

Experiment # 2 Lab Report

Thermochemistry

By: Skyler Cole
30006435
Nicole Weisemberg
30015875
James Zarrello
30022753
Sally Raad
30025357
Orion Kalloo
30018429
Orion Samuel
30015937

CHM1311-Section 3

TA: Marina Sanita
msani009@uottawa.ca

October 3rd, 2017

Department of Chemistry
University of Ottawa

Introduction

The purpose of this experiment was to find out which amount of salt would effectively cause a decline in temperature of 5 degrees. First, we had to determine which salt would be most efficient in cooling the contents of the can. The first option was Ammonium Chloride, after extensive research it was concluded that human exposure to this salt can result in many health implications including, irritation of eyes, skin, and respiratory system, headaches, hyperventilation, and in extreme cases can lead to an induced coma. The second option was Ammonium Nitrate, when handling under normal conditions, Ammonium Nitrate is proven to not be harmful/toxic to humans. Given the following information it was concluded that Ammonium Nitrate was the best option. As this ionic compound would be coming into contact with many people, it was imperative that the product we were using was non toxic. Our experimental design was as follows. An aluminum can with its top cut off was filled with 100mL of water and was to be placed in a semi-sealed styrofoam container that would also be filled with 110 mL of water. This allowed space for our salt to be mixed into the outside of the can. Next, we used the specific heat capacity formula, $Q=mc\Delta t$, to determine the correct amount of salt which would be needed to change the temperature by 5 degrees.

<https://www.thoughtco.com/definition-of-specific-heat-capacity-605672>, Anne Marie Helmenstine, Specific Heat Capacity in Chemistry.

Procedure

- 1) Ensure proper eye protection, and lab coats are worn while dealing with chemicals and through the duration of the experiment.
- 2) Fill can with 100 mL of water.
- 3) Fill area around can with water, remove can, and pour water into graduated cylinder to measure.
- 4) Using $Q=mc\Delta t$, determine an estimate of the amount of Ammonium Chloride that will be placed outside the can.
- 5) Using the number found in step 3, find two other measurements equidistant from the optimal amount determined.
- 6) Measure out desired amount of salt that was determined in step 4.
- 7) Distribute salt in body of water surrounding the aluminum can making sure all salt is dissolved.
- 8) Take note of change in temperature (Δt), and put data into calorimetry graph.
- 9) In the graph label the independent variable as mass of salt (g), and the dependant is the temperature of water (celsius).
- 10) Extrapolate the graph to find the proper ideal amount of salt needed to change temperature by 5 degrees.

Limitations:

- The styrofoam container used, will absorb heat energy, not making it a closed system.
- The volume of water outside the can cannot be measured accurately.
- The optimal volume of water cannot be measured accurately.

Observation

For our outer volume of water, we decided that 110 mL of water was appropriate because the can, when filled with 100 mL of water, did not float too far out of the styrofoam container. This made it easier to keep the lid closed in order to maintain the temperature inside the system. After making a theoretical calculation to determine the mass required, we began our reactions with Ammonium Chloride. 11 g, 14 g, and 17 g, were chosen as our three mass intervals to test of Ammonium Chloride to obtain a 5 C difference in temperature. Prior to mixing our salts into the 110 mL of water, it was noted that container 1 (receiving 11 g of NH₄Cl) was 20.7 C, and container 2 (receiving 14 g of NH₄Cl) was 21.7 C, and container 3 (receiving 17 g of NH₄Cl) was 22.1 C. Upon adding the salts, a 5 minute timer was started. During this 5 minute time period, temperatures slowly decreased by intervals of 0.1-0.2 C. The temperature did not begin to decrease instantly, it took at least 10-15 seconds before seeing the temperature to begin to decline.. The containers with less mass were seen to decrease temperature slightly slower, but not slow enough to determine a noticeable difference. Container 1 decreased to 18.1 C (2.6 C difference) before the 5 minutes was over, and idled around that temperature before very slowly starting to increase in temperature nearing the 5 minute ending. Container 2 followed a similar path to container 1, but decreased from 21.7 C to 17.7 C (4.0 C difference). Container 2 reached its minimum temperature nearing the 5 minute mark (appx. 4:35 +/- 5 seconds) before rapidly increasing temperature to nearly 19.8 C. This was assumed to be caused from an outer source of temperature (outer air) getting in, possibly the lid was lifted up somehow. Container 3 received our largest amount of mass of Ammonium Chloride. The water in the can decreased at a slightly faster rate compared to container 1, and had the largest decrease in temperature. Container 3 starting at 22.1 C ended the 5 minutes with a temperature of 17.1 C. Conveniently, the container with 17 g of NH₄Cl added gave us an exact change in temperature of 5 C, just what we were looking for.

Test Tables

*Test values were chosen based on the mass determined through the manipulation of enthalpy and $q=mc\Delta t$.

	Mass of NH ₄ Cl (g)	Initial Temperature (°C)	Final Temperature (°C)	ΔTemperature (Final-Initial Temperatures)
Test # 1	11 g	21 °C	18.4 °C	-2.6 °C or a change of 2.6°C
Test # 2	14 g	21 °C	17 °C	-4.0 °C or a change of 4°C
Test # 3	17 g	22.1 °C	17.1 °C	-5.0 °C or a change of 5°C

Raw Data

Observations

	mass of NH_4Cl	Temp	
		Initial $^{\circ}\text{C}$	Final $^{\circ}\text{C}$
1.	17(g)	22.1	20.7 17.1
2	14(g)	21	17
3	11(g)	21	18.4

water and calorimeter are in thermal equilibrium

$$Q_{\text{system}} = Q_{\text{surroundings}}$$

$$= - \left[(210\text{g})(4.18 \frac{\text{J}}{\text{g}\cdot^{\circ}\text{C}}) + (8.33\text{g})(0.9 \frac{\text{J}}{\text{g}\cdot^{\circ}\text{C}}) \right] \Delta T$$

$$= 4.429\text{kJ}$$

$$\frac{4.429\text{kJ}}{17 \text{ mol}} \times 53.491 = 13.94 \text{ kJ/mol}$$

$$Q = m_1 c_1 \Delta T + m_2 c_2 \Delta T \quad 1 = \text{water} \quad 2 = \text{can}$$

$$= (210\text{g})(4.18)(-5^{\circ}\text{C}) + (8.33\text{g})(0.9)(-5^{\circ}\text{C})$$

$$= -4351.5\text{J}$$

$$= -4.35\text{kJ}$$

to find n use $\Delta H = \frac{q}{n}$ $\Delta H = 17\text{kJ}$

$$\Delta H = \frac{q}{n}$$

$$17\text{kJ} = \frac{4.35\text{kJ}}{n}$$

$$n = 0.256\text{mol}$$

$$m = n \cdot M$$

$$M = 14.0\text{g/mol} + 4.04\text{g/mol} + 35.45\text{g/mol}$$

$$= 53.5\text{g/mol}$$

$$m = 0.256\text{mol} \cdot 53.5\text{g/mol}$$

$$m = 13.7\text{g}$$

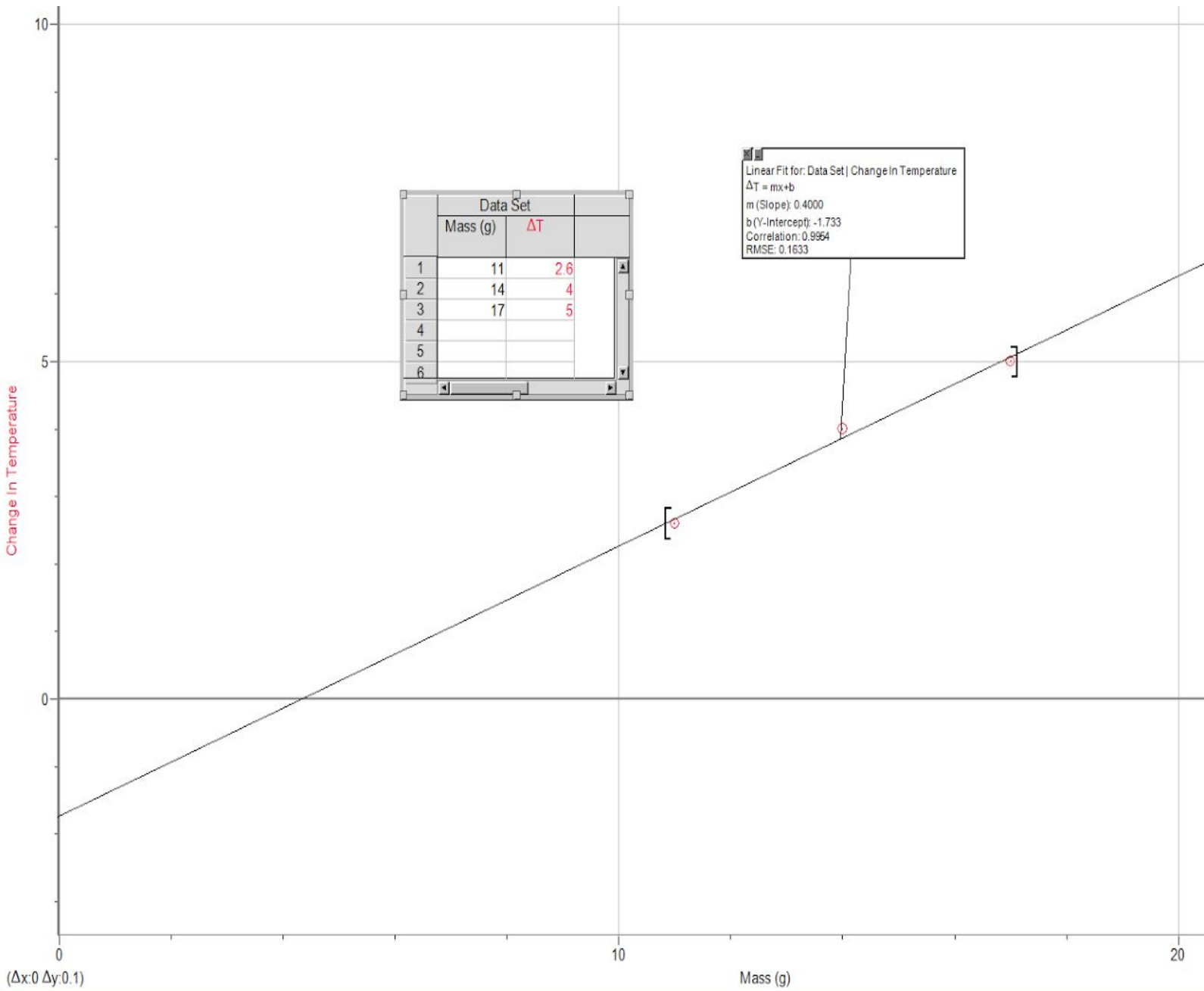
chosen test values 11g, 14g, 17g

When 11g of NH_4Cl is added Temp dropped from 20.7 $^{\circ}\text{C}$ to 18.1 $^{\circ}\text{C}$ \rightarrow 2.6 $^{\circ}\text{C}$ change

When 14g of NH_4Cl is added Temp dropped from 21.7 $^{\circ}\text{C}$ to 17.7 \rightarrow 4.0 $^{\circ}\text{C}$

When 17g of NH_4Cl is added Temp dropped from 22.1 $^{\circ}\text{C}$ to 17.1 $^{\circ}\text{C}$ \rightarrow 5.0 $^{\circ}\text{C}$

Graph



Calculations

$$q=mc\Delta t$$

q=Heat energy gained or lost by the substance

m=Mass of the substance

c= Specific Heat Capacity

Δt = Change in temperature

*The equation above represents what we can calculate in a specific substance individually not necessarily with other substances within contact. For example water alone rather than water within a metal container.

In this lab we are determining the mass needed of NH_4Cl to reduce the temperature of water by 5°C within a 5 minute period of time.

$$q=m_1c_1\Delta t + m_2c_2\Delta t$$

$m_1=210\text{g}$ of water

c_1 = Specific heat capacity of water = $4.18\text{ joules/gram }^\circ\text{C}$

$\Delta t= 5^\circ\text{C}$

$m_2=8.33\text{g}$ of the metal container

c_2 = Specific heat capacity of Aluminum can = $0.9\text{ joules/gram }^\circ\text{C}$

$\Delta t= 5^\circ\text{C}$

$$\begin{aligned} q &= (210) * (4.18) * (5) + (8.33) * (0.9) * (5) \\ &= 4426.485\text{J} \end{aligned}$$

***Convert to KJ**

$$4426.485/1000 = 4.426485\text{KJ}$$

Determine the Enthalpy of the solid solution of NH_4Cl

$$\Delta H_{Sol} = \Sigma \Delta A_{Hyd} - \Delta H$$

$$\Delta H_{\text{NH}_4\text{Cl}} = (-381\text{KJ/mol}) + (-381\text{KJ/mol}) - (-705\text{KJ/mol})$$

$$\Delta H_{\text{NH}_4\text{Cl}} = 17\text{KJ/mol}$$

Determine moles by dividing the q by the Enthalpy of the solution

Since Enthalpy is KJ/mol then we can rearrange the equation to solve for the moles of the solution.

