Experiment 2

Enthalpy of Various Reactions

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Introduction

Various fundamental laws have been created to support chemical reasoning to date. Thermodynamics branches into the examination of the relationship between heat and other types of energy. [3] There are three types of enthalpies discussed prior to beginning the lab. Enthalpy of solution is the heat energy changing, at a constant pressure when one mole of ions is dissolved completely in water. [1] Lattice energy is the change of one mole of ions from their solid state to their gaseous state. [1] Enthalpy of hydration is when one mole of isolated gaseous ions dissolves in water to form one mole of aqueous ions under standard conditions. [1]

In addition, [4] Hess's law can be utilized to calculate the overall energy required for a chemical reaction. [1] If the enthalpy calculated is negative, the reaction exhibits exothermic processes, while a positive enthalpy change indicates an endothermic process. [1] An exothermic process means energy is given up to the surroundings, cooling the system. [1] An endothermic reaction results in the heating of a system as energy is absorbed, and the cooling of the surroundings. [1]

Calorimetry is the scientific measurement of heat, involving an apparatus such as the calorimeter to accurately measure the heat in the reaction. [1] Calorimetry involves specific heat capacity which is a measurement of the amount of heat required to increase the temperature of the reaction by 1 Kelvin. [1] A properly insulated system does not give up excess energy or heat to the surroundings. [1] It also involves the initial and final temperature of the reaction which may be affected depending on the insulation of the calorimeter. [1] With a specific mass and the variables previously mentioned, heat can be found and can be divided by the number of moles in a reaction to retrieve the change in enthalpy. [1] In this lab, three measurements of mass will be used to find the change in temperature over a five-minute period. The change in temperature over this period will be recorded and observed, for similar trends as the mass of the salt is increased or decreased, in relation to the theoretical mass calculated.

This lab involves ammonium chloride and an aluminium can. Ammonium chloride was used instead of ammonium nitrate because ammonium chloride is safer for the environment and is cheaper per 500 g [1]. Ammonium nitrate is also an explosive chemical, while ammonium chloride is simply irritating [13]. Therefore, it would not be practical to use ammonium nitrate around hot fluids and heating components, as an explosion could occur. [9] Goggles and lab coat must be worn at all times for protection during the experimental process.

Procedure

1) Gather a digital thermometer, LabQuest 2, a 250 mL beaker, a 100 mL graduated cylinder, a Styrofoam calorimeter container, an aluminum can, 220 mL of water and 43.18 g of NH_4Cl. Set up the thermometer into LabQuest 2.

2) In a neat and organized table record the mass of the aluminum can.

3) Add 100 mL of water into the aluminum can, and add 120 mL of water into the beaker, record their initial temperature in a table.

4) Add 14.99 grams of NH_4Cl into the Styrofoam calorimeter.

5) Quickly add 120 mL of water into the calorimeter, then place the aluminum can inside of the NH_4Cl and water mixture, place the lid on top.

6) Holding the thermometer tight and steady, begin observing the temperature change over the next 5 minutes, recording both the initial and final temperatures.

7) Rinse the NH_4Cl from the calorimeter and dispose of that waste in fume hood inorganic waste bin.

8) Repeat steps 1-7 for both 10.0 g and 18.19 g of NH_4Cl.

