**GENERAL CHEMISTRY**

**LAB COMPONENT CHE101L**

**GUIDED INQUIRY EXPERIMENTS**

**CONTENT: LAB 3**

# DISSOLUTION REACTIONS: HEATS OF DISSOCIATION

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**DATE** 15-05-2024 **TIME** 12:15PM

29-05-2024 12.15PM

**NAME OF THE INSTRUCTOR** Dr. Oly Ahmed

**SIGNATURE & DATE** Mastoora Mafiz Arman 29-05-2024

**REPORT SUBMISSION DATE (ASSIGNED BY INSTRUCTOR)** ..............................

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 water temperature : 26°C
Final solution temperature : 27°C
Since the temperature increased, it is exothermic.

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

a. Sodium Nitrate, $NaNO_3$ (Initial : 26°C , Final : 25°C) → Endothermic

b. Sodium Chloride, NaCl (Initial : 26°C , Final : 25°C) → Endothermic

c. Hydrated Calcium Chloride, $CaCl_2.2H_2O$ (Initial : 26°C, Final : 27°C) ↳ Exothermic

d. Ammonium Nitrate, $NH_4NO_3$ (Initial : 29°C, Final : 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)**

Similarities in the behavior of these compounds are all dissociate in water to form ions and all results in change of temperature. If we talk about differences, then in compound $MgSO_4$ and $CaCl_2.2H_2O$. the temperature rises from 26°C to 27°C respectively. So, when they reacts with water they release energy to the surrounding by increasing temperature. This is why these reactions are Exothermic reaction. On the other hand, in NaCl and $NaNO_3$, the temperature falls from 26°C

25°C, so, they absorb energy from the surroundings by lossing temperature. These reactions are Endothermic reaction.

..., Heat energy is related to chemical reactions, when energy is released, it is called Exothermic and when it absorbed, it is called Endothermic.

## 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.

e. Repeat the whole procedure with $NaNO_3$

**Data Table 1:**

**Trails**

| (I) Mass of $MgSO_4$ 0.5 gm | | | (II) Mass of $MgSO_4$ 1.0 gm | |
|---|---|---|---|---|
| Time (s) | Temp(°C) | | Time(s) | Temp(°C) |
| 20 | 26°C | | 20 | 24°C |
| 40 | 26°C | | 40 | 24°C |
| 60 | 26°C | | 60 | 24°C |
| 80 | 27°C | | 80 | 24.5°C |
| 100 | 27°C | | 100 | 25°C |
| 120 | 27°C | | 120 | 26°C |
| 140 | 27°C | | 140 | 26°C |
| 160 | 27°C | | 160 | 26.5°C |
| 180 | 27°C | | 180 | 26.5°C |
| 200 | 27°C | | 200 | 26.5°C |
| 220 | 27°C | | 220 | 27°C |

| | | | | |
|---|---|---|---|---|
| 240 | 27.5°C | | 240 | 27°C |
| 260 | 27.5°C | | 260 | 27°C |
| 280 | 27.5°C | | 280 | 27.5°C |
| 300 | 27.5°C | | 300 | 27.5°C |

| (III) Mass of $MgSO_4$ __1.5 gm__ | | | (IV) Mass of $MgSO_4$ __2.0 gm__ | |
|---|---|---|---|---|
| Time (s) | Temp(⁰C) | | Time(s) | Temp(⁰C) |
| 20 | 25°C | | 20 | 23°C |
| 40 | 25°C | | 40 | 23°C |
| 60 | 25°C | | 60 | 23°C |
| 80 | 26°C | | 80 | 23°C |
| 100 | 27°C | | 100 | 28°C |
| 120 | 28°C | | 120 | 29°C |
| 140 | 28°C | | 140 | 28°C |
| 160 | 28°C | | 160 | 28°C |
| 180 | 28°C | | 180 | 27°C |
| 200 | 27°C | | 200 | 28°C |
| 220 | 27°C | | 220 | 28°C |
| 240 | 27°C | | 240 | 28°C |
| 260 | 27°C | | 260 | 28°C |
| 280 | 27°C | | 280 | 27°C |
| 300 | 27°C | | 300 | 27°C |

| (I) Mass of $NaNO_3$ __0.5 gm__ | | | (II) Mass of $NaNO_3$ __1.0 gm__ | |
|---|---|---|---|---|
| Time (s) | Temp(⁰C) | | Time(s) | Temp(⁰C) |
| 20 | 26°C | | 20 | 24.5°C |
| 40 | 26°C | | 40 | 24.5°C |
| 60 | 26°C | | 60 | 24.5°C |
| 80 | 25°C | | 80 | 23°C |
| 100 | 25°C | | 100 | 22.5°C |
| 120 | 25°C | | 120 | 22.5°C |
| 140 | 25°C | | 140 | 23° |
| 160 | 25°C | | 160 | 23.5°C |
| 180 | 24.5°C | | 180 | 24°C |
| 200 | 24.5°C | | 200 | 24°C |
| 220 | 24.5°C | | 220 | 24.5°C |
| 240 | 24.5°C | | 240 | 24.5°C |
| 260 | 25°C | | 260 | 25°C |
| 280 | 25°C | | 280 | 25°C |
| 300 | 25°C | | 300 | 25.5°C |

| (III) Mass of $NaNO_3$ 1.5 gm | | | (IV) Mass of $NaNO_3$ 2.0 gm | |
|---|---|---|---|---|
| Time (s) | Temp($^0$C) | | Time(s) | Temp($^0$C) |
| 20 | 25°C | | 20 | 26°C |
| 40 | 25°C | | 40 | 26°C |
| 60 | 25°C | | 60 | 26°C |
| 80 | 21°C | | 80 | 21°C |
| 100 | 21°C | | 100 | 20°C |
| 120 | 21°C | | 120 | 19°C |
| 140 | 21°C | | 140 | 21°C |
| 160 | 22°C | | 160 | 23°C |
| 180 | 22°C | | 180 | 22°C |
| 200 | 22°C | | 200 | 23°C |
| 220 | 23°C | | 220 | 22°C |
| 240 | 23°C | | 240 | 23°C |
| 260 | 23°C | | 260 | 24°C |
| 280 | 23°C | | 280 | 24°C |
| 300 | 24°C | | 300 | 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 occurs up to one point, the temperature increased and after that the temperature starts to decrease. Also, the highest was 29°C which first occured at 120 seconds and the highest temperature of each experiment was different due to change in mass of $MgSO_4$ added in each trials. Adding $NaNO_3$ into the water, temperature of water decreases generally in all. Endothermic reaction occurs up to one point, the temperature decrease and after that the temperature starts to increase. Also, the lowest was 19°C which first occured at 120 seconds and the lowest temperature of each experiment was different due to change in mass of $NaNO_3$ added in each trials.

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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)

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

Mass of water, $M = \rho \cdot V = 1 \times 20 = 20$ gram [$\rho$ = 1 gram/cm$^3$, V = 20 ml]

Mass of $MgSO_4$ = (24 + 32 + (16×4)) = 120 gram

So,

$Q_1 = 4.18 \times 20 \times (27.5 - 26) = 125.4J$ $\quad n_1 = \frac{0.5}{120} = 0.0042$ mole

$Q_2 = 4.18 \times 20 \times (27.5 - 24) = 292.6J$ $\quad n_2 = \frac{1}{120} = 0.0083$ mole

$Q_3 = 4.18 \times 20 \times (28 - 25) = 250.8J$ $\quad n_3 = \frac{1.5}{120} = 0.0125$ mole

$Q_4 = 4.18 \times 20 \times (29 - 23) = 501.6J$ $\quad n_4 = \frac{2}{120} = 0.0167$ mole.

Mass of $NaNO_3$ = (23 + 14 + (16×3)) = 85 gram

So,

$Q_1 = 4.18 \times 20 \times (26 - 24.5) = 125.4J$ $\quad n_1 = \frac{0.5}{85} = 0.0059$ mole.

$Q_2 = 4.18 \times 20 \times (25.5 - 22.5) = 250.8J$ $\quad n_2 = \frac{1}{85} = 0.0118$ mole

$Q_3 = 4.18 \times 20 \times (25 - 21) = 334.4J$ $\quad n_3 = \frac{1.5}{85} = 0.0176$ mole.

$Q_4 = 4.18 \times 20 \times (26 - 19) = 585.2J$ $\quad n_4 = \frac{2}{85} = 0.0235$ mole

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)**

Answer in the last Page.

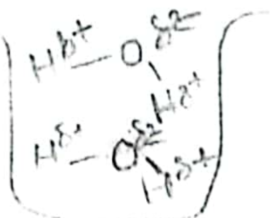
Answer in the last Page.

**FIGURE:** plot here

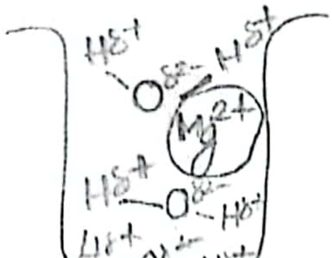
**MENTAL MODEL:** Use the chemical equation given above to represent the dissolution reaction in this experiment. Draw a picture(s) which describes what is happening in atomic or in molecular level. How heat release or absorbed can be described from these pictures? **(5 points)**

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

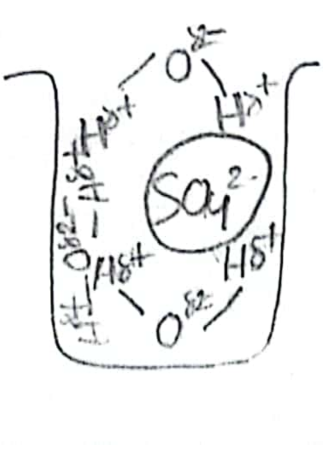
$MgSO_4 + H_2O \rightarrow Mg^{2+} + SO_4^{2-} + H^+ + OH^-$




water molecules have Hydrogen bonds to hold them together. When the hydrogen bonds breakdown 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.

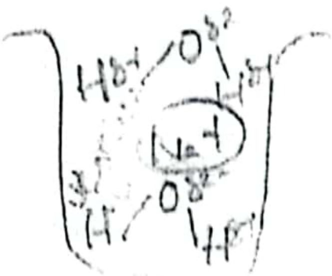



The positive dipole of hydrogen surrounds the negative ion and release energy. In this case, hydration enthalpy is greater than lattice energy. So, the solid structure breaks and dissolved. The surplus energy is used up to increase the temperature.

chemical equation: $NaNO_3 \rightarrow Na^+ + NO_3^-$

$NaNO_3 + H_2O \Rightarrow Na^+ + NO_3^- + H^+ + OH$

water molecules have a Hydrogen bonds to hold them together, when the hydrogen bonds break down inside water it requires energy. So, it is an endothermic process.




When $NaNO_3$ is added negative dipole oxygen get surrounded to the positive ion and this ordered arrangement of water absorbed energy called endothermic process.


The positive dipole of hydrogen surrounds the negative ion and absorbed energy. In this case, the hydration enthalpy is less than the lattice energy.