Experiment 3: Enthalpy of Reaction

Procedure

CHE 347 TA: Alec Beaton

Introduction

In this experiment, we will measure the enthalpy change for three different reactions and use these values to determine the enthalpies of protonation and deprotonation of glycine. Please refer to the journal article by Ramette (1984) available to you on blackboard for literature values as well as additional context on this experiment. You will also be provided with a jupyter notebook for further data analysis.

Note: An announcement will be posted when the jupyter notebook becomes available as some details regarding the lab are being worked out.

Objectives

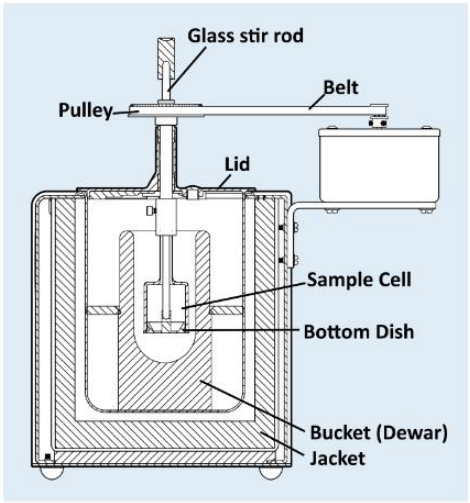
- Apply Hess's Law to determine reaction enthalpies from experimental data

- Effect of weak acids on thermodynamic data

- Role of ionic strength in solution calorimetry

Equipment:

- Parr 6772 Calorimetric Thermometer
- Parr 6755 Solution Calorimeter
  - Bucket (Dewer)
  - Lid
  - Belt
  - Pulley
  - Sample Cell (130C)
  - Bottom Dish (126C)
  - Glass stir rod



6755 Calorimeter Cross Section


130C Sample Cell with 126C Bottom Dish

Materials

- Glycine
- 0.3 M Sodium Chloride (NaCl *(aq)*)
- 0.3 M Hydrochloric Acid (HCl *(aq)*)
- 0.3 M Sodium Hydroxide (NaOH *(aq)*)

Procedure:

Reaction I: Dissolution of glycine in NaCl solution

$$\mathrm{HGly}_{(s)} \rightarrow \mathrm{HGly}_{(aq)}$$

Fill dewar with 100 mL of 0.3 M NaCl solution. Place dewar inside jacket of calorimeter. Measure out 1.5 g of glycine onto rubber bottom of solution cell (place weigh paper between rubber and tray of balance to avoid contamination). Record exact mass in lab notebook.

Move rubber bottom of sample cell to a flat surface and carefully press glass reaction vessel onto rubber bottom. Attach sample cell to pulley/stirrer of calorimeter.

Carefully place glass reaction vessel into Dewar. Attach rubber belt to motor and pulley. Set stir to low. Once system has reached equilibrium, record initial temperature in lab notebook.

Push the stir rod down completely to punch out the rubber bottom and initiate the dissolution reaction. Once system has reached equilibrium, record final temperature in lab notebook.

Stop stirring. Empty waste into designated containers. Thoroughly rinse all components with deionized water and dry with paper towels.

Reaction II. HCl and glycine

$$H_3O^+_{(aq)} + \mathrm{HGly}_{(\mathrm{aq})} \rightarrow H_2O_{(l)} + H_2\mathrm{Gly}^+_{(aq)}$$

Repeat procedure above with 0.3 M HCl solution.

Reaction III. NaOH and glycine

$$\mathrm{OH}^-_{(aq)} + \mathrm{HGly}_{(aq)} \rightarrow H_2O_{(l)} + \mathrm{Gly}^-_{(aq)}$$

Repeat procedure above with 0.3 M NaOH solution.

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Post-Lab

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Introductory Information

1. What is a calorimeter?

2. Provide some background information on glycine:

   - What is glycine?
   - Where is it naturally found?
   - Why is it important to study? (hint: does it have medicinal or therapeutic uses, and if so what are they?)

3. What equations will you need to turn the values recorded in your lab notebook into the main values (*i.e.*, meaningful physical quantities) that you wish to report?

4. What are the main values you are reporting?

5. Which of your main values are thermodynamic state functions?

Experimental Details

1. Name the chemicals used in this experiment. Provide the names and concentrations of solutions.

2. Report any additional observations during the course of the experiment.

Results

1. Based on the data collected in lab, report the following results in a formatted table (**must include units**):

   - Heats for each reaction (acidic, neutral, basic) (Q)
     ***Note*:** The heat capacity of the calorimeter and aqueous solutions (C_p) is 506.6198 J/K)
   - Enthalpies for each reaction (acidic, neutral, basic) (ΔH)

2. Report results in a separate formatted table (**must include units**):

   - Enthalpy of protonation of glycine (experimental)
   - Enthalpy of protonation of glycine (literature)
   - Enthalpy of deprotonation of glycine (experimental)
   - Enthalpy of deprotonation of glycine (literature)
   - Percent error comparison between experimental and literature values

3. Noting that the pKa of H_2Gly^+ is 2.3503, determine the fraction of Glycine that is protonated when it is mixed with 0.3 M HCl

4. Show work for determining the value for the enthalpy of protonation of glycine.

   - Be sure to reference the relevant equations, and note that you must account for the incomplete protonation of glycine (see Ramette reference for further details).

5. In a similar fashion, describe how you arrived at the value for the enthalpy of deprotonation of glycine.

Discussion

1. How do your experimental results compare to literature? Which factors may have most contributed to any difference between the two?

2. We were interested in the enthalpy of protonation and deprotonation of glycine. Why was it not enough to monitor the temperature change/heat transfer of glycine in HCl and glycine in NaOH? In other words, what is the point of measuring the temperature change/heat transfer of glycine in NaCl?

3. If we had neglected the incomplete protonation of glycine, how would this have affected our results?

Extra Credit

1. Use the jupyter notebook to plot the thermograms (temperature *vs.* time) for all three solutions and include the .png files in your post lab.
2. Repeat steps 1 and 2 of the Results section using the ΔT determined by the fits in the jupyter notebook in the step above (step 1 of Extra Credit).
3. Is there better agreement to the literature values using the ΔT determine by the fits in the jupyter notebook, compared to the percent error you determined using the numbers you read off the instrument during the lab section?

Experiment 3: Enthalpy of Reaction – Rubric

Student:

Introductory Information (24 pts)

1. (/3 pts)
2. (/9 pts)
3. (/6 pts)
4. (/3 pts)
5. (/3 pts)

Total: (/ 24 pts)

Experimental Details (12 pts)

1. (/6 pts)
2. (/6 pts)

Total: (/ 12 pts)

Results (34 pts)

1. (/9 pts)
2. (/10 pts)
3. (/5 pts)
4. (/5 pts)
5. (/5 pts)

Total: (/ 34 pts)

Discussion (30 pts)

1. (/10 pts)
2. (/10 pts)
3. (/10 pts)

Total: (/ 30 pts)

Report Total: (/ 100 pts)

Extra Credit

1. (/5 pts)
2. (/5 pts)
3. (/5 pts)

Total: (/ 15 pts)

General Comments: