General Chemistry
Lab component CHE101L
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Content: Lab 1

Dissolution Reactions: Heats of Dissociation

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Experiment 1

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°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.

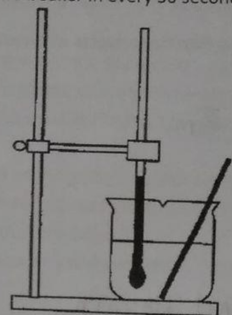


Figure 1: Experimental setup for dissolution reaction

Place a moderate amount (which would be 1 to 3 cm³) of supplied anhydrous magnesium sulfate ($MgSO_4$) to the beaker. Mix vigorously with the glass rod for 5 minutes. Record your observations. **(2 points)** 25°c – 27°c

$MgSO_4$ → 25°c – 27°c → Exothermic

Exothermic

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

a. Sodium Nitrate, $NaNO_3$ → 25°c – 24.5°c → Endothermic

b. Sodium Chloride, NaCl → 24.75°c – 24.5°c → Endothermic

c. Hydrated Calcium Chloride, $CaCl_2.2H_2O$ → 24.5°c – 25.25°c → Exothermic

d. Ammonium Nitrate, NH_4NO_3 → 24.25°c – 24°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)

Heats are associated with the chemical reaction. At first all compounds dissolved and chemical bond breaks. Energy is required to break the bonds. Then chemical reaction occurs and new bonds forms. Energy transforms and for some heat realeased and for some heat absorbed. If total heat of energy of the system is greater than zero then the reaction is endothermic. If total heat of energy of the system is less than zero then the reaction is exothermic.

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__			(II) Mass of $MgSO_4$ __1.0 gm__	
Time (s)	Temp(^{0}C)		Time(s)	Temp(^{0}C)
20	26.0		20	27.1
40	27.3		40	28.0
60	28.0		60	28.3
80	30.0		80	29.3
100	30.1		100	30.5
120	30.5		120	31.5
140	30.5		140	31.5
160	30.5		160	31.5
180	30.5		180	32.0
200	29.8		200	31.8
220	29.5		220	31.5
240	29.1		240	31.0
260	29.2		260	31.0
280	28.8		280	30.8
300	28.1		300	30.8

Water

(III) Mass of $MgSO_4$ __1.5 gm__			(IV) Mass of $MgSO_4$ __2.0 gm__	
Time (s)	Temp(^{0}C)		Time(s)	Temp(^{0}C)
20	25.5		20	27.5
40	25.5		40	28.5
60	25.5		60	29.5
80	27		80	30.5
100	29		100	31.5
120	32		120	32.5
140	33.25		140	32.5
160	33.25		160	32.5
180	33		180	32.3
200	33		200	31.5
220	33		220	31.5
240	32.75		240	31.0
260	32.5		260	31.0
280	32.25		280	30.8
300	32.25		300	30.8

Data Analysis

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

Quantity of the heat evolved or absorbed is directly proportional to the amount reacted. Heat changes with the time and goes to its highest point. than started decreasing.

2. Calculate the heat, Q & moles, n, of the reaction. Take help from the equitation $Q = C \times M \times \Delta T$. Assume C = 4.18 Joules/gram ^{0}C and M is the mass of water (take the water density as 1.00 grams/cm^3). **(4 points)**

For 1.5 g $MgSO_4$

$Q = M \cdot C \cdot \Delta T$

$= 20 \times 4.18 \times 7.75$

$= 647.9$ J

Ans

here

M = 20 g

c = 4.18 J/g

$\Delta T = (33.25 - 25.5)$

$= 7.75$ °C

$MgSO_4 = 120$ g

120 g $MgSO_4 \longrightarrow$ 1 MOL

1 g $MgSO_4 \longrightarrow \frac{1 \times 1}{120}$ MOL

1.5 g $MgSO_4 \longrightarrow \frac{1.5}{120}$ MOL

$= 0.0125$ MOL

Ans

For 0.5 g $MgSO_4$

Q = 376 J

n = .004 MOL

For 1 g $MgSO_4$

Q = 409 J

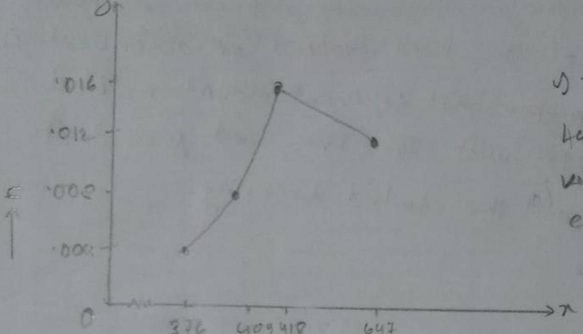
n = .008 MOL

For 2 g $MgSO_4$

Q = 418 J

n = 0.016 MOL

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)**



$y = mx + c$

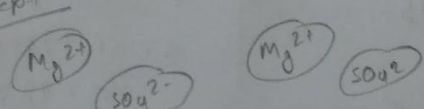
Looks like one kind of linear equation.

FIGURE: plot here → Q

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)**

$MgSO_4 + H_2O \rightarrow Mg^{2+} + SO_4^{-} \pm$ Heat

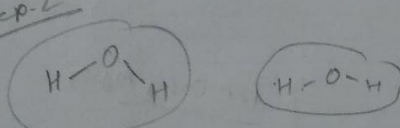
step-1



→ ionic bond broken

$\Delta H_{MgSO_4} = (+)$ kcal/mol

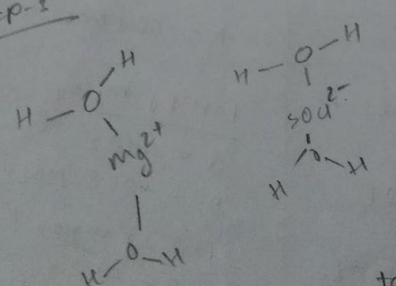
step-2



→ Hydrogen bond broken

$\Delta H_{H_2O} = (+)$ kcal/mol

step-3



→ ion-dipole interaction

$\Delta H_{solvation} = (-)$ kcal/mol

total = (−) kcal/mol