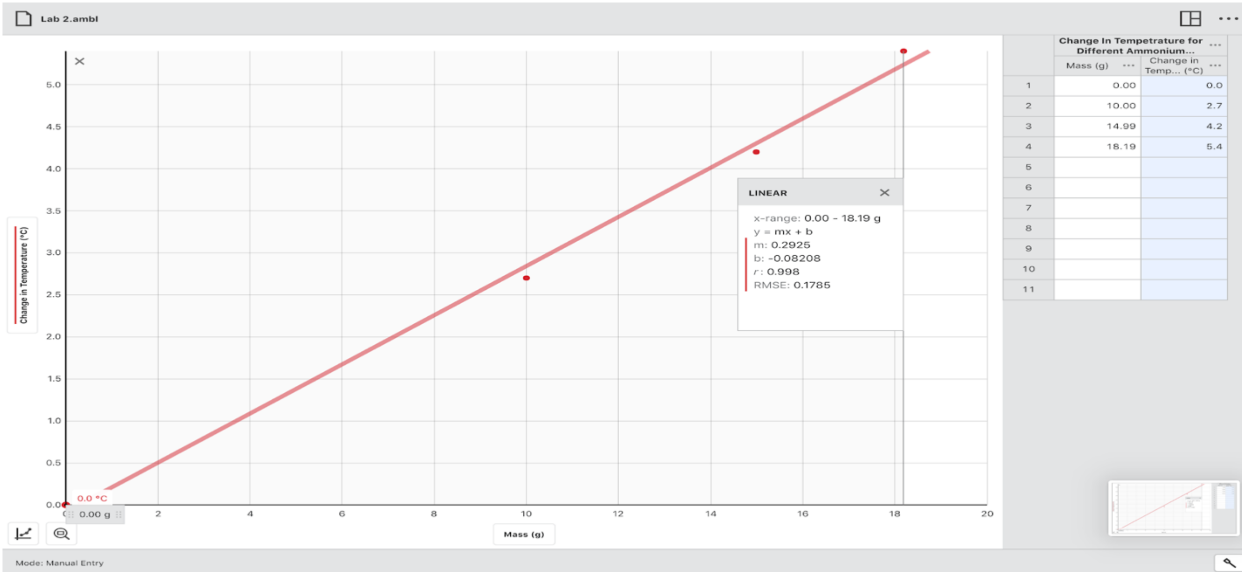
9) Clean up station and ensure all apparatus is properly put away.

Discussion:

Table 1.0: Change in Temperature for Three Different Masses of NH_4Cl Over Five Minutes

Mass of Aluminium Can (g)	Mass NH_4Cl (g)	Initial Temperature °C	Final Temperature °C	Change in Temperature °C
7.77	14.99	22.40	18.20	4.20
7.77	10.00	22.40	19.70	2.70
7.77	18.19	24.40	19.00	5.40

Graph 1.1: Change in Temperature for Different Ammonium Chloride Masses Over 5 Minutes



Three trials using different masses of Ammonium chloride were completed and recorded in Table 1.0. From this table, the initial and final temperature were used to calculate the overall change in temperature over a period of five minutes. The purpose of the lab was to decrease the temperature of the calorimeter by five °C in five minutes. According to Table 1.0, this was not achieved in all three trials.

To achieve more accuracy in the results three trials where done. One trial was very similar to the theoretical mass of 14.73 g, and the other two trials were chosen by adding and subtracting roughly 4 g. This led to mass of 14.99 g, 18.19 g and 10.0 g respectively. With 14.99 g, it was observed that after five minutes, the temperature decreased by 4.20 °C. With 10.0 g it was observed that the calorimeter dropped 2.7 °C in five minutes. Lastly, with 18.19 g the system's temperature decreased by 5.20 °C in five minutes. Furthermore, there were several similar trends noticed in all the graphs. First, the graphs all decreased exponentially, meaning that they all decreased very rapidly at the beginning and then slowed down towards the end (see appendix graph's A, B and C). Therefore, when more ammonium chloride was added, the reaction occurs quicker than the calculated theoretical mass. In graph 1.1, it can be determined that the mass which would result in the five °C drop over five minutes would be 17.37 g of NH_4Cl (see calculations section D). This means that the theoretical mass differed from the actual mass required for the decrease in temperature.

