1-1-2016

22.0.B Discussion Chemical Heat

Christopher F. Bauer
University of New Hampshire, chris.bauer@unh.edu

Follow this and additional works at: https://scholars.unh.edu/day22

Recommended Citation
https://scholars.unh.edu/day22/37

This Report is brought to you for free and open access by the Fire and Ice at University of New Hampshire Scholars' Repository. It has been accepted for inclusion in Day 22 by an authorized administrator of University of New Hampshire Scholars' Repository. For more information, please contact nicole.hentz@unh.edu.
RECORDER REPORT, Chem 444A "Fire & Ice"

<table>
<thead>
<tr>
<th>Group Member Name</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charles C.</td>
<td>Spokesman</td>
</tr>
<tr>
<td>Jan F.</td>
<td>Manager</td>
</tr>
<tr>
<td>Caleb F.</td>
<td>Recorder</td>
</tr>
</tbody>
</table>

Date: April 14, 2015

Christopher F. Bauer, Principal Investigator.
This material is based upon work supported by the National Science Foundation under Grant No. 1245730.
Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.
Licensed: http://creativecommons.org/licenses/by-nc-sa/3.0/

Initial temp: 72.8°F
Final temp: 69°F


Expt. Qs:
1. This is the first expt. that we've done that explores heat in the context of chemistry.
2. Explain both substances react independently have potential energy & when they come together in a chemical reaction, they transfer their energy & have less energy after the reaction is finished, resulting in a lower temp of the two substances combined. Energy released during the reaction causes fizzing & bubbles & releases heat into the air. (This is our idea, anyway)

PART 1

Exp 1.1: 20 ml vinegar + 1, 2, 3 scoops of baking soda.

Hypothesis: Initial temp: 76°F Final temp: 69°F. fizzed more slowly than first exp.

Obs: (ST 76.5°F; FT 69.0°F) went higher faster than 1 scoop

3 ml of vinegar

Obs: (ST 76.5°F; FT 69.0°F): didn't go as high excess baking powder forms a lump in the middle.

2 scoops of baking soda: went slower than previous.

Exp 1.2: 15 ml vinegar + 2 scoops of baking soda.

Hypothesis: Same as before.

Obs: (ST 76.8°F; FT 66.5°F) very quick reaction no excess baking soda.

Exp 1.3: 20 ml vinegar + 2 scoops of baking soda.

Hypothesis: Same as before.

Obs: (ST 76.8°F; FT 66.5°F) even quicker than previous, up to top.

Exp 1.4: 25 ml vinegar + 2 scoops of baking soda.

Hypothesis: Same as before.

Obs: (ST 76.8°F; FT 66.5°F) even quicker than previous.

Exp 1.5: 5 ml vinegar + 2 scoops of baking soda.

Hypothesis: Same as before.

Obs: (ST 76.8°F; FT 66.5°F) it bit the same.

Exp 1.6: 10 ml vinegar + 2 scoops of baking soda.

Hypothesis: Same as before.

Obs: (ST 76.8°F; FT 66.5°F) it bit the same.

PART 2

Exp 2.1: How does our knowledge of heat--a chemical reaction draws heat from the environment in order to occur. The heat is released because it takes energy to compute the reaction. It's released in the form of gas, resulting heat.

2. What happened differs from the substance's surroundings it is released as the reaction releases energy in this form, solid or a gas.

Exp 2.2: Did they dissolve into a liquid or did the reaction create a liquid?

3rd group: Why did they get so cold? (1st & 2nd)

Q's: Is paraffin a bad conductor? Why didn't oxidation occur with small amount of vinegar?

More: How exactly do exothermic processes occur? How is heat drawn in?

Q's: For ours, the opposite happened--more baking soda, lower temp, why?

Q's: So is using batteries dangerous?
ECORDER REPORT, Chem 444A “Fire & ice”

<table>
<thead>
<tr>
<th>Group Member Name</th>
<th>Role</th>
<th>Date: 4 April 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elisa</td>
<td>Manager</td>
<td></td>
</tr>
<tr>
<td>Marina</td>
<td>Spokesperson</td>
<td></td>
</tr>
<tr>
<td>Monday</td>
<td>Recorder</td>
<td></td>
</tr>
</tbody>
</table>

Initial temp: 23.9°C

After: 31.4°C

We were able to see a visible reaction, the in which, heat was produced. The reaction was also quick. In the past we have observed transfer of heat through conduction, convection, and radiation, this is quite different.

The immediate reaction was bubbling, fizzing, and production of heat. At the molecular level, the molecules gained speed and the water changed from liquid to gas. The liquid left did not mix with the solid - baking soda and calcium chloride.

When changing the amounts, the size of reaction will change. With more baking soda solution, the reaction may decrease, and when increasing the calcium chloride, the reaction will increase in size.

**Experiment 1**

<table>
<thead>
<tr>
<th>Cup 1: (1 scoop)</th>
<th>Cup 2: (2 scoops)</th>
<th>Cup 3: (3 scoops)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial temp: 23.1°C</td>
<td>Initial temp: 26.4°C</td>
<td>Initial temp: 26.0°C</td>
</tr>
<tr>
<td>Temp after: 60.3°C</td>
<td>Temp after: 55.6°C</td>
<td>Temp after: 69.9°C</td>
</tr>
</tbody>
</table>

The resulting solid turned into chunks (precipitate?). The vinegar bubbled and fogged up the glass, leaving condensation on the sides.
Experiment 2

**Cup 1:** (5 mL of baking soda in)
- Initial temp: 30.2°C
- Final temp: 69.8°C
- Temp after run: 86.2°C

**Cup 2:** (10 mL of baking soda in)
- Initial temp: 30.7°C
- Final temp: 83.6°C
- Temp after run: 92.0°C

**Cup 3:** (15 mL of solution)
- Initial temp of calcium chloride: 32.0°C
- Final temp of solution: 79.0°C
- Temp after run: 92°C
- Error? Put solution in in 2 steps

Exothermic process - giving off heat

Reaches peak temp, then drops after reaction.

With more baking soda solution, we saw a greater increase in temperature. This illustrated exothermic process because it gave off heat. Heat comes from the chemical reaction and leaves to heat up the air and glass.

**Question:**
- What determines if a reaction is exothermic or endothermic?
- If these were both solids (powder), how were they able to react so greatly?
- What is the difference between adding more solid or liquid, what are the different results?
- Why did different amounts of reactants not change the results of the reactions (hydrogen peroxide + baking soda experiment)?
- Why does vinegar strip away steel wool's g coating?
- What are the reactants involved causing a production of heat (in steel wool exp) ?
- How is heat transferred in the reaction?
- What created the heat in the battery run?
Klemmayer float: initial = 24.8°C (76.6°F)
the temperature is not changing but there seems to be a pressure change, which is pulling the paraffin in a suction slightly inward.

at 10:30 Two
the steel wool is changing colors!
possibly the color is being changed
in the area where the vinegar has removed the protective coating from
air.

Temp: 10 min in: 28.1°C
15 min in: 24.1°C
20 min in: 30.3°C

This heat exploration is different than others we have done because we are exploring a solid in a contained vessel. We are making the steel wool more susceptible to temperature by removing a natural coating it has instead of adding something to make it more susceptible. We are taking away its insulative properties and making it a poor insulator. Oxidation is occurring and it is heating. This is an exothermic reaction because heat is exiting.

At one
when we initially did the experiment with a small piece of steel wool with less vinegar and the temperature didn't change at all. Since we did part 2 without knowing, we realized we changed the size of steel wool and amount of vinegar at the same time. In order to isolate the variable, we will do the experiment again to isolate amount of vinegar.
Starting temp 24.4

5 min: 25.4°C
10 min: 26.4°C
15 min: 27.5°C
20 min: 28.2°C

Vinegar allows the O₂ to bond to the iron.

Q. Why allow O₂ to bond to the iron?

* What does this mean?

