chemicals – properly utilizing superscripts, subscripts, and Greek letters if they are required.

Reports are due one week from the day that the experimental portion of the lab is performed, at the beginning of the lab period as a **hard copy**. Reports handed in after the beginning of the lab period will be considered 1 day late.

Introductory Information

- What is the difference between specific heat and heat capacity?
- What is ethanol (part of which class of chemical compounds, uses)?
- What equations will you need to turn the values recorded in your lab notebook into the main values (*i.e.*, meaningful physical quantities) that you wish to report?
- What are the main values you are reporting?
- Which of your main values are thermodynamic state functions?

Experimental Details

- Name the chemicals used in this experiment. Provide the names and concentrations of solutions, where applicable.
- Report any additional observations during the course of the experiment.

Results and Discussion

- Present a table of mass of ethanol, mass of water, initial temperature of water, initial temperature of ethanol, and final temperature of water + ethanol mixture for each trial (**include all units for full credit**)
- Show work for calculating the specific heat for at least one trial (**include all units for full credit**)

- Present the specific heat of ethanol found for the trials conducted by **your group**, and calculate the percent error relative to the literature specific heat of ethanol. Is there a large variation in the specific heats across the different trials? Which trial is closest to the literature value, which trial is farthest? Can you offer a possible explanation why this might be?

- Using the specific heat of ethanol found for trials conducted by **your group**, state whether there were any outliers as determined by Dixon's Q-test at the 95% confidence interval.

- Using the specific heat of ethanol found for trials conducted by **your class section**, identify whether there were any outliers as determined by Dixon's Q-test at the 95% confidence interval.

- Calculate the average of the specific heat of ethanol found for trials conducted by **your class section**, and compare this to the literature value. If there were any outliers found in part 5, remove the trials for these outliers and calculate the average of the specific heat of ethanol again. Does this new value compare more favorably to the literature value? If there were not any outliers found in part 5, what does this say about the set of data collected by your class section?

Experiment 1: Specific Heat of Ethanol – Rubric

Student:

Introductory Information (24 pts)

1. (/ 3 pts)
2. (/ 9 pts)
3. (/ 6 pts)
4. (/ 3 pts)
5. (/ 3 pts)

Total: (/ 24 pts)

Experimental Details (12 pts)

1. (/ 6 pts)
2. (/ 6 pts)

Total: (/ 12 pts)

Results and Discussion (64 pts)

1. (/ 18 pts)
2. (/ 18 pts)
3. (/ 7 pts)
4. (/ 7 pts)
5. (/ 7 pts)
6. (/ 7 pts)

Total: (/ 64 pts)

Report Total: (/ 100 pts)

General Comments: