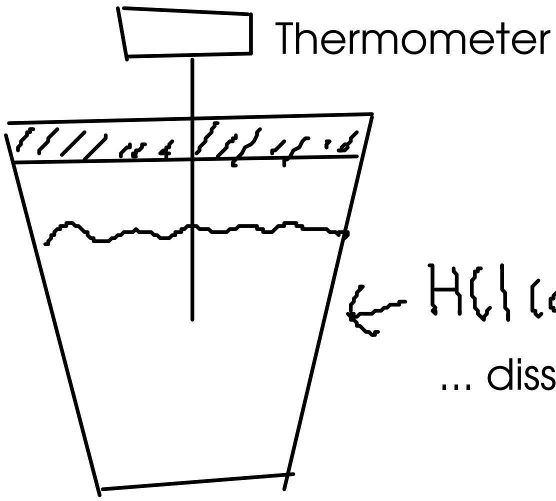
CHM 110 - Experiment 6 Notes

Today's experimental setup looks like this:



← $HCl(aq) + NaOH(aq) \rightarrow H_2O(l) + NaCl(aq)$

... dissolved in about 100 mL of water.

The SYSTEM is considered to be the chemicals directly involved in the reaction - hydrochloric acid, sodium hydroxide, the water made by the reaction itself, and the sodium chloride.

The SURROUNDINGS is everything else, but we will focus on: (1) The water in the cup that was there prior to the reaction (it comes with the hydrochloric acid and sodium hydroxide solutions) and (2) The cup itself.

By the principle of CONSERVATION OF ENERGY, we know that the heat released by the reaction has to be equal to the heat absorbed by the cup and water:

$$q_{rxn} + q_{cup} + q_{water} = 0 \quad \text{(EQUATION 1)}$$

... where qrxn = the energy change of the reaction
qcup = the energy change of the cup

Why are we adding them together? Heat has a DIRECTION. By convention, energy flowing into a system is given a POSITIVE sign, and energy flowing out is given a NEGATIVE sign. Since we observe the cup heating up when the reaction occurs, the sign of qrxn is negative (heat is lost by the reaction). The sign of qcup and qwater are both positive; they absorb the energy given off by the reaction.

The goal of today's experiment is to determine qrxn, and express it in terms of energy change per mole reactant (we'll call this ΔH_r). To do THAT, we'll need to determine all of the other terms in EQUATION 1 above. How? The heat transfer characteristics of the cup and water are already known.

For the WATER, we use SPECIFIC HEAT - the measured energy change needed to change the temperature of a certain amount of substance by a degree. For water, the specific heat is:

$$4.184 \frac{J}{g^\circ C}$$

Find the qwater by taking the specific heat and multiplying it by the MASS OF THE WATER and the MEASURED TEMPERATURE CHANGE of the water:

$$q_{water} = \left(4.184 \, J/g^\circ C\right) \times Mass_{water} \times (t_f - t_i) \quad \text{(EQUATION 2)}$$

... where tf and ti are the final and initial temperatures of the water. Mass here is in grams, and temperatures are in degrees Celsius

For the CUP, the HEAT CAPACITY of the cup is knows. HEAT CAPACITY is the energy change needed to change the temperature of an object by a degree.

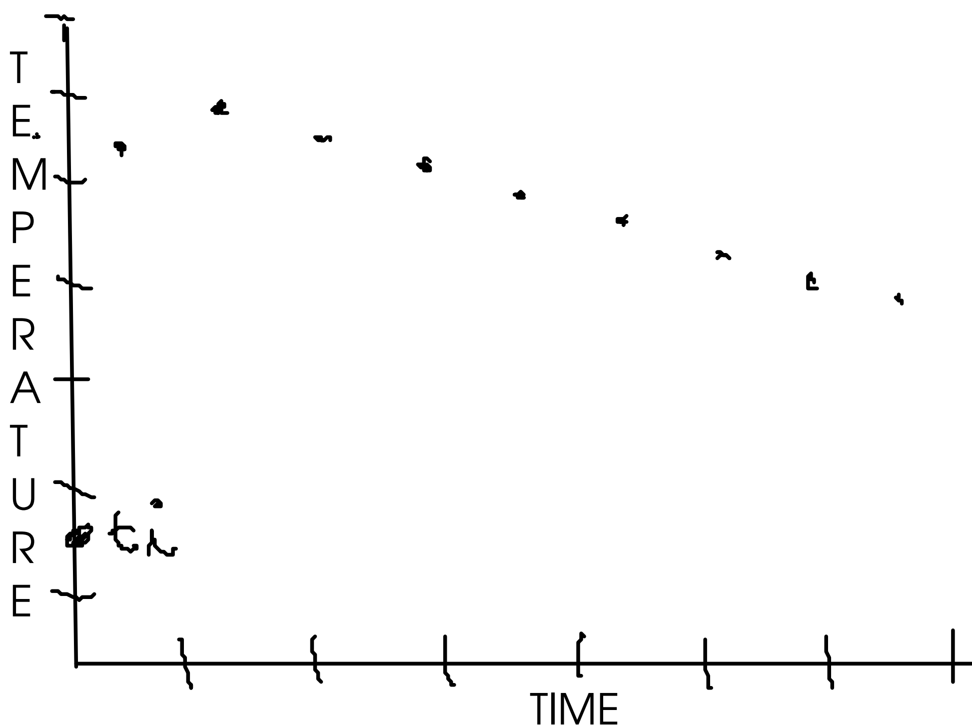
$$q_{cup} = \left(10. \frac{J}{^\circ C}\right) \times (t_f - t_i) \quad \text{(EQUATION 3)}$$

