Lab#2:Enthalpy of Various Reactions

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Introduction

The main goal of this experiment was to create a product that could cool our solution by 5°C. To do this we used Hess's Law, which states that if you convert reactants into products, the overall enthalpy change will be exactly the same whether you do it in one step or multiple steps. To put it in simpler words, what is being said is that the heat of a reaction is the sum of the heat of all reactions used to get from the reactants to the products. However the reaction takes many steps, ultimately the overall enthalpy change will be the same, because the positions of reactants and products on an enthalpy diagram will always be the same. Heat or enthalpy of a solution is referred to as the energy released or absorbed when the solute dissolves in the solvent. Molar heat or enthalpy of solution is the energy released or absorbed per mole of solute being dissolved in solvent. There are two types of reactions that can take place: endothermic and exothermic.

If heat is absorbed when the solute dissolves, the temperature of solution decreases, therefore the reaction is endothermic, and ΔH is positive.

solute + solvent → solution $\Delta H_{soln} = +$

If heat is released when the solute dissolves, the temperature of solution increases, therefore the reaction is exothermic, and ΔH is negative.

solute + solvent → solution $\Delta H_{soln} = -$

The reaction type observed during this experiment is an endothermic reaction because the liquid surrounding the soft drink can is getting colder (losing heat), as is the aluminum can.

To calculate the amount of energy (heat) released or absorbed you use the equation → $Q = mc\Delta T$, where Q = amount of energy released or absorbed, m = mass, c = specific heat capacity, and ΔT = change in temperature (using difference between initial and final temperature)

Then using the amount of heat (released/absorbed), you can calculate the enthalpy of solution (heat of solution) by first calculating the moles of the solute (n), then the amount of energy (heat) released/absorbed per mole of solute (ΔH_{soln}) →

1. $n = m \div M$ where, n = moles of solute, m = mass of solute, M = molar mass of solute)
2. $\Delta H_{soln} = q \div n$ where, ΔH_{soln} = molar enthalpy (heat) of solution, q = amount of energy (heat) released/absorbed, n = moles of solute

This experiment required us to use a styrofoam calorimeter, which included a soft drink aluminum can inside. Styrofoam is well known as a good insulator, and in the experiment it is used to demonstrate that the only energy being absorbed by the reaction is from the water in the cup and not the surrounding environment.

When is came to using aqueous ammonium chloride or aqueous ammonium nitrate, the chloride was used because when calculating the enthalpies of both crystals, the ammonium chloride had a lower ΔH. We know that if the ΔH of a reaction is high, there is also a higher chance of an explosion taking place (due to heat difference). Also, in general it was safer to use ammonium chloride since aqueous ammonium nitrate is toxic and it is used in explosives and because ammonium chloride since it is commonly used in agriculture, as a flavouring agent and in medications to regulate the pH levels in urine.

These key concepts and equations were helpful in setting up a successful result of this experiment.

Materials

1. Styrofoam calorimeter
2. Thermometer
3. LabQuest 2
4. Tin can
5. Water
6. Graduated cylinder
7. Electrical scale
8. USB flash drive.

Procedure

1. Turn LabQuest 2 on and set it up by connecting the thermometer to system.
2. Use a graduated cylinder to measure 100g of water for the aluminum can and 100g of water for the calorimeter.
3. Place thermometer through the styrofoam calorimeter and into aluminum can to measure initial temp as it starts to become more levelled and steady. Remove thermometer after recording the initial temperature.

4. Weigh the calculated mass of ammonium chloride on scale and place it into 100g of water to dissolve in the calorimeter. Make sure all ammonium chloride is dissolved by stirring the aqueous solution.
5. Place the lid on calorimeter while having the thermometer through the styrofoam lid and into can to measure the temp of water inside the can. Observe the reaction for 300 seconds and record the final temperature.
6. Save data from LabQuest 2 onto a USB.
7. Repeat steps 2-6, increasing the ammonium chloride in increments of 1g. Continue this process the desired temperature is reached.
8. Turn off LabQuest 2 system and clean up station.

