Exothermic & Endothermic Reaction

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INTRODUCTION:

You learned last week that the term thermobaric derives from two Greek words: thermos (hot) and baros (pressure). Last week, we studied compression waves by using a model system – sound waves. This week we are going to look at the "thermos" portion of the process by studying the energy of chemical reactions. You will be carrying out three different chemical reactions and recording the energy transfer that occurs in each one by monitoring temperature changes.

PURPOSE & HYPOTHESIS:

To answer the following questions:

1. *What is a chemical reaction?*

I hypothesize that a chemical reaction is two or more chemicals mixing together altering one or both of the chemical structures of the chemicals.

2. *What is an exothermic reaction?*

I hypothesize that an exothermic reaction is a reaction between chemicals that produces heat.

3. *What is an endothermic reaction?*

I hypothesize that an endothermic reaction that lowers the temperature of where the reaction takes place.

MATERIALS & EQUIPMENT:

- ❑ *NaCl (sodium chloride)*
- ❑ *$CaCl_2$ (Calcium chloride)*
- ❑ *NH_4Cl (Ammonium chloride)*
- ❑ *Water*
- ❑ *3 Test tubes*
- ❑ *Test tube rack*
- ❑ *Test tube holder*
- ❑ *Thermometer*
- ❑ *Metal spatula*
- ❑ *Wax paper square*

PROCEDURE:

SAFETY: You must wear goggles throughout this entire lab.

1. *Add 5ml of water a clean test tube*
2. *Wait for 2 minutes and measure the temperature of the water*
3. *Weigh approximately 3g of NaCl*
4. *Carefully add the NaCl to the test tube*
5. *Measure the temperature every 15 seconds for a total of 2 minutes*
6. *Record your results in a data table*

7. *Add 5ml of water to a clean test tube*
8. *Wait for 2 minutes and measure the temperature of the water*
9. *Weigh approximately 3g of $CaCl_2$*
10. *Carefully add the $CaCl_2$ to the test tube*
11. *Measure the temperature every 15 seconds for a total of 2 minutes*
12. *Record your results in a data table*

13. *Add 5ml of water to a clean test tube*
14. *Wait for 2 minutes and measure the temperature of the water*
15. *Weigh approximately 3g of NH_4Cl*
16. *Carefully add the NH_4Cl to the test tube*
17. *Measure the temperature every 15 seconds for a total of 2 minutes*
18. *Record your results in a data table*

Dispose of the contents of your test tubes as instructed by your teacher.

DATA TABLES AND OBSERVATIONS:

Time	NaCl	$CaCl_2$	NH_4Cl
Water Temp.	24 Celsius	24 Celsius	24 Celsius
15 seconds	24 Celsius	45 Celsius	19 Celsius
30 seconds	24 Celsius	52 Celsius	18 Celsius
45 seconds	23 Celsius	55 Celsius	18 Celsius
60 seconds	23 Celsius	55 Celsius	14 Celsius
75 seconds	23 Celsius	55 Celsius	13 Celsius
90 seconds	23 Celsius	54 Celsius	13 Celsius

Time	NaCl	$CaCl_2$	NH_4Cl
105 seconds	23 Celsius	54 Celsius	13 Celsius
120 seconds	23 Celsius	53 Celsius	13 Celsius

Observations of the water when I added NaCI:

Most of the NaCI (table salt) has settled to the bottom of the water. Some of the smaller grains of NaCI are floating to the top of the water and disappearing at the meniscus. Some of the NaCI appears to have stuck to the side of the test tube. The water is very foggy, the salt has dissolved and the saltier water has settled at the bottom of the test tube above the reservoir of salt. The top of the water just below the meniscus is a lot clearer than the rest of the water, however the line in between the fresh water and the salty water is not very distinct.

Observations of the water when I added $CaCl_2$:

All of the $CaCl_2$ has settled to the bottom of the test tube. The water level has risen a lot, and it seems that the water is fogging up from the heat. A lot of $CaCl_2$ is floating in the water, the remnants of the balls of $CaCl_2$ that have dissolved are floating up to the top of the water. Just above the pile of $CaCl_2$ the water is very distorted, the water is clear in the middle and very foggy at the meniscus.