Substitute EQUATIONS 2 and 3 into EQUATION 1, then solve EQUATION 1 for qrxn. To find ΔH_r, divide this number by the number of moles of limiting reactant. Since you're using stoichiometric amounts of reactants, the moles of either reactant will do.

Finding tf:

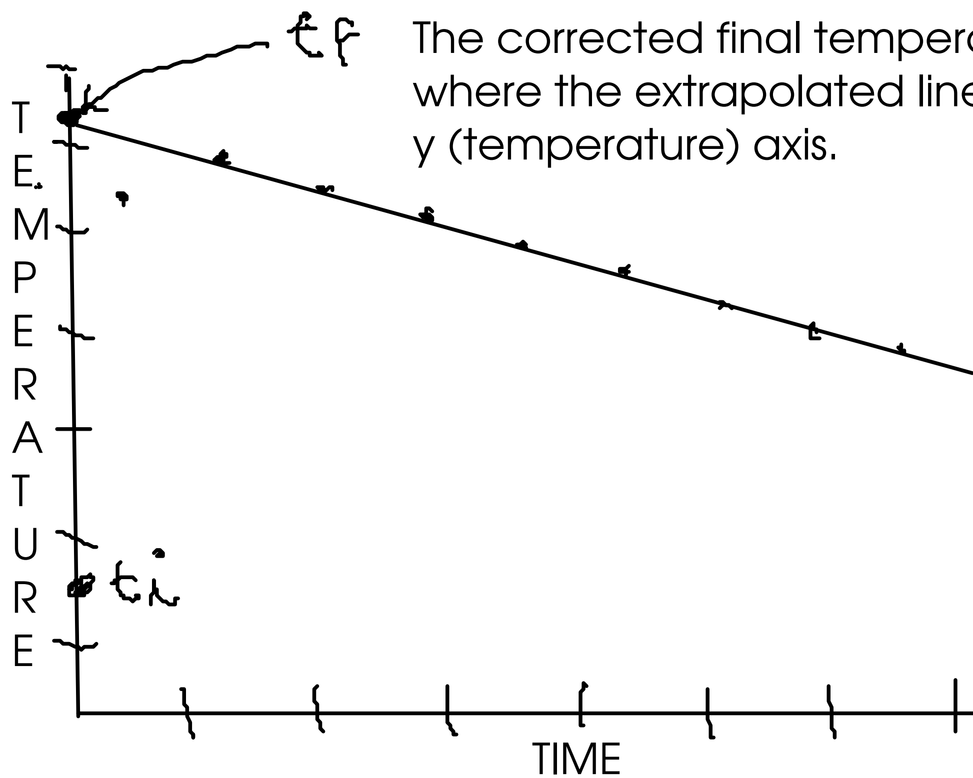
One difficulty in today's lab is finding the final temperature. Our caclulations assume that no energy is lost to the environment - that our cup is PERFECTLY insulated. Unfortunately, that's not true. Once our cup is above room temperature, it will continually lose heat to the environment. The fact that the cup is insulated slows, but does not stop, the heat loss.

If we plot the temperature of the cup vs. time, it looks like this



Notice that the temperature change over time (after the initial rise from ti) is LINEAR.

So, to correct the final temperature for heat loss, record temperature data in your cup over time, plot the data as shown on the previous page, then EXTRAPOLATE back to zero time.



The corrected final temperature is the temperature where the extrapolated line crosses the y (temperature) axis.

For more information, see pages 491-493 in your lab manual, and section 6.6 in the textbook