Observations

Trial Number	Mass of ammonium chloride (g)	Initial temperature (°C)	Final Temperature (°C)	Temperature change (°C)
Trial 1	13.25 g	23.8°C	18.8°C	5.0°C
Trial 2	13.75 g	23.5°C	18.9°C	4.6°C
Trial 3 (ignored)	14.23 g	23.8°C	19.4°C	4.4°C
Trial 4	15.25 g	23.7°C	18.4°C	5.3 °C

Average temperature change = (5.0°C + 4.6°C + 4.4°C + 5.3 °C)/4
= 4.825 °C

Calculations

$q_{H2O}= mc\Delta T$
$q_{H2O}= (200g)(4.18J/g°C)(5°C)$
$q_{H2O}=4180\ J$
$q_{H2O}=4.180\ KJ$

$q_{Al}= mc\Delta T$
$q_{Al}=(7.76g)(4.18J/g°C)(5°C)$
$q_{Al}=34.9976\ J$
$q_{Al}=35.00\ J$
$q_{Al}=0.035\ KJ$

$q_S= q_w + q_{Al}$
$q_S= 4.180\ KJ + 0.035\ KJ$
$q_S= 4.215\ KJ$
$\Delta H_{Sol}=17\ KJ/mol$

$q_S= 4.215\ KJ$
$\Delta H_{Sol}= q_S/n_{NH4Cl}$

$n_{NH4Cl}= 4.216\ KJ/(17\ KJ/mol)$
$n_{NH4Cl}= 0.248\ mol$

n_{NH4Cl}= 0.248 mol
M_{NH4Cl}=53.49 g/mol
m_{NH4Cl}= ?
m_{NH4Cl}= n x M
m_{NH4Cl}= (0.248 mol)(53.49 g/mol)
m_{NH4Cl}= 13.23 g

q_T= $(C_{water} \cdot m_{water} \cdot \Delta T) + (C_{Al} \cdot m_{can} \cdot \Delta T)$
q_T= $((4.18 J \cdot k^{-1} \cdot g^{-1}) \times (200g) \times (5°C)) + ((0.90 J \cdot k^{-1} \cdot g^{-1}) \times (7.76g) \times (5°C))$
q_T= 4214.92 J
q_T= 4.124.92 KJ

$c = Q_{total} \div \Delta H_{sol}(NH_4Cl)$
= 4214.92 J ÷ 17 kJ/mol
= 0.2479mol

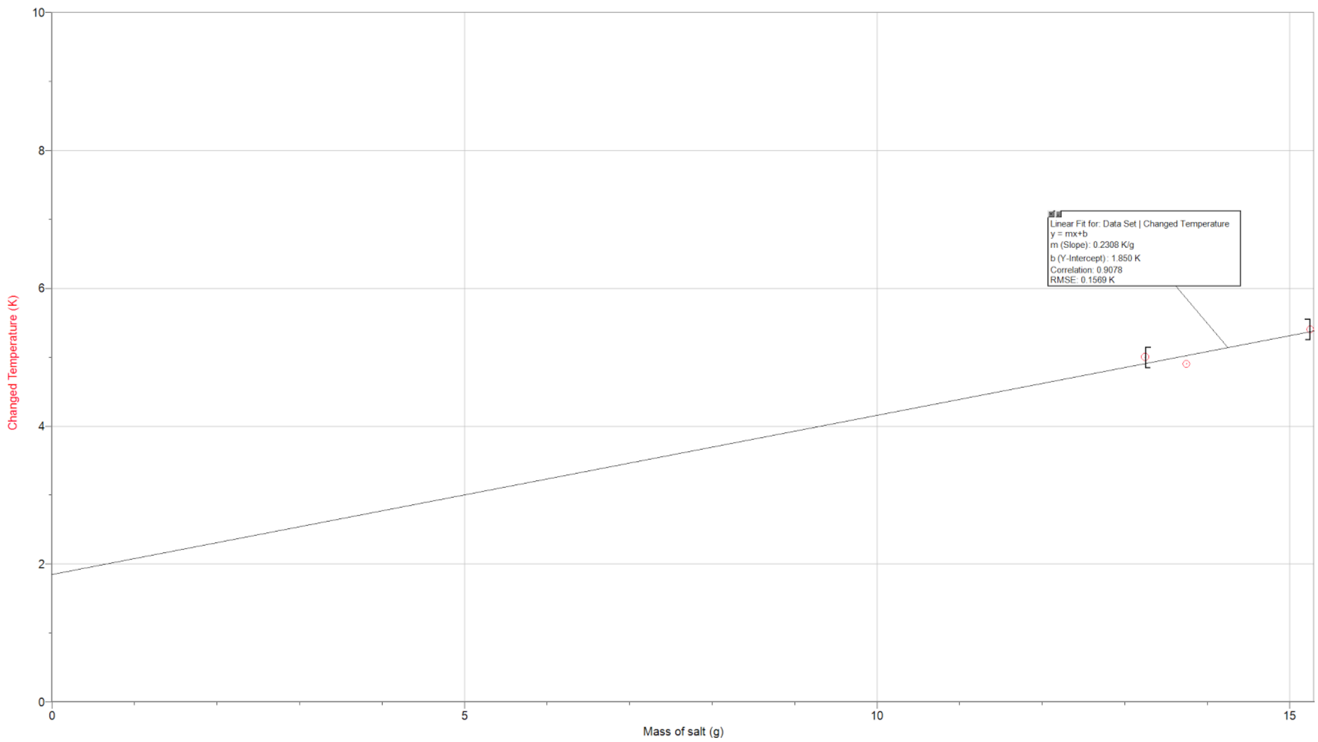
$m = c \cdot M(NH_4Cl)$
= 0.2479mol × 53.49 g/mol
= 13.26g