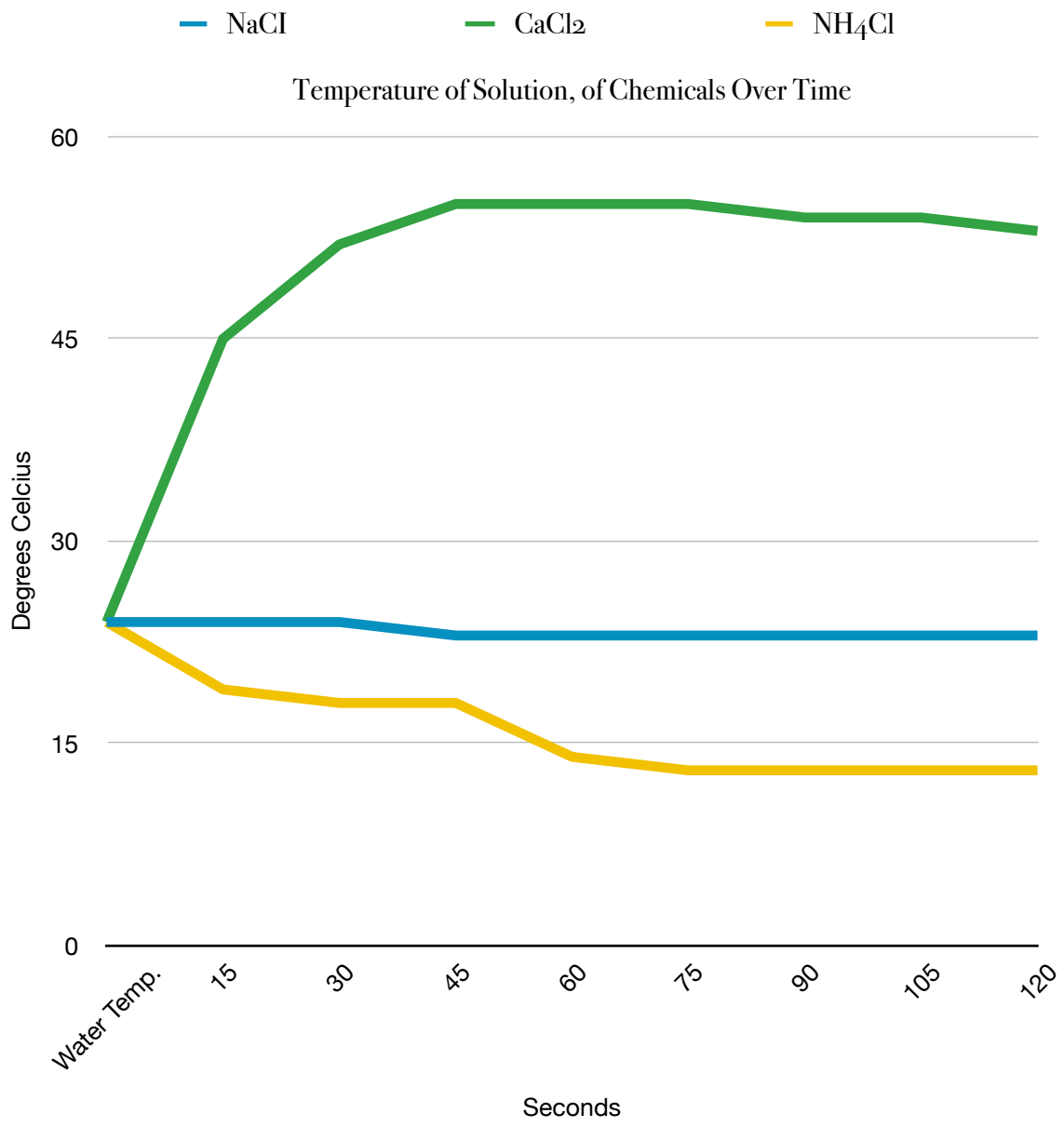
Observations of the water when I added NH_4Cl:

When we added the NH_4Cl it froze when it hit the water, half of the substance was below the water line and half of the substance was above. After the clumps started to pull apart small grains began to fall to the bottom of the test tube but most of them dissolved before they reached the it. Then our teacher stirred the water with the thermometer and all of the substance fell to the bottom.