Question bank:

* Each presentation:
  * Potassium hydroxide - effect on absorbent balance in the temperature dropping? Why was the 2:2 ratio so much more drastic?
  * Vinegar, baking soda, heat - what would happen if you trapped the heat?
  * Hydrogen peroxide, baking soda - why did the second reaction not work?
  * Steel wool - why oxygen is being added, how?
  * Water + ammonium chloride - what is the amount of ammonium chloride used (kept constant)
  * Exothermic process - what practical application does this have?
  * Battery - what if a larger sized battery was used instead of more batteries?
1) When ammonium chloride was dropped in it & went to the bottom of the cup, this is different because we have never added assistance in order to remove heat from a mixture. We also usually record temps for a longer period of time. Usually when we do cool something it with ice and a shaker, this instead was direct mixture of two substances to cool over time. Some of the ammonium chloride is rising to the surface. It is diluting throughout the liquid.

2) The ammonium chloride gained heat from the water. This explains the temp of the water &铵离子 in the anion of the ammonium chloride. The longer the time, the more the molecules are able to participate in a heat transfer. The water + the molecules remain in the water & the molecules gain heat from the water. The movement of the ammonium ions up through the water + to the surface exhibits the heat + temp. As the molecules gain more energy, they move faster. Eventually, the ammonium ions heat + rise. When solid is mixed in with the liquid, the mixture solid + liquid. When solid was mixed in with the liquid, the solution reaches thermal equilibrium. Since solid is moving toward a solution, the solution needs to be equal using a gain in temp from water. Solution needs to be equal. We need ammonium chloride.

<table>
<thead>
<tr>
<th>Temp 1</th>
<th>Temp 2</th>
<th>Temp 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>23.3</td>
<td>23.1</td>
<td>0.2</td>
</tr>
<tr>
<td>22.7</td>
<td>21.8</td>
<td>0.9</td>
</tr>
<tr>
<td>22.1</td>
<td>20.8</td>
<td>1.8</td>
</tr>
</tbody>
</table>

Observations seem consistent with part #1. This experiment does further our understanding as it supports our previous hypothesis. What we see illustrates an endothermic reaction because the ammonium chloride is gaining heat from the water.
Heat is going from the water (liq) to the ammonium chloride (solid). We also found that as we added more ammonium chloride, the temperature of the water was significantly more. This indicates the amount of energy transfer is proportional to the amount of ammonium chloride added to the solution.

Questions

1. Ammonium hydroxide + Ammonium nitrate
   • What is it that causes the ν increase?

2. Vinegar, Baking Soda + Heat
   • Besides visual observations, how are you sure the reaction speed increased?

3. Hydrogen peroxide + Baking Soda
   • What do you think contributed to the baking soda results not showing as hypothesized?

4. Steel wool
   • What causes the reaction between vinegar + steel wool?

5. Water + Ammonium chloride
   • Our presentation: Does the state of the substances make a difference? (solid vs liquid)

6. Exothermic Process
   • How much of an effect does the type of container affect the heat increase?

7. Chemical reaction in Battery
   • What evidence do you have of the chemical reaction?
RECORGER REPORT, Chem 444A “Fire & Ice”

Group Member Name  Role  Date: 4/14/15

Miriam  Recorder
Emily  Manager
Amanda  Spokesperson

---

1. Temp. Data before 76.5º after 75.7º  every 30º
   74.4º  75.0º  74.7º  1st trial

2. Trial  Battery Bases After 73º -> 85º
   88.0º  81.0º  82.4º  70.0º  103.0º  104.5º  102.9º  100.9º  101.4º
   98.1º

---

PART 1

1. Can't directly visualize what is happening. Can't see inside battery.
   The experiment involved a chemical reaction and we were not directly adding
   heat to warm the wire. A battery at 75º can heat a wire up to 116º.

2. Saw temperature fluctuate, couldn't see much. COuldn't feel.
   Wire and battery heating
   → not conduction, convection, or radiation

PART 2

1. Expect wire to heat up more with more batteries.

2. 108.6º  116.7º  190.0º  195.0º  Battery
   Much hotter than battery
   Exothermic

---

1. Movement of electrons generate energy which is exhibited as heat energy.

2. Heat is going from the negative end to the positive. The end of the wire on the positive terminal is hotter.
   Electrons move (↑) to (↓). More batteries = more electron travelling.
What is the make up of a battery that causes a chemical reaction to occur?

