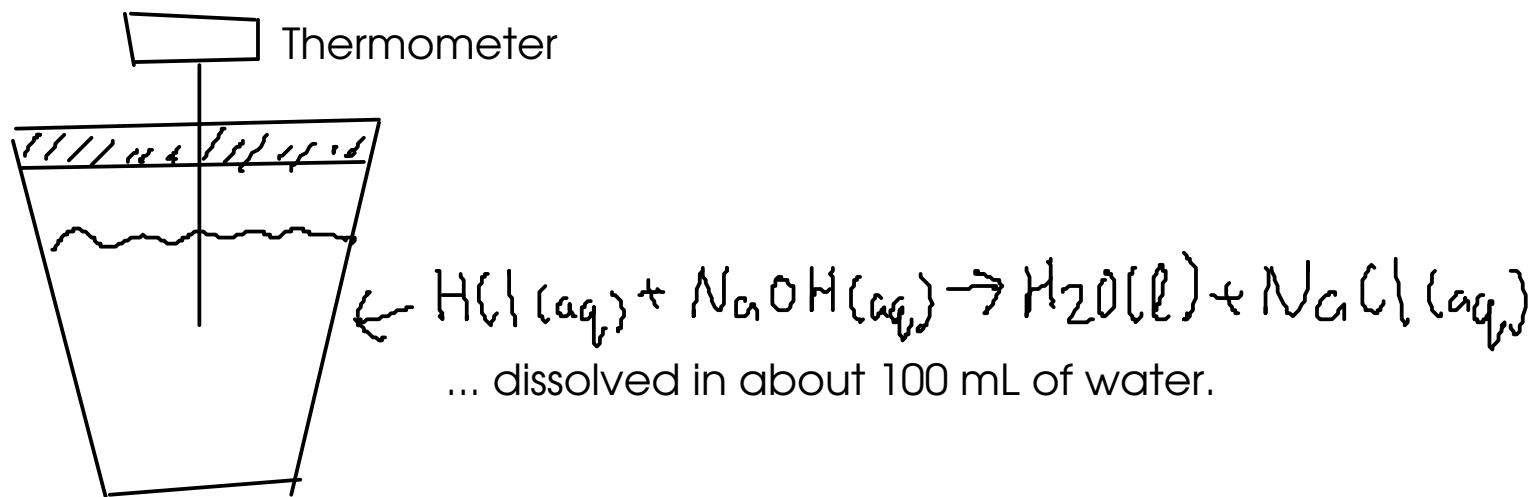


Today's experimental setup looks like this:



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  $q_{rxn}$  = the energy change of the reaction  
 $q_{cup}$  = 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  $q_{rxn}$  is negative (heat is lost by the reaction). The sign of  $q_{cup}$  and  $q_{water}$  are both positive; they absorb the energy given off by the reaction.

The goal of today's experiment is to determine  $q_{rxn}$ , and express it in terms of energy change per mole reactant (we'll call this  $\Delta H_r$ ). 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:

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

Find the  $q_{\text{water}}$  by taking the specific heat and multiplying it by the MASS OF THE WATER and the MEASURED TEMPERATURE CHANGE of the water:

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

... where  $t_f$  and  $t_i$  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 known. HEAT CAPACITY is the energy change needed to change the temperature of an object by a degree.

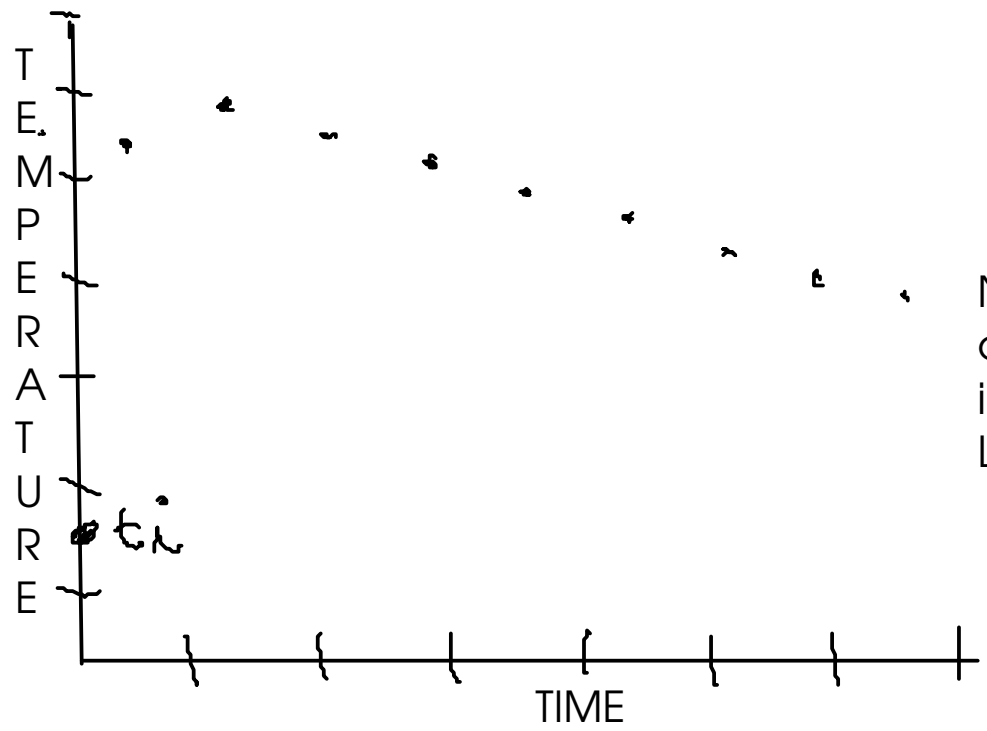
$$q_{\text{cup}} = \left( 10 \frac{\text{J}}{^\circ\text{C}} \right) \times (t_f - t_i) \quad (\text{EQUATION 3})$$