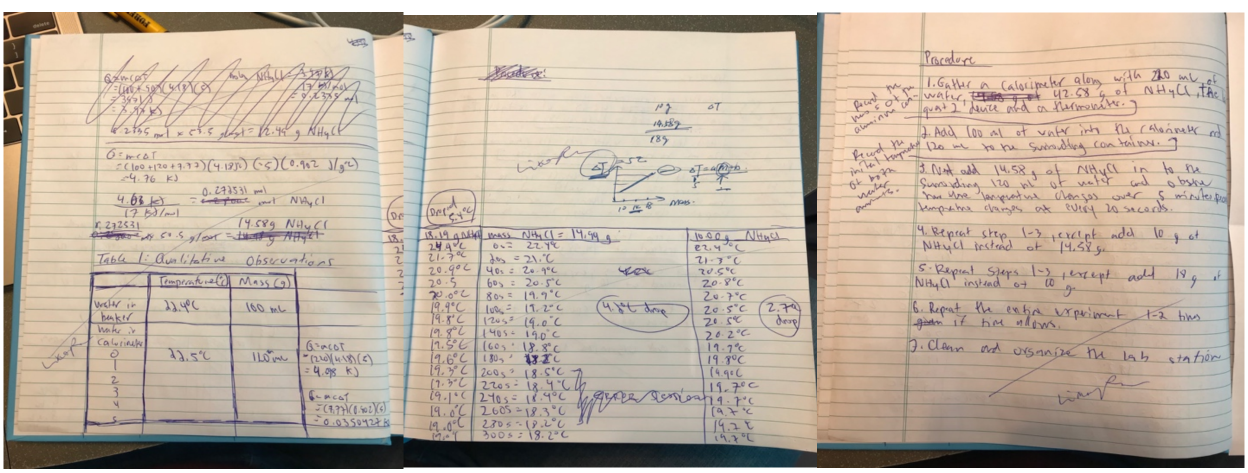
By analysing the results obtained, it was clear that the design functioned as expected. This was seen, due to the fact the temperature eventually decreased by 5 °C. However, due to various sources of error, the accuracy of the results was skewed. To begin, the calorimeter used was not a good insulator. It was formed from Styrofoam and aluminum which has a hole for the placement of the thermometer. It was not sealed properly allowing for possible heat gain from the surroundings. This slowed down the cooling process and therefore the system required more than five minutes to decrease by 5 °C. To prevent this from reoccurring, the lid should be covered with tape to limit the amount of heat entering the system. In addition, the procedure suggested the reaction was to be stirred gently until dissolution. When a reaction is stirred, kinetic energy increases, and therefore the heat and enthalpy increase. The excessive amount of stirring in this case, decreased cooling process and final change in temperature. To avoid this, the procedure should be specific in the amount of time the solution should be stirred for in order for the kinetic energy to balance out instead of being too high or too low.

Conclusion:

In conclusion, the product was a success as the temperature decreased by 5.4 °C in 5 minutes. It was then calculated using the experimental data that to decrease the temperature of the drink by 5 °C in 5 minutes, 17.37 g of NH_4Cl should have been used.

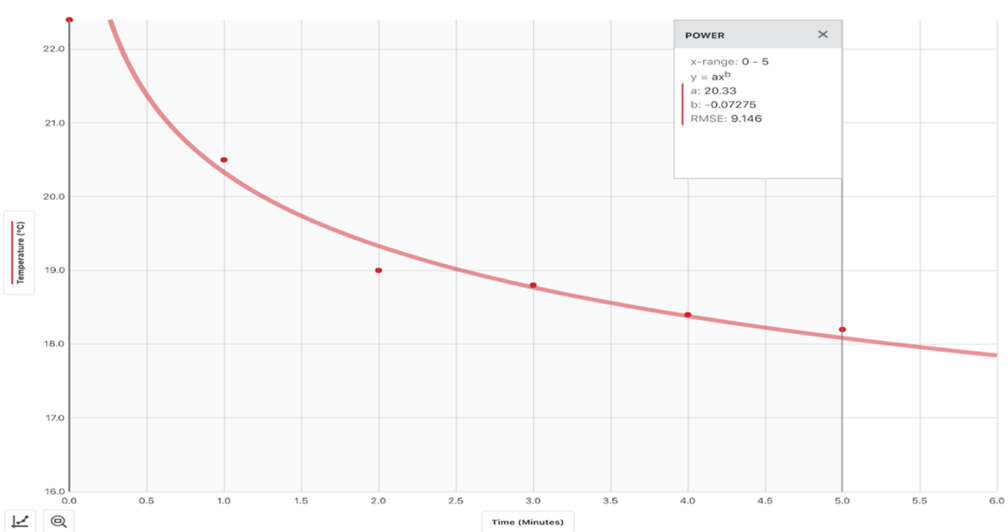
Appendix:

Raw Data:



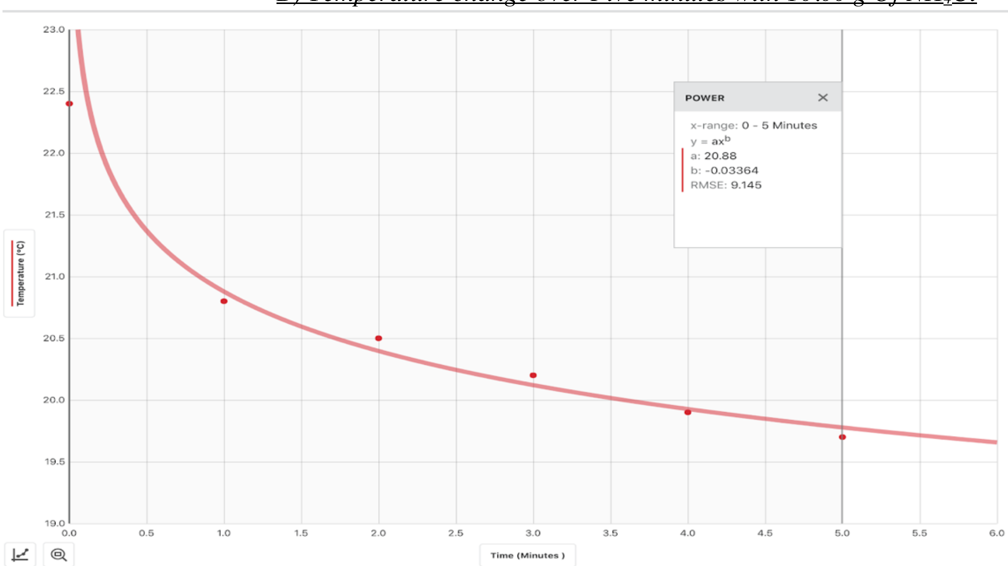
Graphs:

<u>A) Temperature change over Five minutes with 14.99 g Of NH_4Cl</u>



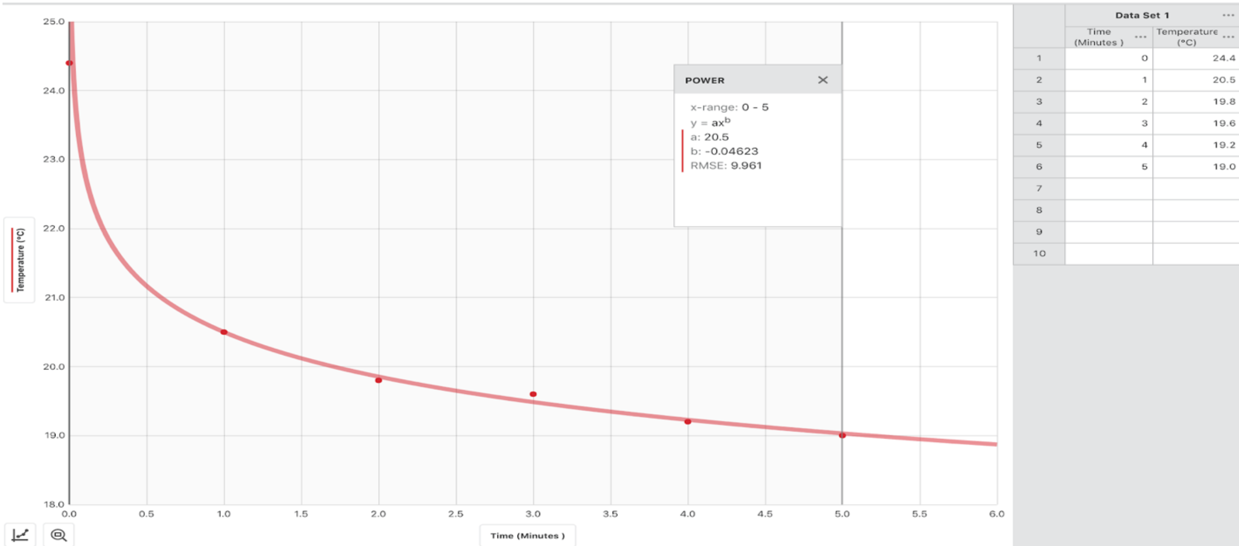
	Data Set 1	
	Time (Minutes)	Temperature (°C)
1	0	22.4
2	1	20.5
3	2	19.0
4	3	18.8
5	4	18.4
6	5	18.2
7		
8		
9		
10		

