Heats of Solution and Reaction

Introduction:

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 solvation process. Both are the difference between the energy absorbed to break bonds and the energy released when new bonds form. In this activity you will investigate three examples of heat of solution and one example of heat of reaction and calculate the heat given off in each case.

The first 2 examples of heat of solution is the heat transferred when ionic solids (ammonium chloride and calcium chloride) dissolve in water. The third is the heat of solution when concentrated sulfuric acid is added to water.

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.

We can calculate the overall heat change of reactions using calorimetry. In calorimetry the heat given off by a process is measured through the temperature change in another substance. In our experiment, the temperature change will occur in water. Because of the law of conservation of energy, any energy given off in a process must be absorbed by something else. We will make the assumption that the energy given off in the reactions will be absorbed by the water and cause a temperature change. This temperature change can be measured and then used to calculate the heat through the equation: $Q=mC\Delta T$.

Procedures:

Part 1: Heat of solution of Sulfuric Acid

1. Measure the mass of an empty calorimeter
2. Fill calorimeter about 2/3 full of water.
3. Measure the initial temperature of the water
4. Measure the mass of the water and the calorimeter together.
5. Measure out about 1 mL of concentrated sulfuric acid
6. Carefully add the acid to the calorimeter and gently stir with the thermometer.
7. Record the highest temperature.
8. Measure the mass of the solution
9. Pour solution into waste beaker for sulfuric acid.

Part 2: Heat of solution of calcium chloride and ammonium chloride

Do the following steps for both calcium chloride and ammonium chloride separately

1. Measure the mass of an empty calorimeter
2. Fill calorimeter about 2/3 full of water.
3. Determine the mass of the water.
4. Measure the initial temperature of the water.
5. Measure out 0.5 g of the salt and add to the water
6. Record the highest/lowest temperature.
7. Solution can be poured down the drain.

Part 3: Heat of neutralization

1. Using a graduated cylinder, measure 5.0 mL of 1.0 M HCl.
2. Pour the acid into an empty calorimeter
3. Insert a thermometer into the cup of acid. Record the temperature of the acid when it stabilizes.
4. Using a clean graduated cylinder, measure 5.0 mL of 1.0 M NaOH. Add the solution carefully to the HCl, stirring with the thermometer.
5. Record the highest temperature attained.
6. Use pH paper to determine if solution is neutral. If within a pH 0f 6-8, it can be poured down the drain. If not, let me know.
7. Weigh the mass of the mixture in the calorimeter

Analysis:

1. Determine whether each process was exothermic or endothermic and explain how you made your decision.

Show calculations clearly (this means a label saying what is being calculated, the equation, how the numbers are put into the equation, any unit analysis that is done, and your final answer with correct significant figures) and put results into a properly labeled table.

2. Calculate the heat given off in reaction (for the sulfuric acid you will need the density: 1.84 g/mL and the Molarity: 18 M)
3. Calculate the heat per mole of reactant. (
    a. DO NOT USE MOLAR MASS of SULFURIC ACID (that is incorrect and DO NOT USE 22.4 L – that is for gases only).
    b. You will need to know: Concentrated sulfuric acid: 18 M, density = 1.84 g/cm^3
4. Write chemical equations for reactions that occurred and include heat of reaction for each.
5. Explain why it is not necessary to know the temperature just after the two substances have been mixed.
6. What controls were used in these experiments?
7. If you were to compare the heat of each reaction, is it important to have used the same mass of reactant or the same mass of water? Why or why not?

Data:
(20 pts) Make an appropriate data table that will allow you to calculate the heat given off per mole of reactant. It must include ALL measured data (e.g. don't record the change in temp, record the initial and final and make another column to include the change in temperature)

Remember to include constants/givens, and observations.

Analysis:

1. (5 pts) Determine whether each process was exothermic or endothermic and explain how you made your decision.

Show calculations clearly (this means a label saying what is being calculated, the equation, how the numbers are put into the equation, any unit analysis that is done, and your final answer with correct significant figures) and put results into a properly labeled table.

2. (16 pts) Calculate the heat given off in reaction
3. (8 pt) Calculate the heat per mole of reactant
    a. You may need some additional data: Concentrated sulfuric acid: 18 M, density = 1.84 g/cm^3
4. (8 pts) Write chemical equations for reactions that occurred and include heat of reaction for each.
5. (2 pts) Explain why it is not necessary to know the temperature just after the two substances have been mixed.
6. (5 pts) What controls were used in these experiments?
7. (2 pts) If you were to compare the heat of each reaction, is it important to have used the same mass of reactant or the same mass of water? Why or why not?
8. (14 pts) Write an error analysis for this experiment.

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2. (16 pts) Calculate the heat given off in reaction
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4. (8 pts) Write chemical equations for reactions that occurred and include heat of reaction for each.
5. (2 pts) Explain why it is not necessary to know the temperature just after the two substances have been mixed.
6. (5 pts) What controls were used in these experiments?
7. (2 pts) If you were to compare the heat of each reaction, is it important to have used the same mass of reactant or the same mass of water? Why or why not?
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