Enthalpy=Kilojoules/Mole

∴ Mole=Kilojoules/Enthalpy

Enthalpy= 17 KJ/mole

Kilojoules = 4.426485 KJ

Moles=(4.426486)/(17)

=0.260381471 moles

Determine the mass of the solid solution

Moles= Mass/Molar Mass

Molar Mass of NH_4Cl = 53.59 g/mol

∴ Mass of NH_4Cl = (Moles)*(Molar Mass)

Mass of NH_4Cl = (0.260381471)*(53.59)

Mass of NH_4Cl = 13.95384303

Mass of NH_4Cl = 14 g

Theoretical Test values of based on calculations

Test #1 = 11g of NH_4Cl

Test #2 = 14g of NH_4Cl

Test #3 = 17g of NH_4Cl

Discussion

The design of the product has effectively allowed to measure the amount of heat lost by dissolving NH_4Cl in water inside the calorimeter. As observed in the third trial, the water was indeed cooled down by a 5°C difference when using 17.0 grams of Ammonium Chloride salt, thus providing with the desired outcome when sealed in an almost fully isolated system. The design also allowed to measure the water temperature decrease on specific time intervals and provide knowledge of the length of the cooling down process, thus, helping determine if the dissolving mass of salt is sufficient for the product. Overall, this allowed getting the most realistic model design that would have to be used to cool down the drink.

When 11.0 grams were used, the initial temperature, 20.7°C , was only decreased 2.6°C , achieving a final temperature of 18.1°C , which did not meet the desired result of 5.0°C temperature decrease. After increasing mass to the calculated theoretical mass, 14.0 grams, that is required to cool down the drink, the initial temperature of 21.7°C only decreased to 17.7°C , marking only a 4.0°C difference which is 1.0°C less than the desired temperature change. When increasing the mass of ammonium chloride to 17.0 grams, the temperature dropped from 22.1°C to 17.1°C , thus providing the desired 5.0°C drop and proving to be the mass to realistically achieve the desired result.

This procedure proved the theoretical mass of ammonium chloride required to absorb 5.0°C and cool the water to not be accurate as the experiment was not performed in a fully ideal conditions. The experiment could be improved through revising its limitations and minimizing them, which could be performed through better and more accurate measurements for the volume in water residing both inside and outside the can. Moreover, due to the inability to fully ensure that the experiment is performed in a fully isolated system, escaped heat could affect the observations of the temperature difference, as it was noted in trial #2 how the temperature rose after it was assumed that the water temperature was done increasing. Finally, the inability to properly stir and contribute or fasten the dissolving of salt in water could have led to an incomplete reaction thus limiting our results for each experiment.

Conclusion

After all the calculations, and trials have been done for this experiment, it has been concluded that the ideal mass of NH_4Cl that will decrease the temperature of 100 mL of water by 5 degrees, is 17g. The theoretical value that was said to give a 5 degree

temperature change was 14 g of NH_4Cl , but it was concluded because of nonideal conditions and other sources of error that would explain the reason for a higher quantity of mass than predicted.

Creative aspect



There will be a circular container named "Cool Container". This container is made of two layers of metal, and in between the metal there are layers of Styrofoam to keep the heat inside of the container. On the inside, there is a marking to where 110mL of water can be filled by the user of the product. The consumer then pours 17g of NH_4Cl into the water inside of the Cool Container (packets of 17g of NH_4Cl will be provided with the Cool Container), and simultaneously places their own 100mL drink that's inside of an aluminum can into the Cool Container. The consumer then shuts the lid to the Cool Container, and waits until the built-in timer for 5 min goes off before getting their cool drink out of the Cool Container.

Advertisement:

