GENERAL CHEMISTRY
LAB COMPONENT CHE101L
CONTENT: LAB 3

Dissolution Reactions: Heats of Dissociation

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EXPERIMENT 3

DISSOLUTION REACTIONS: HEATS OF DISSOCIATION

Heats (exothermic or endothermic) are associated with chemical reactions. Quantity of heat evolved or absorbed is directly proportional to the amount reacted. Consider the reaction:

$$MgSO4(s) + H_2O\ (l) \longrightarrow Mg^{2+}(aq.) + SO_4^{2-}(aq.) \pm \text{heat}$$

Heat could be generated or absorbed in this reaction. When heat is generated/released from a chemical reaction it is called exothermic reaction (you can feel it by touching the reaction container (warmer) and when heat is absorbed the reaction is called endothermic (colder). When reactions occur in a reaction vessel (*e.g.,* Beaker) in aqueous condition, formation and dissociation of chemical bonds occur simultaneously. Bond formation and dissociation involves heat energy of the system which is expressed by the term Q which is called enthalpy.

PROBLEM STATEMENT: *Is heat energy related to chemical reactions, how?*

This experiment is subdivided into two parts:

I. QUALITATIVE & II. QUANTITATIVE

PART I. QUALITATIVE

DATA COLLECTION:

Place about 30 mL of distilled water into a 50 mL beaker. Suspend a thermometer (having 0.1^{0}C division mark) into the beaker using thermometer clamp and ring stand. Please make sure that the thermometer is not touching the bottom of the beaker, as any movement of the beaker could break the thermometer. Record the temperature of water in the beaker in every 30 seconds for 240 seconds.

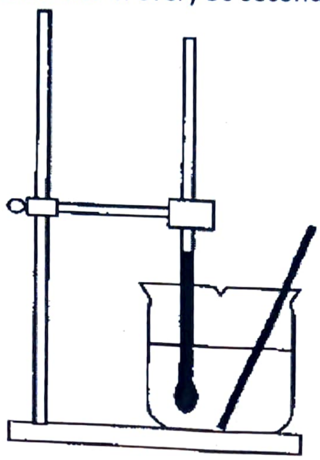


FIGURE 1: Experimental setup for dissolution reaction

Place a moderate amount (which would be 1 to 3 cm^3) of supplied anhydrous magnesium sulfate ($MgSO_4$) to the beaker. Mix vigorously with the glass rod for 5 minutes. Record your observations. **(2 points)**

Initial Tem Final tem. Type

Magnesium sulfate, $MgSO_4$ → 24.9°C - 26.1°C - Exothermic

Repeat this procedure with each of the following compounds: **(2 points)**

a. Sodium Nitrate, $NaNO_3$

b. Sodium Chloride, NaCl → 25°C - 24.2°C - Endothermic

c. Hydrated Calcium Chloride, $CaCl_2.2H_2O$ → 24.5°C - 25°C - Exothermic

d. Ammonium Nitrate, NH_4NO_3 → 25.25°C - 24.1°C - Endothermic

DATA ANALYSIS:

What are the similarities and differences in the behavior of these compounds? Can you find out any generalization concerning all chemical reactions here? What conclusion can be drawn from these data? **(4 points)**

Similarities in the behaviour of these compounds are all dissociates in water to form ions. and all results in change in temperature.

If we talk about differences, then in compound, $MgSO_4$ and $CaCl_2 \cdot 2H_2O$, the temperature rises from 24.9°c to 26.1°c and 24.5°c to 25°c respectively. So, when they reacts with water they release energy to the ~~so~~ surrounding by increasing temperature. This is why these reactions are Exothermic reaction. Again, In NaCl and NH_4NO_3, the temperature falls from 25°c to 24.2°c and 25.25°c to 24.1°c in 30 sec. So they absorb energy from the surrounding by lossing temperature. Thus, these reactions are Endothermic reaction.

Conclusion: Heat energy is related to chemical reactions. When heat energy is released, it is called Exothermic and when energy absorbed it is called endothermi

PART II. QUANTITATIVE

DATA COLLECTION:

a. Accurately weigh a 3 to 5 gm sample of $MgSO_4$ on the analytical balance. Record the exact mass here. For 4 different trials below measure four different weight samples (e.g., 1,2, 4 & 5 grams respectively).
b. Suspend the thermometer into a polystyrene cup/coffee cup. Make sure of the thermometer is not touching the bottom of the cup. Measure 20 mL of distilled water by a volumetric cylinder into the cup and stir for 240 second. Record the temperature in every 20 seconds. After 240 seconds add $MgSO_4$ with vigorous mixing while continuing to record data for 5 minutes.
c. Determine the temperature change, ΔT, for the reaction. This can be done from the difference of the highest temperature minus the slope of the line go through the points from first 240 seconds of data.
d. Draw a temperature vs. time graph. Draw the best curve through the points and point out what is happing in each part of the curve.

DATA TABLE:

TRAILS

(I) Mass of $MgSO_4$ __0.5 gm__	
Time (s)	Temp(^{0}C)
20	25.1°C
40	25.1°C
60	25.1°C
80	29°C
100	29.9°C
120	30°C
140	30°C
160	30°C
180	30°C
200	29.9°C
220	29.9°C
240	29.8°C
260	29.8°C
280	29.2°C
300	29°C

(II) Mass of $MgSO_4$ __1.0 gm__	
Time(s)	Temp(^{0}C)
20	24.75°C
40	24.75°C
60	24.75°C
80	29°C
100	29.25°C
120	29.5°C
140	30°C
160	30.25°C
180	30.5°C
200	30.5°C
220	30.5°C
240	30.5°C
260	30.5°C
280	30.5°C
300	30.5°C

(III) Mass of $MgSO_4$ __1.5 gm__	
Time (s)	Temp(^{0}C)
20	24.75°C
40	24.5°C
60	24.5°C
80	28.0°C
100	29.5°C
120	29.9°C
140	30.0°C
160	30.5°C
180	30.75°C
200	30.9°C
220	31.0°C
240	31.0°C
260	31.0°C
280	31.1°C
300	31.0°C

(IV) Mass of $MgSO_4$ __2.0 gm__	
Time(s)	Temp(^{0}C)
20	23.0°C
40	23.00°C
60	23.0°C
80	25.0°C
100	32.75°C
120	33.0°C
140	33.0°C
160	33.0°C
180	33.5°C
200	33.75°C
220	33.25°C
240	33.0°C
260	33.0°C
280	32.75°C
300	32.25°C

DATA ANALYSIS

1. What do you understand form the data you recorded and from the other trials?**(4 points)**

from the recorded data and other trials, we can say that, adding $MgSO_4$ into the water, temperature of water rises generally in all. Exothermic reaction occur. upto one point, the temperature increased and after that the temperature start to decrease. Also, the highest was 33.75°C which first occured at 200 seconds and the highest temperature of each experiment was different due to change in mass of $MgSO_4$ added in each trials.

2. Calculate the heat, Q & moles, n, of the reaction. Take help from the equitation Q = C x M x ΔT. Assume C = 4.18 Joules/gram °C and M is the mass of water (take the water density as 1.00 grams/cm³). **(4 points)**

We know that. heat $Q = C \times M \times \Delta T$ and $n(\text{mole}) = \frac{\text{mass}}{\text{molar mass}}$

Here. mass of water $M = \rho V = 1 \times 20 = 20$ gram $[\rho = 1 \text{ gram/cm}^3, V = 20 \text{ ml}]$

