CHE 101L

General Chemistry Lab

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Expt 2: 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: $MgSO_{4(s)} + H_2O_{(l)} \longrightarrow Mg^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \pm$ 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).

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- When reactions occur in a reaction vessel (e.g., Coffee-Cup/plastic 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 0.10C 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 300 seconds.

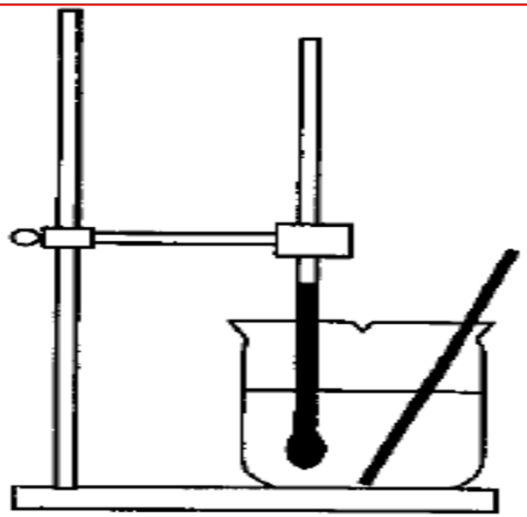


FIGURE 1: Experimental setup for dissolution reaction

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

Part I. Qualitative

Repeat this procedure with each of the following compounds:

(5 points)

Observation:

Compound	Initial temp. (only H_2O)	Final temp.	Reaction
$MgSO_4$	22°C	23°C	Exothermic
$NaNO_3$	22°C	21°C	Endothermic
NaCl	22°C	21.5°C	Endothermic
$CaCl_2.2H_2O$	22°C	25°C	Exothermic
NH_4NO_3	22°C	21°C	Endothermic

PART I. QUALITATIVE

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? **(5 points)**

- All of these compounds are different types of salt. While dissolving in water they release their ions which shows different reaction like endothermic or exothermic. They either absorb heat or release heat in the atmosphere.
- Here, the components, $NaNO_3$, NaCl, NH_4NO_3 shows similarities by the change of temperature is decreasing.
- On the other hand, $MgSO_4$, $CaCl_2.2H_2O$ shows similarity as their temperature is increased.

PART I. QUALITATIVE

Reactions:

$MgSO_{4(s)} + H_2O_{(l)} \longrightarrow Mg^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}$; ΔH = –ve

$NaNO_{3(s)} + H_2O_{(l)} \longrightarrow Na^{+}_{(aq)} + NO_3^{-}{}_{(aq)}$; ΔH = +ve

$NaCl_{(s)} + H_2O_{(l)} \longrightarrow Na^{+}_{(aq)} + Cl^{-}_{(aq)}$; ΔH = +ve

$CaCl_2.2H_2O_{(s)} + H_2O_{(l)} \longrightarrow Ca^{2+}_{(aq)} + Cl^{-}_{(aq)}$; ΔH = –ve

$NH_4NO_{3(s)} + H_2O_{(l)} \longrightarrow NH_4^{+}{}_{(aq)} + NO_3^{-}{}_{(aq)}$; ΔH = +ve

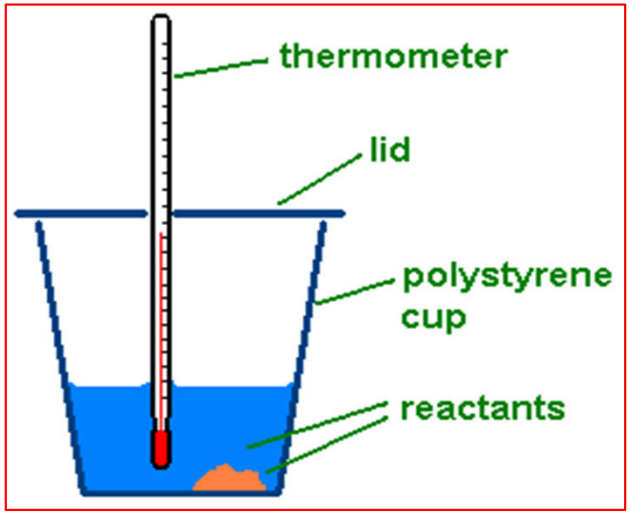
- In conclusion, we can state that solubility of a solid depends on the temperature as we can notice that different solids.

PART II. QUANTITATIVE

DATA COLLECTION:

a. Accurately weigh a 1 to 3 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., 0.5, 1.0, 1.5 & 2.0 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.

PART II. QUANTITATIVE

DATA COLLECTION:

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PART II. QUANTITATIVE

d. Draw a temperature vs. time Table. Draw the best curve through the points and point out what is happing in each part of the curve.

