Week 3: Calorimetry Lab

This week we will be performing calorimetry experiments in order to determine ΔH_{rxn} for:

(a) $H^+ + OH^- \rightleftharpoons H_2O$ (strong acid-base)

(b) $CH_3COOH + OH^- \rightleftharpoons CH_3COO^- + H_2O$ (weak acid-base)

(c) $2Fe^{3+} + Sn^{2+} \rightleftharpoons 2Fe^{2+} + Sn^{4+}$ (redox)

We will do this by measuring heat exchange with the surroundings. Recall at constant pressure

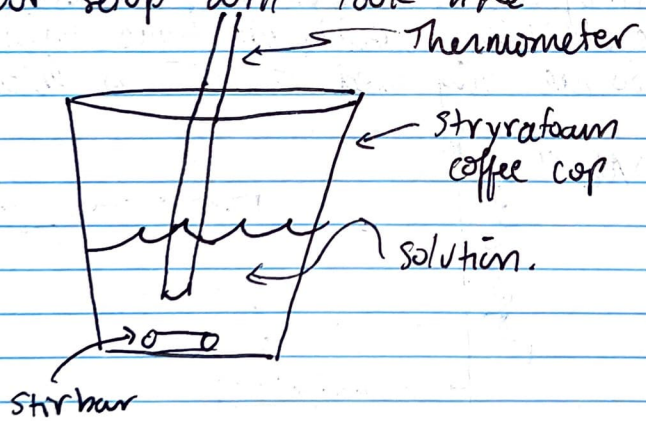
$$\Delta H = q_{sys}$$

and in general that

$$q_{sys} = -q_{surr}$$

$$q_{sys} = mC_s\Delta T$$

Our setup will look like



The thermometer measures temperature of the bath + coffee cup, hence q_{surr} in the rxns above. Hence

$$\Delta H_{rxn} = q_{sys} = -\left[mC_{sr} + m_c C_{sc}\right]\Delta T$$

where m_r is mass of solution, C_{sr} is specific heat capacity of solution, and $m_c C_{sc}$ is the calorimetry constant (specific to setup). We will first determine $m_c C_{sc}$ experimentally.

We do this by adding cold water (at T_{cold}) to room temperature water in the coffee cup (at T_{RT}). Upon equilibration, the entire system will reach a final temperature T_f. Then we know

$$q_{cold} = -q_{bath}$$

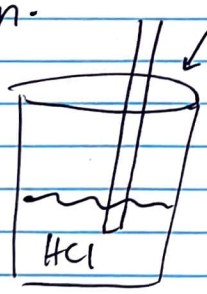
Hence, $$m_{cold} C_s (T_f - T_{cold}) = -[m_{RT} C_s + m_c C_{cs}](T_f - T_{RT})$$

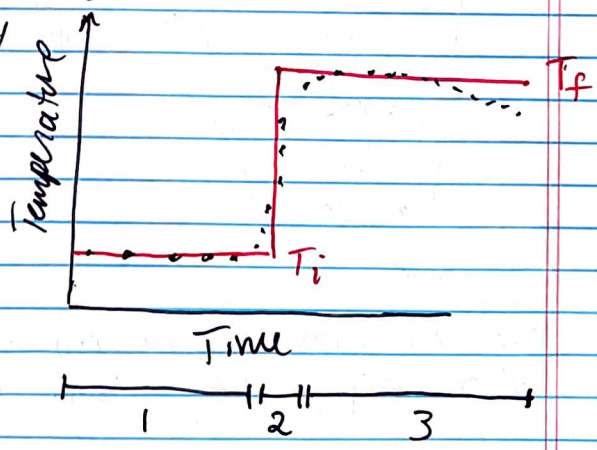
We know C_s for water is 1 calorie or $4.18 \frac{J}{g \cdot K}$

Hence we can solve for $m_c C_{cs}$ as:

$$C_{sc} M_c = \left(4.184 \frac{J}{g \cdot K}\right)\left[\frac{m_{cold}(T_f - T_{cold})}{(T_{bath} - T_f)} - m_{bath}\right]$$

Returning to $-\Delta H_{rxn} = q_{surr} = [m_r C_{sr} + m_c C_{sc}]\Delta T$ we can approximate C_{sr} as 4.184 J/g·K since these will be fairly dilute reactions. M_r comes from the density of the solution which we have tabulated in the Manual. So we only need T_i & T_f to determine ΔH_{rxn}.





1) Add 1st reagent and measure T_i
2) Add 2nd reagent and measure temperature
3) Continue to measure T_f

Taking plateaus in Temp vs time graph gives us T_i & T_f.

§ Safety:

1) Working with acid/bases hence proper PPE is a must. Gloves, goggles always on. Of course long pants, closed toe shoes, and t-shirt (long sleeve best).

2) Don't put acetone in coffee cup. This is how you dissolve styrofoam.

3) Don't hit thermometer with stirbar, could break it.

§ Waste/Cleaning

1) All acid waste → Acid reaction waste bottle
2) All base waste → Base Reaction waste bottle
3) All Fe^{2+}, Sn^{2+} s/n → Redox reaction waste bottle
4) After redox rxn, a yellow precipitate forms. Soak/clean styrofoam with tap water until clean?