HEAT OF SOLUTION

(Last Revision: August 30, 2022)

- ABSTRACT:

A modification of the text procedure is used to determine the heat of solution of KNO_3 in water. A computer is used both to control and record the data from the heat of solution calorimeter.

- TEXT REFERENCE:

  "Experiments in Physical Chemistry", Garland et al., Eighth Ed., McGraw-Hill, 2009, pp.167-171.

- GENERAL DESCRIPTION AND THEORY:

The heat of solution of a salt in water may be determined by dissolving a known amount of the salt in a known amount of water in a calorimeter. If the heat capacity of the calorimeter and contents are known the heat of solution can be determined from the temperature change. A similar experiment is described in the lab text and the differences in procedure will be described in these notes.

- EQUIPMENT:

Dewar flask calorimeter with heater, thermistor, stirrer and connector block (Figure 1). Powerpak with circuit block containing the circuit for the thermistor bridge (Figure 2). Separate power supplies for the stirrer and the heater (Figure 3). Data acquisition module and computer running LabView program with the vi program, heatsol.vi . Stop watch.

- PROGRAMS:

LabView program running heatsol.vi.

- CHEMICALS:

KNO_3

- DIAGRAMS:

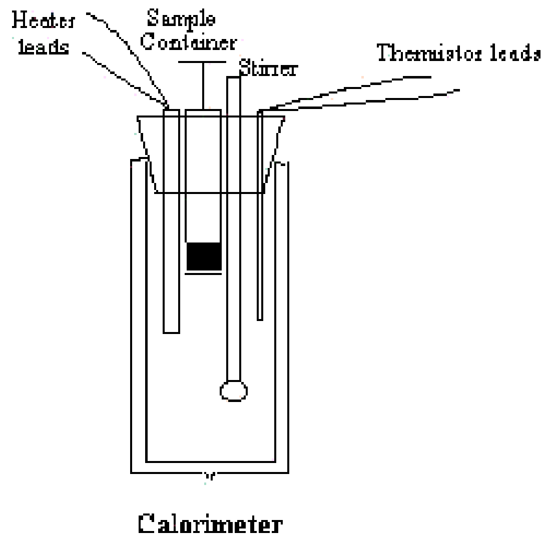

Figure 1.

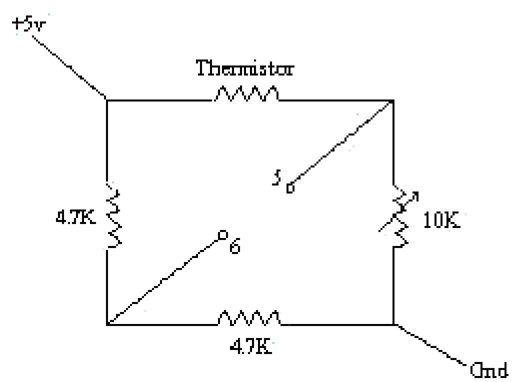

Figure 2.

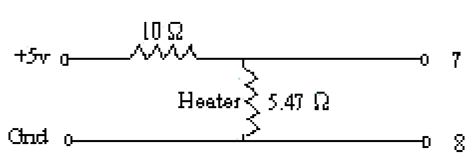

Figure 3.

- LABORATORY PROCEDURE:

The procedure is similar to that described in the text with some exceptions. The calorimeter should contain 180 ml of distilled water. The water should be brought to 25°C in a thermostat before use. Samples of 0.5 to 0.8 g of KNO_3 should be weighed into the sample holder, which is a plastic syringe with a neoprene plug in the end. First make sure the circuits are connected correctly according to the diagrams. The power for the heater is obtained from a power pack which is connected to the wiring board. The power for the thermistor circuit is obtained from a separate power pack.

Assemble the apparatus and turn on the stirrer. Allow the stirring to continue for several minutes. Then adjust the potentiometer on the circuit board so that zero volts are being produced by the bridge circuit. Then start the program, heatsol.vi, simultaneously with starting the stopwatch. The experiment will consist of one (very long) run. Allow the program to acquire data for five minutes. At the end of the five minute period, turn on the heater for five minutes. Then turn off the heater and allow the program to acquire data for another five minute period. Then inject the first sample. Allow five minutes for equilibration, the turn on the heater for a five minute period. Repeat the above process until all of the samples have been injected into the solution, each bracketed by a heating cycle followed by a rest cycle.

- CALCULATIONS:

The temperature changes for the heating and sample reaction are obtained from the data recorded by the program. Import the data into Excel and do a linear regression on the before and after temperature- time curves. (The temperature will be listed in volts.) The heat capacity of the calorimeter can be determined by dividing the energy introduced by the temperature change introduced in v, (J/v). The heat of solution for the sample is then found by multiplying the heat capacity by the temperature change caused by the sample dissolving in the water. The temperature change may be found from the regression equations evaluated at the mid-point of the heating or reaction. The energy is equal to the heater's power supply voltage across the heater squared divided by the resistance of the heater multiplied by the time duration of the heating cycle.

The heat of solution per mole is then found by dividing the total heat energy produced or absorbed (by all of the samples that are in the solution) by the number of moles of sample (all that are in the solution.) The heat of solution should then be plotted versus the square root of the molal concentration to find the heat of solution at infinite dilution. The differential heat of solution may be found by using :

$$\Delta H_{diff} = \Delta H_{int} + \frac{m^{\frac{1}{2}}}{2} \frac{d\Delta H_{int}}{dm^{\frac{1}{2}}}$$

- LITERATURE VALUES: ΔH at infinite dilution for KNO_3 is 35.77 kJ mol^{-1}.