CALCULATIONS:

For each reaction, create a line graph showing the temperature of the solution over time. Your graphs should be drawn on graph paper and should be labeled with a title and axis titles that include units.

Using your graphs, estimate the rate of change in temperature.


NaCl
CaCl2
NH4Cl
Temperature of Solution, of Chemicals Over Time
60
45
30
15
0
Degrees Celcius
Water Temp.
15
30
45
60
75
90
105
120
Seconds

Formula:

$$\text{Rate Of Change} = \frac{\text{Ending Temperature - Starting Temperature}}{\text{Total Amount of time}}$$

1. Rate Of Change for NaCl

Ending Temperature = 23 Celsius
Starting Temperature = 24 Celsius
Total Amount of time = 120 Seconds

$$\text{Rate of Change} = \frac{\text{23 Celsius - 24 Celsius}}{\text{120 Seconds}} = \frac{\text{-1 Celsius}}{\text{120 Seconds}}$$

-1 Celsius / 120 Seconds = - ½ Celsius / 1 Minute

2. Rate Of Change for $CaCl_2$

Ending Temperature = 53 Celsius
Starting Temperature = 24 Celsius
Total Amount of time = 120 Seconds

$$\text{Rate of Change} = \frac{\text{53 Celsius - 24 Celsius}}{\text{120 Seconds}} = \frac{\text{29 Celsius}}{\text{120 Seconds}}$$

29 Celsius / 120 Seconds = 14 ½ Celsius / 1 Minute

3. Rate of Change for NH_4Cl

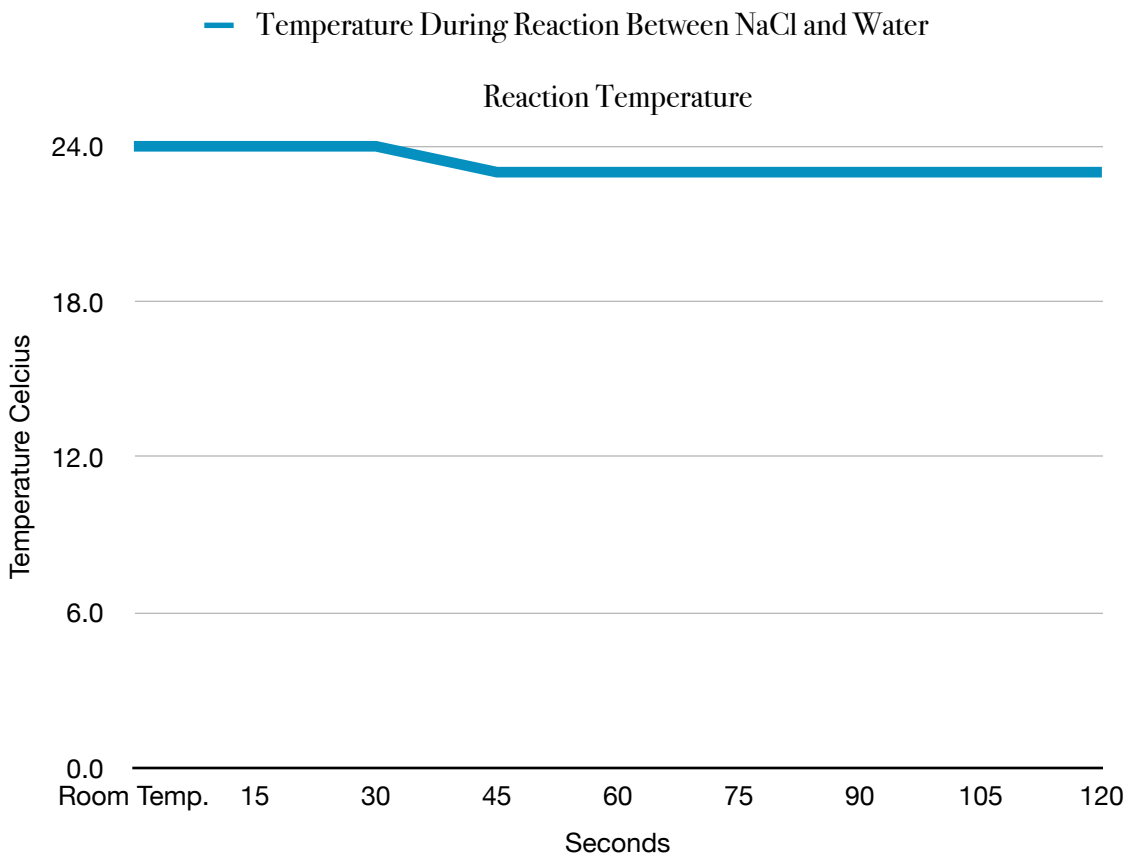
Ending Temperature = 13 Celsius
Starting Temperature = 24 Celsius
Total Amount of time = 120 Seconds