Substitute EQUATIONS 2 and 3 into EQUATION 1, then solve EQUATION 1 for  $q_{\text{rxn}}$ . To find  $\Delta H_r$ , 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  $t_f$ :

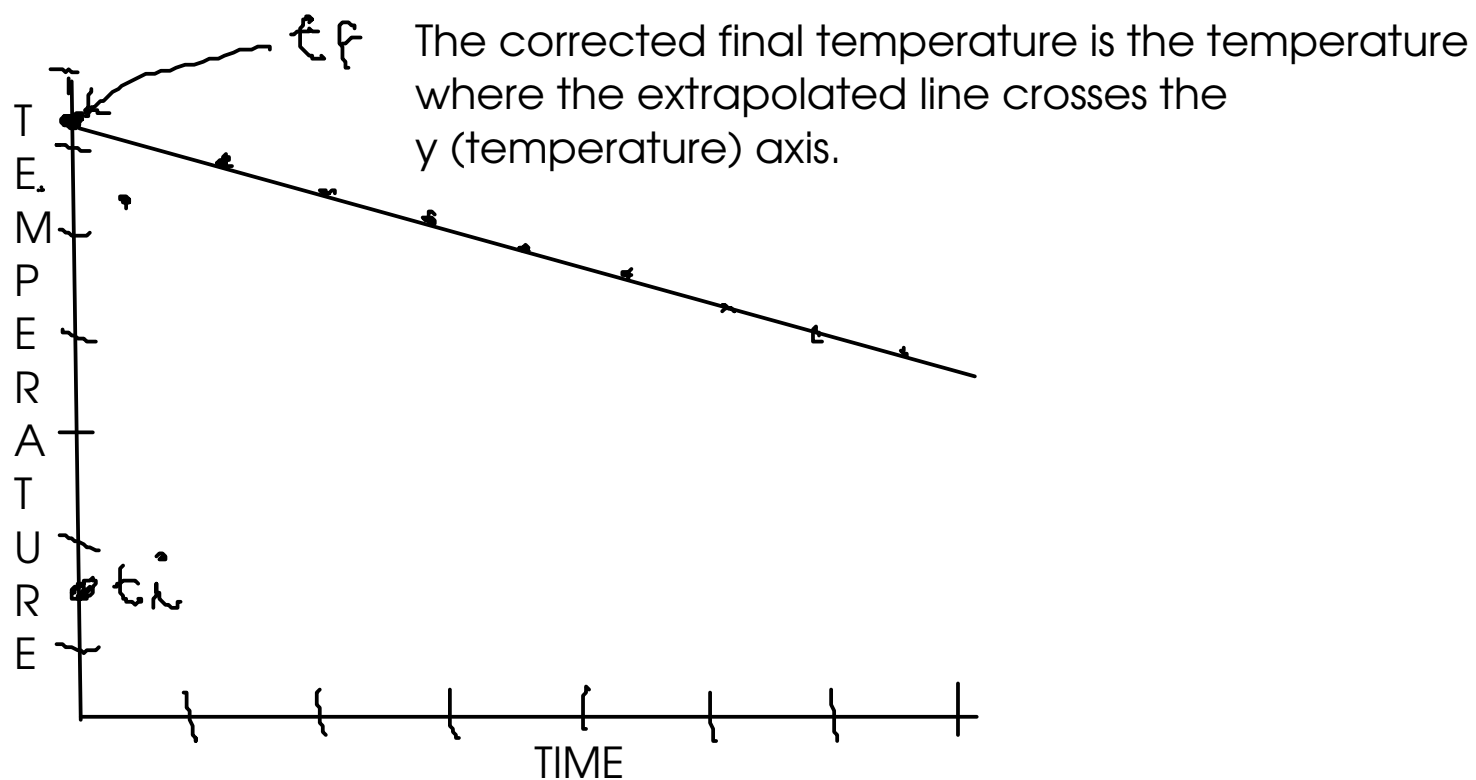
One difficulty in today's lab is finding the final temperature. Our calculations assume that no energy is lost to the environment - that our cup is PERFECTLY insulated. Unfortunately, that's not true. Once our cup is above room temperature, it will continually lose heat to the environment. The fact that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



For more information, see pages 486-488 in your lab manual, and section 6.6 in the textbook