Heat Capacity & Heat of Solution Laboratory

FABE 325 – Dr. Gönül Kaletunç
TA – Kelley Yosick
Winter 2003

I. **Objectives** :

a) To determine the heat capacity of oil and orange juice

b) To measure the heat of solution in the dissolving of sodium hydroxide, ammonium nitrate, and sodium acetate.

II. **Concepts**: Data acquisition with LabVIEW software, Heat content and sensible enthalpy of materials, heat of solution, energy conversion, energy losses.

III. **Method:** The LabVIEW software will be utilized to record the temperature of selected materials heated by an immersion heater as a function of time.

IV. Materials & Equipment:

Water, oil, orange juice

NaOH, NH_4NO_3, $NaCH_3CO_2$

250 ml beakers, immersion heaters, thermocouples, magnetic stirrers, magnetic stir rods, variable voltage transformers

V. Procedure:

<u>All Stations</u>

- Start the LabVIEW software located in C:/Program Files/National Instruments/LabVIEW/325 class/HeatCapacity Lab (or double click on icon on desktop)
- Turn on the magnetic stirrer.
- Turn on the transformer and adjust it to a setting so as to give a power of 135 Watts. Adjust slightly as necessary. Do NOT adjust after the experiment has started.
- Simultaneously start recording the data in LabVIEW and turn on the immersion heater via the transformer. Select a unique file name that you can remember.
- Record the actual power, current, and voltage every 30 seconds.
- After 3 minutes, stop recording the data and turn off the immersion heater.

<u>Precautions:</u>

- Never turn the immersion heater on without immersing it in liquid
- Do not make adjustments when the experiment is on

Special precautions for the station with Oil

- Ensure that the immersion rod is completely dry before inserting into the oil, wipe any water on the immersion rod
- The temperature of oil after the experiment may be high enough to cause burns, hence be very careful in removing the oil after the experiment.

ALL Stations – Heat of Reaction

- Start the LabVIEW software located in C:/Program Files/National Instruments/LabVIEW/325 class/Heat Capacity Lab
- Simultaneously start recording the data in LabVIEW and add the specified chemical for your station (Figure 2) to 120 g of distilled water. Use a stir bar to facilitate mixing.

VI. Calculations:

1) Determine the resistance of the immersion heater.
2) Calculate the energy given by the electrical system (via power, voltage, current measurements).
3) Use MATLAB to plot the Temperature vs. time for the water, oil, and orange juice systems.
4) Use the previous plot to determine the rate of heating for all three systems.
5) Determine the temperatures of the three systems at 30-second intervals over the 3 min period.
6) Calculate the energy received by the water at 30 second intervals over the 3 min period
   a) If the heat capacity of water is assumed to be constant at 4.18 J/g ºC.
   b) Using an average heat capacity calculated from the heat capacities at the initial and final temperatures. (use Figure 1)
   c) Using the mean heat capacity over the temperature range you collected data (use Figure 1)
   d) Which value of heat capacity do you expect to be most accurate?
7) Using the most accurate heat capacity value from part 5 and assuming that the same amount of heat energy is delivered to all of the systems, calculate the heat capacities

of the oil and orange juice at 30 second intervals over the three minute period. Plot the heat capacity of the oil and orange juice as a function of temperature.

8) Calculate the ratio of energy received by the water, oil, and orange juice systems to the electrical energy delivered.
9) What is the error in the enthalpy calculation if the heat capacity of the orange juice is assumed to be equal to that of water?
10) From your heat of solution data, calculate the following for each of the three chemicals used:
    a) The temperature change of the water.
    b) The quantity of heat absorbed (or given off) by the water during the dissolving, given that the heat capacity of water is 4.18 J/(g ºC).
    c) The number of moles of solid used.
    d) The quantity of heat involved per mole of solid dissolved (molar heat of solution).
11) Using the data from Figure 2, calculate the percent error of your experimental heat of solution values.

VII. Report:

You are expected to submit one report for each group. The report must be typed.

Your report will include:

1) Graphs you prepared and Calculations
2) Discuss following points
    a) For the water, oil, and orange juice systems, was the energy delivered by the electrical system equal to the energy received by the fluid? What factors influence the conversion of electric energy to heat energy? What are typical efficiency values for conversion of electric energy to heat?
    b) Make recommendations to improve the design of the systems to make more accurate temperature measurements.
    c) Heat capacity of oil and orange juice as a function of temperature

A.2-5 Heat Capacity of Liquid Water at 101.325 kPa (1 Atm)

Temperature		Heat Capacity, c_p		Temperature		Heat Capacity, c_p	
°C	K	cal/g · °C	kJ/kg · K	°C	K	cal/g · °C	kJ/kg · K
0	273.15	1.0080	4.220	50	323.15	0.9992	4.183
10	283.15	1.0019	4.195	60	333.15	1.0001	4.187
20	293.15	0.9995	4.185	70	343.15	1.0013	4.192
25	298.15	0.9989	4.182	80	353.15	1.0029	4.199
30	303.15	0.9987	4.181	90	363.15	1.0050	4.208
40	313.15	0.9987	4.181	100	373.15	1.0076	4.219

Source: N. S. Osborne, H. F. Stimson, and D. C. Ginnings, *Bur. Standards J. Res.*, **23**, 197 (1939).

Figure 1: Heat Capacity of Water

Chemical	**Heat of Solution (kcal/gmole)**	Amount used in experiment (grams)
Ammonium Nitrate, NH_4NO_3	-6.47	15
Sodium Acetate, $NaC_2H_3O_2$	4.085	15
Sodium Hydroxide, NaOH	10.18	10

Figure 2: Heat of Solution and amount to be used for each chemical

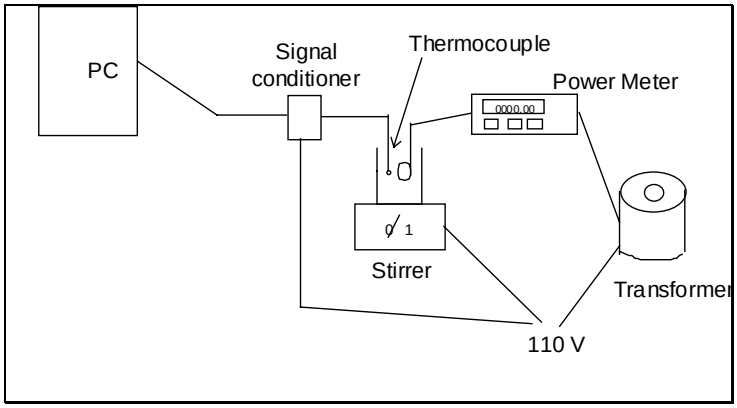

Figure 3: Schematic for the experimental setup

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FABE 325 WI03
Lab Groups and Projects for Lab 2

Lab: 9am –9:50am	***Group 1*** ***Water & Ammonium Nitrate***	Ryan Gierhart Hadi Gani Brian Henslee
	Group 2 ***Orange juice & Sodium Acetate***	Jacob Preston Eric Neer Chitra Kusnadi
	Group 3 ***Oil & Sodium Hydroxide***	Issac Schroeder Susan Martin Cole Sanford
Lab:11:00am – 11:50am	***Group 4*** ***Water & Ammonium Nitrate***	Brian Moeller Alex King Michael Podrosky
	Group 5 ***Orange juice & Sodium Acetate***	Erik Gracly Molly Heller Megan Clary Nicholas Bucurel
	Group 6 ***Oil & Sodium Hydroxide***	Clayton Bettin Ethan Schneider Scott Smith Julia Valigore