- Would the temperature difference continue as you used more ammonium nitrate & barium hydroxide?
- Does the fact that baking soda is a solid and hydrogen peroxide is a liquid affect the experiment?
- Why was it important to keep the flask sealed in the steel wool experiment?
- Why some materials/substances more important to certain reactions than other materials/substances.
Initial Temp = 64.8°C

In baking soda, we add the hydrogen peroxide; the temperature immediately decreased. The baking soda sank to the bottom of the cup. Over time, a paste-like material formed.

This exploration of heat is different because there is a chemical reaction taking place. We are not adding or removing heat, the chemical reaction itself is the reason for the decrease in temperature.

That we are seeing is a chemical reaction that is taking in heat. The decrease in temperature can be explained by the reaction between the chemicals. Heat needed to be taken in in order to break apart the bonds.

We hypothesize that as more of the substances are mixed together, the end temp will be lower.

Experiment 1:
- 1 ml Hydrogen Peroxide W/ 1 scoop Baking Soda
- Initial Temp = 64.8°C
- Final Temp = 63.1°C
- Total Change = 1.7°C

Experiment 2:
- 2 scoops Baking Soda W/ 3 ml Hydrogen Peroxide
- Initial Temp = 94.5°C
- Final Temp = 93.4°C
- Total Change = 1.1°C

Experiment 3:
- 3 scoops Baking Soda W/ 5 ml Hydrogen Peroxide
- Initial Temp = 94.5°C
- Final Temp = 93.4°C
- Total Change = 1.1°C

The experiments add to our understanding of heat. Based on our results, except for 1, the more reactants that were added, the greater the temperature change. More heat will be needed to break the bonds for the reaction to take place. More bonds must be breaking apart than are being made because energy (heat) is being taken in from the environment.

The heat is being taken from the environment, which is why we see the decrease in temperature. The heat is going into the molecular bonds in order to cause a chemical reaction.
**Question Bank:**

**Why are some exothermic and some reactions endothermic?**

**Endothermic Reaction of Barium Hydroxide + Ammonium Nitrate**

- If even more of each substance was added, could you eventually see water freeze underneath as a result?

**Negar, Baking Soda, & Heat**

- If enough of each substance was added, would it all turn to the gas phase?

**Feel Wool**

- What was occurring that caused the soil wool to change color?

**Exothermic Reaction Between Water and Ammonium Chloride**

- How did the water molecules cause the Ammonium Chloride molecules to speed up? Conduction?

**Thermic Process**

- Why was there condensation? And why did more appear when more baking soda was added?

**Chemical Reaction in a Battery**

- Why did the battery physically change? What caused the coating to peel off? What keeps electrons from flowing across the battery on the inside?
We aren't producing or removing any heat. We don't have a source of heat. Instead it's a chemical reaction.
We think it might be an endothermic reaction. The mix of the two is making water, ammonia, and barium nitrate.

The heat is coming from the surrounding air and it is going to the forming/breaking of chemical bonds. It makes sense that the temperature dropped more when we increased the mixture size because we needed more heat from the surroundings.

Questions: Is the gas carrying heat out or is the heat stored in chemical bonds? (vinegar/baking soda)

Which one more endothermic? (showed a greater change) vinegar or peroxide? (peroxide & baking soda)

What was the cutting on the steel that the vinegar removed?
What differences between baking soda and vinegar cause the chemical reaction they saw (early / baking soda)?

How did they measure the temperature in the mine? (Battery?)

Core questions: how did you observe changes in density? (water/ammonium)
Vinegar, Baking Soda, & Heat

Heat is released in the form of a gas in the bubbles because of the energy expended in the reaction so the combined mixture has a lower temp than initially.