$$\text{Rate of Change} = \frac{13\ \text{Celsius} - 24\ \text{Celsius}}{120\ \text{Seconds}} = \frac{-11\ \text{Celsius}}{120\ \text{Seconds}}$$

-11 Celsius / 120 Seconds = -5 ½ Celsius / Minute

DATA ANALYSIS AND RESULTS:

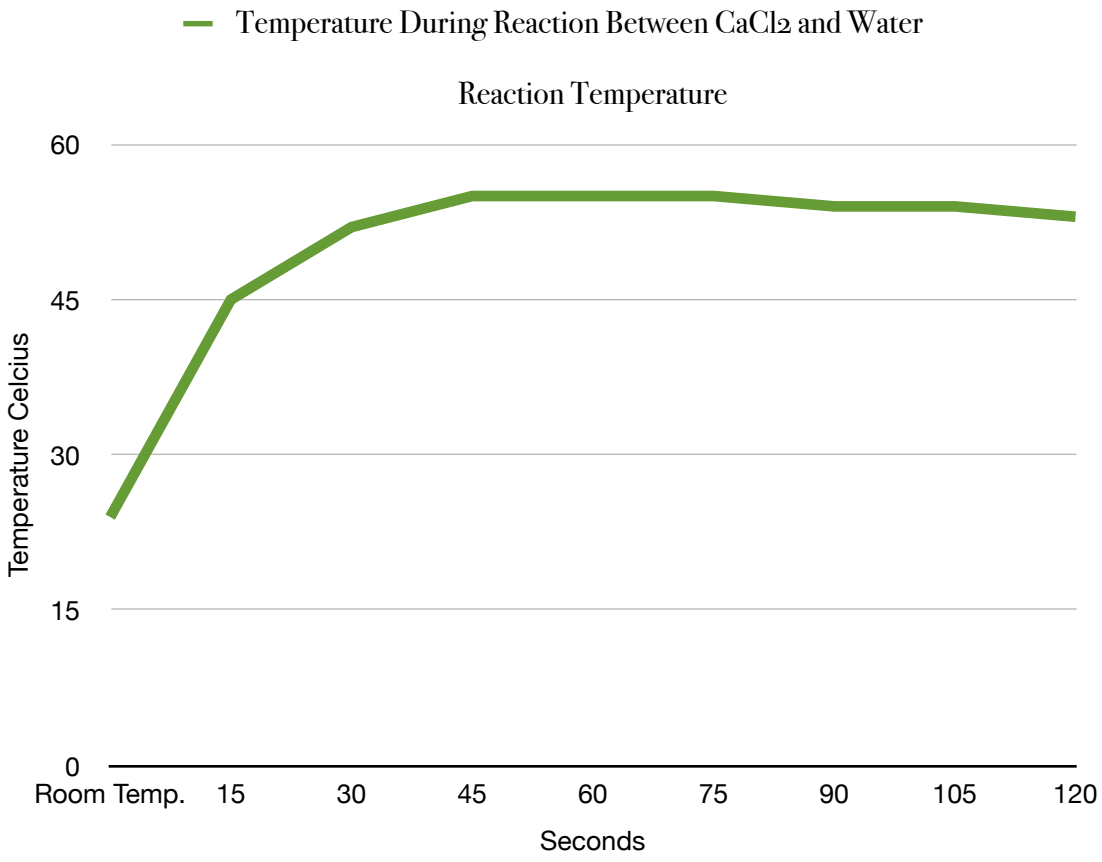
In this lab I measured the temperature of water and other substances mixing. I began by adding 3 grams of NaCl (table salt) into water in a test tube after it had acclimated to room temperature. After fifteen seconds of allowing the NaCl to react to the water we measured the temperature. We continued this every fifteen seconds while recorded observations. To help better understand my data I plotted this graph:



This graph indicates that this chemical reaction was neither exothermic nor endothermic. In this chemical reaction the amount of energy needed for the reaction to take place was equal to the amount of energy created by the reaction. Thus, there was no (or hardly any) need for the chemical reaction to absorb energy (which in this case is heat) from it's environment.