<u>B) Temperature change over Five minutes with 10.00 g Of NH_4Cl</u>



	Data Set 1	
	Time (Minutes)	Temperature (°C)
1	0	22.4
2	1	20.8
3	2	20.5
4	3	20.2
5	4	19.9
6	5	19.7
7		
8		
9		
10		

C) Temperature change over Five minutes with 18.19 g Of NH_4Cl



Calculations:

A) Energy required for temperature decrease

Q=mcΔT
Qwater=(100g +120g)(4.18 J/goC)(5 oC)
Qwater=4598 J
Qwater=4.598 kJ

QAluminum=(7.77 g)(0.902 J/goC)(5 oC)
QAluminum=35.0427 J
QAluminum=0.0350 kJ

QTotal=4.598 kJ + 0.0350 kJ
QTotal=4.633 kJ

B) Enthalpy of solution of NH4Cl(s)

$\Delta H(NH4^+)$= -307 kJ/mol
$\Delta H(Cl^-)$= -381 kJ/mol
$\Delta HL(NH_4Cl)$= 705 kJ/mol
$\Delta HSolution(NH_4Cl)$= 705 kJ/mol – 381 kJ/mol -307 kJ/mol
$\Delta HSolution(NH_4Cl)$= 17 kJ/mol

C) Theoretical mass of NH4Cl required
mols (NH_4Cl)= QTotal / $\Delta HSolution(NH_4Cl)$
mols (NH_4Cl)= (4.633 kJ)/(17 kJ/mol)
mols (NH_4Cl)= 0.2753 mols

MM (NH_4Cl)= (14.01 u)+(4.04 u)+(35.44 u)
MM (NH_4Cl)= 53.49 u

m (NH_4Cl)= (Moles(NH_4Cl)) x (MM (NH_4Cl))
m (NH_4Cl)= 0.2753 mols x 53.49 g/mol
m (NH_4Cl)= 14.73 g

D) Actual mass required to drop 5 °C in 5 minutes

Y=mx+b
0.2925(x)-0.03364=5
0.2925(x)=5.03364
x=17.37 g

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Assessment Criteria for Planning A Tall Cold Drink of Water

TA Name: **Lixuan Ren**		**Names of Students in Group:**	A. Alexandra Nesrallah B. Joseph Albert
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		E. Reem Hamzah	F. Emelda Aitafo
		Date: September 24th 2019	
Criteria:	**Marks**	**Assessment**	
	Possible	**Self**	**TA**
1. Identify the problem and state it clearly in a way that can be tested.	**1**	1	1
2. Use proper apparatus, techniques and safety precautions.	**0.5**	0.5	0.5
3. Plan to vary only one independent variable at a time.	**1**	1	1
4. Controls on other variables are clearly stated.	**0.5**	0.5	0.5
5. Measurement errors are minimized by appropriate procedures or apparatus.	**0.5**	0.5	0.5
6. No invalid assumptions are made.	**0.5**	0.5	0.5
7. Reagents that need accurate measurement are identified.	**0.5**	0.5	0.5
8. Lab trials and repeats are clearly stated.	**0.5**	0.5	0.5
TOTAL:	**5**	5	5