* constant amt. of baking soda
+ more vinegar = lower temp
2 scoops + 10mL = 64.5°
+ 20mL = 65.2
+ 30mL = 62.1

Jon Charles Cale
Exothermic Process

- Heat is leaving the chemical reaction and heating the glass and surrounding air

Initial temp: 30.2°C
- Mixture steamed
- Bubbled
- Sizzling noise
- Solidified on bottom of glass
- Condensation

Final temp:
- 64.3°C

30.7°C
- 5 mL of vinegar
- 2 scoops of CaCl₂

86.2°C
- 10 mL of vinegar
- 2 scoops of CaCl₂

32.0°C
- 15 mL of vinegar
- 2 scoops of CaCl₂

(1 scoops of baking soda last)

- Experiments done with vinegar still experienced a temperature increase, but was not as reactive as the baking soda solution
- When CaCl₂ was added in greater quantities (1, 2, 3 scoops) the temperature rose, but not as significantly as when the baking soda solution was increased

Christopher F. Bauer, Principal Investigator.
This material is based upon work supported by the National Science Foundation under Grant No. 1245730.
Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.
Licensed: http://creativecommons.org/licenses/by-nc-sa/3.0/
**Steel Wool**

**PART 1**
- Small piece of steel wool
- Little amount of vinegar
- No change in temp.

**PART 2 - Initial temp: 24.8°C**
- Large piece of wool
- Large amount of vinegar
- After 10 min: 28.1°C
- 15 min: 29.4°C
- 20 min: 30.3°C

**PART 3 - Initial temp: 24.4°C**
- Small piece of wool
- Large amount of vinegar
- After 10 min: 26.4°C
- 15 min: 27.5°C
- 20 min: 28.2°C

Temp Increases
Heat is exiting, but trapped

Part soaked in vinegar

Oxidation

---

Christopher F. Bauer, Principal Investigator.
This material is based upon work supported by the National Science Foundation under Grant No. 1245730.
Any opinions, finding and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.
Licensed: http://creativecommons.org/licenses/by-nc-sa/3.0/
Endothermic Reaction Between Water + Ammonium Chloride

Initial Temp: 23.3 °C
End Temp: 23.1 °C

- Heat transfer
- Water
- Ammonium Chloride

- Heat is transferred from $H_2O \rightarrow NH_4Cl$
- $NH_4Cl$ gains heat (kinetic energy), lowers density, molecules rise
- High activity of $H_2O$ molecules causes $NH_4Cl$ molecules to move faster

License: http://creativecommons.org/licenses/by-nc-sa/3.0/
Chemical Reaction in a Battery

- Electrons travel (-) to (+)
- More batteries = more electrons traveling
- No other hot object heating it, it heats itself

One Battery
Initial wire temp: 76.5°F
30 sec: 81.0°F
1.5 min: 103°F
2 min: 104.8°F
Initial battery: 73°F
Final battery: 83°F

Two Batteries:

<table>
<thead>
<tr>
<th>Time</th>
<th>Temp (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 sec</td>
<td>108.6</td>
</tr>
<tr>
<td>30 sec</td>
<td>116.7</td>
</tr>
<tr>
<td>45 sec</td>
<td>110</td>
</tr>
<tr>
<td>1 min</td>
<td>195</td>
</tr>
</tbody>
</table>

Battery @ 180 after
When \( \text{H}_2\text{O}_2 \) was kept constant, as more baking soda was added, the resulting paste was colder.

When baking soda was kept constant, as more \( \text{H}_2\text{O}_2 \) was added, the resulting paste was colder (except for 15mL \( \text{H}_2\text{O}_2 \) for some unknown error).

When a chemical reaction occurs, breaking old bonds requires energy input, while making new bonds releases energy. In this case, more bonds are broken than are made, so heat is pulled from the environment to the rxn.
Endothermic Reaction of barium hydroxide and ammonium nitrate

<table>
<thead>
<tr>
<th>Initial $T^\circ C$</th>
<th>Final $T^\circ C$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1</td>
<td>17.8°C</td>
</tr>
<tr>
<td>2:2</td>
<td>1.0°C</td>
</tr>
<tr>
<td>1:2</td>
<td>18.8°C</td>
</tr>
<tr>
<td>2:1</td>
<td>19.8°C</td>
</tr>
</tbody>
</table>