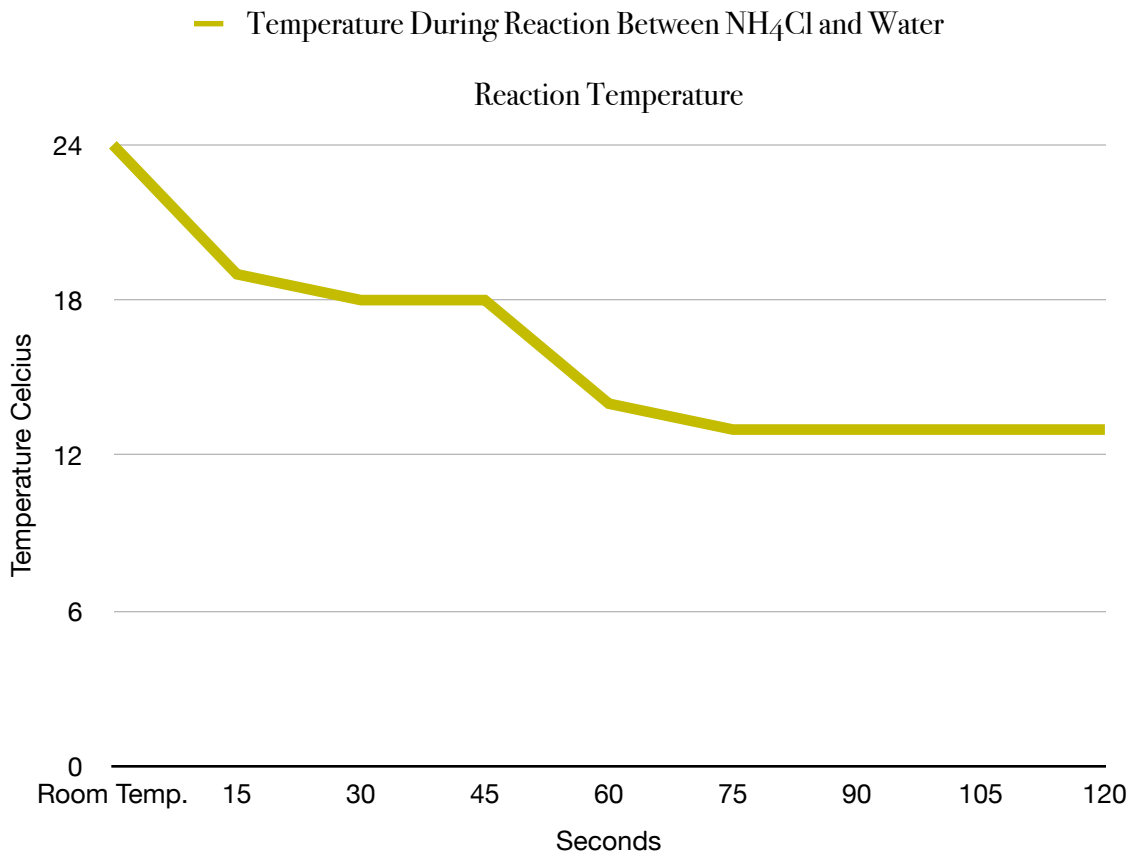
After measuring and recording the temperature we performed the next step of the experiment. It was the exact same procedure however, instead of adding NaCl though we added $CaCl_2$ (Calcium Chlo-

ride). This reaction was much different than the first. Once again we recorded our data and observations. I created this graph to help better understand my data:



This graph clearly indicates that the chemical reaction between water and $CaCl_2$ (Calcium Chloride) is an exothermic reaction. This means that the energy the chemical reaction needed to take place was smaller than the amount of energy the reaction created. Thus, there was an increase in energy (which in this case is heat) to the surrounding environment.