%error= [experimental value - theoretical value] / theoretical value x 100%

= 5-5/5 x100%

= 0%

Graph 1. Data Analysis in the A Tall Cold Drink of Water



Discussion

Some assumptions that were made →

1. No heat was lost to the environment, we assumes that the energy transfers would only take place between the ammonium chloride solution and water
2. Reaction is always complete
3. There are no impurities in the aluminum can or the coffee cup calorimeter

4. The specific heat capacity for the ammonium chloride solution is the same as that of water (4.18 J/g °C)

The purpose of this experiment was to calculate the correct amount of ammonium chloride needed to cool down the temperature inside the aluminum can by five degrees celsius. It was hypothesized that by using 13.25 g of ammonium chloride the temperature of the water in the can would decrease by 5°C. After conducting the experiment in four trials, it was realized that a larger mass would be needed to get the results wanted. A mass of 13.25 g gave the ideal temperature within 5 minutes. Therefore, the results from the pre-lab calculations nearly exact in comparison to the ideal mass. Our first trial proved that this mass would help us achieve our goal and it did. But when we ran our other trials of adding more sodium chloride, we noticed that some fluctuations in temperatures were occurring. In our third trial, some error must have taken place since the temperature was higher when more ammonium chloride was added, which seemed to not make any sense since it was supposed to have a lower temperature. We then concluded that we should take out that trial as it did not it the rest of our data. This result made sense because of the errors that could have been made in association with the experiment.

Some sources of error were that the ammonium chloride was not fully dissolved into the water when the temperature was being measured (3rd Trial). This caused the temperature to not decrease as much as expected. A way to prevent this error would have been to stir the ammonium chloride solution until it was fully homogenous before adding the thermometer. The next source of error was that the can was already slightly cold from the previous trials instead being room temperature. This could have been avoided by using a new can in each trial as opposed to the same one. Another important factor that may have played with the results was the quality of the calorimeter. It was not very efficient, therefore we came to conclusion that heat can not be completely isolated with that type of calorimeter. The thermometer used and the hole that was in the lid may have caused air to enter the system which could have altered our data. Finally, the volume of water used was not necessarily exact for all trials. A difference in volume would have caused the calculated mass of ammonium chloride to be somewhat incorrect. This can not be completely solved but can be deterred by always measuring the water from the meniscus at eye level and never removing any water once it has been transferred to the coffee-cup calorimeter. By using all of the given solutions to the sources of error, future experiments would be expected to be more accurate and precise.

Conclusion

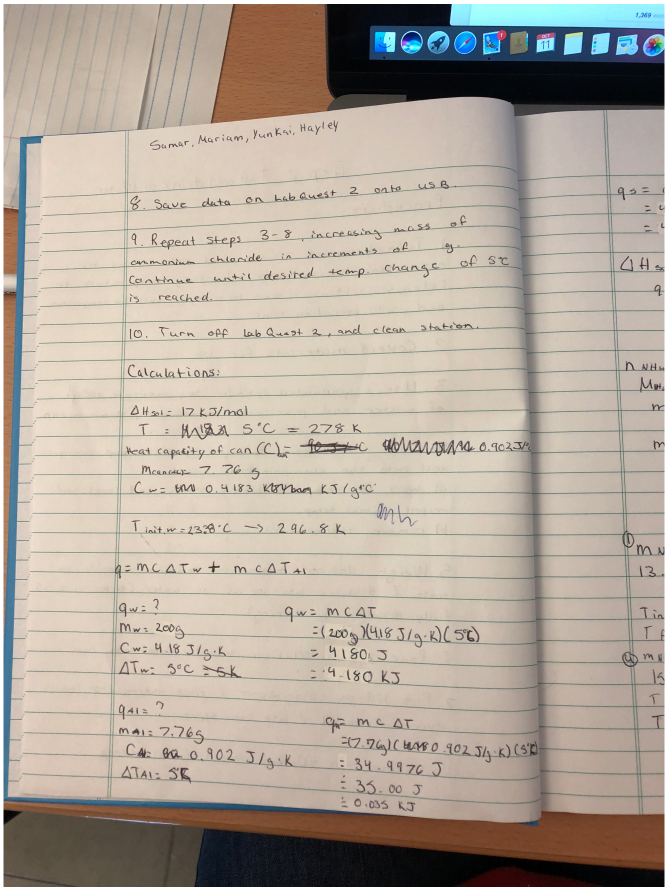
The purpose of this experiment was to determine the required mass of NH_4Cl that is needed to change the temperature of the water in the can by five degrees celsius in less than the required time which is five minutes. This temperature was attained by using the mass of 13.25g of ammonium chloride. The formation of calorimetry and enthalpy were used to determine the ideal mass for this experiment. The percentage error that was calculated was 0%.

References

1. Stubbings, J. (n.d.). Heat of Solution or Enthalpy of Solution Chemistry Tutorial. Retrieved October 06, 2017, from http://www.ausetute.com.au/heatsolution.html

2. Clark, J. (2010). Hess's Law and Enthalpy Change Calculations. Retrieved October 06, 2017, from http://www.chemguide.co.uk/physical/energetics/sums.html

3. Khan Academy . (n.d.). Heat and temperature (article). Retrieved October 07, 2017, from https://www.khanacademy.org/science/chemistry/thermodynamics-chemistry/internal-energy-sal/a/heat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8. Save data on Lab Quest 2 onto USB.

9. Repeat steps 3-8, increasing mass of ammonium chloride in increments of g. Continue until desired temp. change of 5°C is reached.

10. Turn off Lab Quest 2, and clean station.

Calculations:

$\Delta H_{sol} = 17\ kJ/mol$
$T = 5°C = 278\ K$
Heat capacity of can (C) = 0.902 J/g°C
$M_{can} = 7.76\ g$
$C_w = 0.4183\ kJ/g°C$
$T_{init,w} = 23.8°C \rightarrow 296.8\ K$

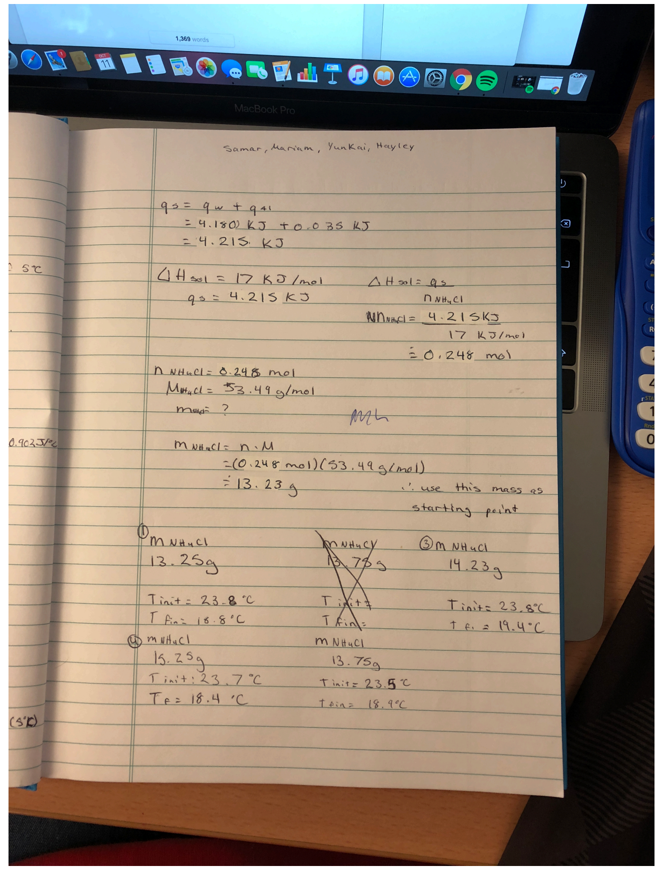
$q = mc\Delta T_w + mc\Delta T_{Al}$

$q_w = ?$
$M_w = 200g$
$C_w = 4.18\ J/g \cdot K$
$\Delta T_w = 5°C = 5K$

$q_w = mc\Delta T$
$= (200g)(4.18\ J/g \cdot K)(5K)$
$= 4180\ J$
$= 4.180\ kJ$

$q_{Al} = ?$
$m_{Al} = 7.76g$
$C_{Al} = 0.902\ J/g \cdot K$
$\Delta T_{Al} = 5K$

$q_{Al} = mc\Delta T$
$= (7.76g)(0.902\ J/g \cdot K)(5K)$
$= 34.9976\ J$
$\doteq 35.00\ J$
$\doteq 0.035\ kJ$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$q_s = q_w + q_{Al}$
$= 4.180\ kJ + 0.035\ kJ$
$= 4.215\ kJ$

$\Delta H_{sol} = 17\ kJ/mol$
$q_s = 4.215\ kJ$

$\Delta H_{sol} = \frac{q_s}{n_{NH_4Cl}}$
$n_{NH_4Cl} = \frac{4.215\ kJ}{17\ kJ/mol}$
$\doteq 0.248\ mol$

$n_{NH_4Cl} = 0.248\ mol$
$M_{NH_4Cl} = 53.49\ g/mol$
$m_{NH_4Cl} = ?$

$m_{NH_4Cl} = n \cdot M$
$= (0.248\ mol)(53.49\ g/mol)$
$\doteq 13.23\ g$
∴ use this mass as starting point

① m_{NH_4Cl} 13.25g — T_{init} = 23.8°C, T_{fin} = 18.8°C
~~m_{NH_4Cl} 13.75g — T_{init}, T_{fin}~~
③ m_{NH_4Cl} 14.23g — T_{init} = 23.8°C, T_{fin} = 19.4°C
② m_{NH_4Cl} 15.25g — T_{init}: 23.7°C, T_f = 18.4°C
m_{NH_4Cl} 13.75g — T_{init} = 23.5°C, T_{fin} = 18.9°C

Rubric for Correction of Experiment 2

Description	Excellent (4)	Very Good (3)	Good/ Acceptable (2)	Poor/ unacceptable (1)
Titlepage (1)				
Introduction (8) **Criterion:** 1.Clear Explanation of theory; 2.Clear explanation of why salt was selected; 3.Clear explanation of why experimental design was chosen and how experimental goal would be achieved 4.Clear referencing was provided for all information				
Procedure (4) **Criterion:** 1.Steps are clear 2.Organization is evident 3.Procedure is logical 4.Procedure will give the desired results				
Observations (2)				
Table(s) (4) **Criterion:** All data neatly and clearly tabulated				
Graphs (4) + 2 bonus				
Calculations (2) 1.Approximate amount 2.Exact amount				
Discussion (8) **Criterion:** 1.Clear explanation of data obtained 2.Clear explanation of whether design worked 3.Clear explanation of impact of the result 4.Clear suggestions for improvement				
Conclusion (2)				
Peer Review (5)				
Creative Aspect 1.Creative name for product. 2.Creative label design for product 3.Creative design for can				
Total	**40** (up to 2 bonus points)			

COURSE: CHM 1311B TA Name: MICHAEL LAZARUS

YOUR NAME (PRINT): Mariam Hasan **SIGNATURE:** *Mariam Hasan*

CONFIDENTIAL PEER EVALUATION FORM FOR EXPERIMENT 2

Each team member must submit one assessment. Teams may consist of 2-18 members.

You may edit this form.

Do not share or discuss the contents or possible contents of this assessment with others.

In assessing the work of your fellow team members, consider the following aspects:

- Quality of work
- Contribution to the work as a whole
- Ability to get along with others
- Improvements when asked to correct

Team member name	Comments	Grade
Samar Salloum	Once again Samar was very prepared procedure wise and concept wise. She was aware of what the main idea of this lab was and new what steps to take in order for this lab to take place successfully. We worked well as a group of 4 and everyone had something to do. We were able to split up the report fairly so everyone was able to participate. Overall Samar was well prepared and I enjoy being her partner.	**A – Excellent (5)**
Hayley Festeryga	Hayley got along well with everyone in the group and participated well too. She was able to grasp the concept of the lab quickly and thus was able to actively participate in the experiment and calculations. For next time, I hope that if she is having any trouble with the report she would ask for help beforehand.	**C: Good (3)**
Ken Wang	Ken may not have been too talkative but he worked well in the group and was able to help us out if we had any questions during the experimental portion of the lab. He was very familiar with the main concepts of the lab and was good at discussing information about our trials and what errors we may have made throughout the experiment	**B: Great (4)**

A – Excellent (5) **B: Great (4)** **C: Good (3)** **D: Fair(2)** **F: Poor (1)**

Note: Do not evaluate yourself on this form