mass of $MgSO_4$ = ~~24+32+~~ $(24 + 32 + (16 \times 4))$

$= 120$ gram

$C = 4.18$ Joules/g

So,

$Q_1 = 4.18 \times 20 \times (30 - 25.1)$
$= 409.6$ J

$n_1 = \frac{0.5}{120}$
$= 0.0042$ mole

$Q_2 = 4.18 \times 20 \times (30.5 - 24.75)$
$= 480.7$ J

$n_2 = \frac{1}{120} = 0.0083$ mole

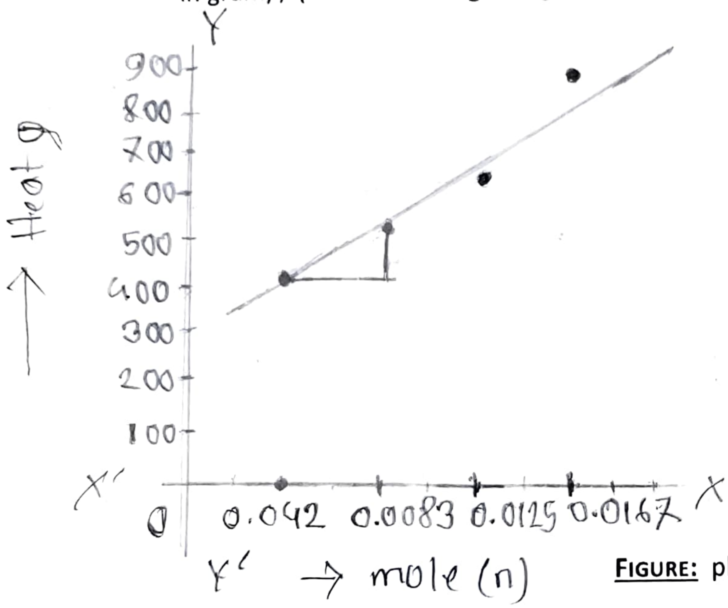
$Q_3 = 4.18 \times 20 \times (31.1 - 24.5) = 551.8$ J, $n_3 = \frac{1.5}{120} = 0.0125$ mole

$Q_4 = 4.18 \times 20 \times (33.75 - 23)$
$= 898.7$ J

$n_4 = \frac{2}{120} = 0.0167$ mole

(Ans)

3. Plot the collected data as moles, n vs. Q. Number of moles can be calculated as n = (mass of sample in gram) / (molecular weight in grams/mole). Try to find an algebraic equation. **(4 points)**



Here, $m = \dfrac{(980.97 - 409.6)}{(0.0083 - 0.0042)}$

$= 17.3 \times 10^3$

so, the linear equation is

$y = mx + c$

$= (17.3 \times 10^3)x + 300$

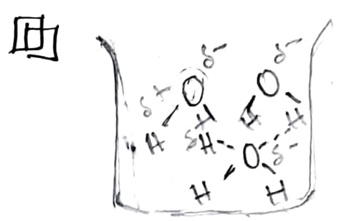
(Any

FIGURE: plot here

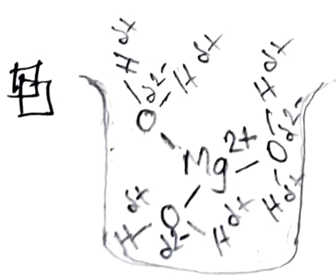
MENTAL MODEL: Use the chemical equation given above to represent the dissolution reaction in this experiment. Draw a picture(s) which describes what is happening in atomic or in molecular level. How heat release or absorbed can be described from these pictures? **(5 points)**

• Chemical equation is: $MgSO_4 \rightarrow Mg^{2+} + SO_4^{2-}$

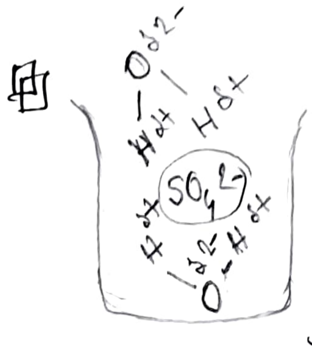
$MgSO_4 + H_2O \rightarrow Mg^{2+} + SO_4^{2-} + H^+ + OH^-$



Water molecules have Hydrogen bonds to hold them together. When the hydrogen bonds break down inside water it requires energy.. so it is an endothermic process.



When $MgSO_4$ is added the negative dipole oxygen get surrounded to the positive ion and this ordered arrangement of water releases energy called hydration enthalpy and this process is exothermic process.



The positive dipole of hydrogen surrounds the negative ion and release energy. In this case, hydration enthalpy is greater than latice energy. so, the solid structure breaks and dissolved. The surplus energy is used up to increase the temperature.