Once again we performed the same procedure as before however we added NH_4Cl (ammonium chloride) to the water. After recording my data and observations I plotted this graph:



This graph clearly indicates that the chemical reaction between NH_4Cl and water is an endothermic reaction. This means that the energy needed for the reaction to take place was greater than the amount of energy the reaction created. Thus, the reaction absorbed energy from it's surroundings (which in this case was also heat) causing a temperature drop.

All of these measurements allowed me to better understand two types of chemical reactions by experiencing them firsthand. They also allowed me to better understand how different chemicals can mix together to form a reaction that is either endothermic or exothermic.

In my calculations I was able to calculate the rate of change in each graph by using this formula:

$$\text{Rate Of Change} = \frac{\text{Ending Temperature - Starting Temperature}}{\text{Total Amount of time}}$$

I calculated that the rate of change when I mixed NaCl and water was ½ Celsius / 1 Minute. This means that every minute after I added the NaCl to the water the temperature would increase approximately ½ Celsius. Because / means per, thus the calculation ½ Celsius / 1 Minute is:
A ½ Celsius increase per 1 Minute.

I calculated that the rate of change when I mixed $CaCl_2$ with water was 14 ½ Celsius / 1 Minute. This means that every minute after I added the $CaCl_2$ to the water the temperature would increase approximately 14 ½ celsius. However this increase would slow down as you can see in my graph. This estimation is only from the results of two minutes and you would need to take results from a longer timeperiod.

I calculated that the rate of change when I mixed NH_4Cl with water was -5 ½ Celsius / Minute. This means that every minute after I added the NH_4Cl to the water the temperature would decrease approximately 5 ½ Celsius. However this decrease would slow down as you can see in my graph. This estimation is also only based on the results of two minutes and you would to take results from a longer timeperiod.

It is certainly worth noting that around 45 seconds into the third test our teacher mixed the NH_4Cl into the water using the thermometer, during all of the tests we did not help the chemicals dissolve giving this a difference in the procedure, this did have an effect on the results with an approximate decrease in temperature of 4.32 degrees centigrade. Other possible sources of error include: Not recording the temperature on the right intervals and to much or to less chemicals added to the water.

QUESTIONS TO CONSIDER:

Is the dissolving of calcium chloride into water exothermic or endothermic? Why?

Dissolving calcium chloride into water is a exothermic reaction. As shown in the graph above the chemical reaction between the calcium chloride and water produces heat. A exothermic reaction is a chemical reaction where the energy needed for the reaction to occur is less than the energy the reaction produces, the energy that is left over is usually a form of heat.

Is the dissolving of ammonium chloride into water exothermic or endothermic? Why?

Dissolving ammonium chloride into water is a endothermic reaction. As shown in the graph above the chemical reaction between the ammonium chloride and water absorbs heat from it's envoirnment. A endothermic reaction is a chemical reaction where the energy needed for the reaction to occur is greater than the energy the reaction produces, thus the enviornment the reaction takes place in becomes cooler.

Are explosions endothermic or exothermic? Why?

Explosions are endothermic reactions because an explosion occurs when a great deal of stored energy is converted into heat very rapidly in a confined area.

Look at the packaging for the heating pack on the lab bench. Describe how you think this product might work.

This product contains iron, charcoal, table salt and water. When these ingredients are exposed to oxygen in the air, a chemical reaction occurs. This reaction is exothermic, which means that the chemical reaction requires less energy to occur than it produces. Thus heating the enviornment it is in.

Look at the packaging for the cold pack on the lab bench. Describe how you think this product might work.

This product contains Ammonium Nitrate and water, when these ingredients are mixed a chemical reaction occurs. This reaction is endothermic, which means that the chemical reaction requires more energy than it creates thus absorbing energy from its environment.

CONCLUSION:

I learned what a chemical reaction is and what an endothermic and exothermic reaction is. I learned what is required for an explosion to take place. I learned how a hot and cold pack works. I learned how things become hot and cold.

My hypothesis was correct. My hypothesis on the definition of an endothermic and exothermic chemical reaction was correct. And my hypothesis on the definition of a chemical reaction was correct. This lab and one of the handouts we received did trigger one question:

What makes a pound of chocolate chip cookies have more energy than a pound of TNT?