Honors Chemistry Hour\_\_\_\_\_ Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
Dr. Wexler
Lab: Heat of Solution and Heat of Reaction (HS-PS1-4)
Date\_\_\_\_\_

**Background:**
Two types of processes commonly involve energy changes – chemical reactions and the dissolving process. Heat of reaction is the overall energy absorbed or released during a chemical reaction. Heat of solution is the overall energy absorbed or released during the solution process. Both are the difference between the energy absorbed to break bonds and the energy released when new bonds are formed.

With regard to heat of solution, when an ionic compound dissolves in water, energy is needed to break the ionic bonds of the crystal. As the ions attach to the water molecules and become hydrated, energy is released. The process is endothermic if the energy needed to break the bonds is greater than the energy released when the ions attach to water. The reaction is exothermic if the energy needed to break the bonds is less than the energy released when the ions attach to water.

Demo: Heat of solution for KCl vs NaOH <http://www.youtube.com/watch?v=o7adWQqvDUU>

Which of these two compounds is exothermic? Explain what this means in terms of the relative amounts of energy absorbed and released.

Which of these two compounds is endothermic? Explain what this means in terms of the relative amounts of energy absorbed and released.

**Objectives:**-Measure the temperature changes of two different chemical processes – dissolving in water (solution) and chemical
 change (reaction).
-Understand the difference between exothermic and endothermic processes.

**Special Materials:**4M H2SO4 Foam cup Ammonium sulfate (NH4)2SO4
4M HCl 0.2g aluminum foil Sodium bicarbonate NaHCO3
2M NaOH Digital thermometer 50mL graduated cylinder Digital scale

**Procedure:**
**Part A: Heat of Solution for Sulfuric acid**
1. Add 40mL water to a foam cup.
2. Measure and record the initial temperature of the water in the cup (Data Table 1)
3. Add 10mL of 4M H2SO4 to the cup. Stir.
4. Measure and record the new temperature (Data Table 1)

**Part B: Heat Solution for Ammonium sulfate**1. Add 30mL water to a foam cup.
2. Measure and record the initial temperature of the water in the cup (Data Table 2)
3. Add 5g (NH4)2SO4 to the cup. Stir.
4. Measure and record the new temperature (Data Table 2)

**Part C: Heat of Reaction – HCl + NaOH**1. Add 20mL 4M HCl to a foam cup.
2. Measure and record the initial temperature of the acid in the cup (Data Table 3)
3. Add 20mL 2M NaOH to the cup. Stir.
4. Measure and record the new temperature (Data Table 3)

**Part D: Heat of Reaction – HCl + Al**1. Add 30mL 4M HCl to a foam cup.
2. Measure and record the initial temperature of the acid in the cup (Data Table 4)
3. Add 0.2g Al (aluminum foil). Wait until the aluminum is totally consumed.
4. Measure and record the new temperature (Data Table 4)

**Part E: Heat of Reaction – NaHCO3 + HCl**1. Add 20mL 4M HCl to a foam cup.
2. Measure and record the initial temperature of the acid in the cup (Data Table 5)
3. Add 5g NaHCO3.
4. Measure and record the new temperature (Data Table 5)

**Results:**

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| Data Table 1 |
| Part A: Heat of Solution for Sulfuric Acid |
| Initial water temperature |  |
| Final water temperature after adding H2SO4 |  |
| Temperature change |  |
| Exothermic or endothermic? |  |

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| Data Table 2 |
| Part B: Heat of Solution for Ammonium Sulfate |
| Initial water temperature |  |
| Final water temperature after adding (NH4)2SO4 |  |
| Temperature change |  |
| Exothermic or endothermic? |  |

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| Data Table 3 |
| Part C: Heat of Reaction for NaOH + HCl |
| Initial acid temperature |  |
| Final temperature after adding NaOH |  |
| Temperature change |  |
| Exothermic or endothermic? |  |

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| Data Table 4 |
| Part D: Heat of Reaction for Al + HCl |
| Initial acid temperature |  |
| Final temperature after adding Al |  |
| Temperature change |  |
| Exothermic or endothermic? |  |

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| --- |
| Data Table 5 |
| Part E: Heat of Reaction for Sodium Bicarbonate and HCl |
| Initial acid temperature |  |
| Final temperature after adding Al |  |
| Temperature change |  |
| Exothermic or endothermic? |  |

**Analysis:**1. What is the experimental evidence that indicates whether a given reaction is exothermic or endothermic?

A. exothermic:

B. endothermic:

2. Would the heat of solution of sulfuric acid (Part A) have been different if a higher concentration of sulfuric acid had been used? Explain.

3. For Part B, compare the amounts of energy used to break ionic bonds of the salt crystal with the energy released when new bonds form between the salt ions and water molecules. How do you know which amount is greater?

4. For Parts C and D, these are chemical reactions that occur spontaneously. This means that energy is not needed to start the reaction. If energy is released, then the reaction will be exothermic.

In Part E, the addition of sodium bicarbonate to hydrochloric acid resulted in cooling.

A. Is this exothermic or endothermic?

B. Explain why.

**Research Questions:**1. Explain how a cold pack, often used in emergency or sports medicine, works.

2. Combustion of fuels is an exothermic reaction. Explain some ways in which the heat energy from this type of reaction can be harnessed to do useful work.

3. With regard to air conditioning (cooling):
A. Explain why it would not be practical to air-condition a home by using an endothermic chemical reaction.

B. How is air-conditioning accomplished in practice?