(i) Mass of $MgSO_4$: 0.5g

Time	Temp	Time	Temp
20	24	160	27
40	24	180	26.8
60 (Salt added)	24	200	26.8
80	25	220	26.5
100	26	240	26.5
120	26.5	260	26.5
140	27	280	26.5

(ii) Mass of $MgSO_4$: 1.0g

Time	Temp	Time	Temp
20	22.7	160	27.5
40	22.8	180	27.4
60 (Salt added)	23	200	27.2
80	26	220	27.6
100	28.2	240	27.6
120	29	260	27.6
140	28	280	27.8

PART II. QUANTITATIVE

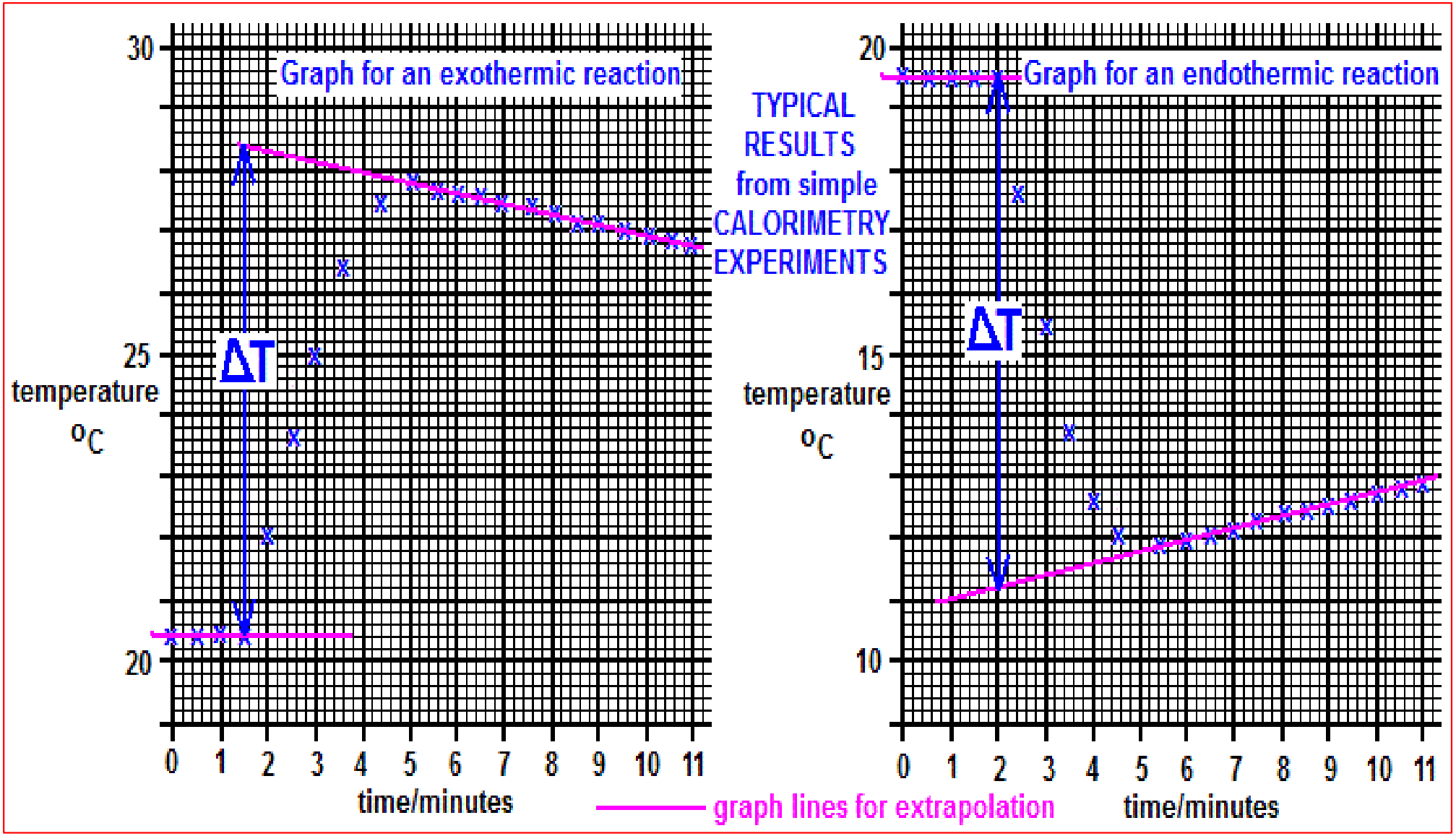
(ii) Mass of $MgSO_4$:1.5 g

Time	Temp	Time	Temp
20	23.8	160	31
40	23.8	180	31
60 (Salt added)	23.8	200	31.1
80	27	220	31.1
100	30.5	240	31.1
120	30.5	260	31.1
140	31	280	31.1
		300	31.1

(iii) Mass of $MgSO_4$: 2.0g

Time	Temp	Time	Temp
20	23	160	33
40	23.1	180	33
60 (Salt added)	24	200	32.8
80	27	220	32.8
100	30	240	31
120	32	260	30.9
140	32.5	280	30.9
		300	30.9

PART II. QUANTITATIVE



PART II. QUANTITATIVE

DATA COLLECTION:

1.What do you understand form the data you recorded and from the other trials? (5 points)

Variations in temperature are found after adding $MgSO_4$ to the solution. For different mass 0.5 g, 1.0 g, 1.5 g and 2.0g up to 240 seconds, temperature of water was observed. We recorded the highest temperature and lowest temperature at specific time. Reaction is observed and recording up to 300 seconds. It is showing exothermic or endothermic change, it is depending to change in temperature.

PART II. QUANTITATIVE

DATA COLLECTION:

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 ^{0}C and M is the mass of water (take the water density as 1.00 grams/cm^3).
(5 points)

1. Q1 = C × M × ΔT_1 = 4.18 joule/gram × 20 g × 3°C = 250.8 joule; Here, mass =m= density × volume = 1 g/cm^3 ×20 cm^3 =20 g, ΔT_1 = (27°C – 24°C) =3°C
2. Q2, Q3 and Q4 determined using previous Table.

PART II. QUANTITATIVE

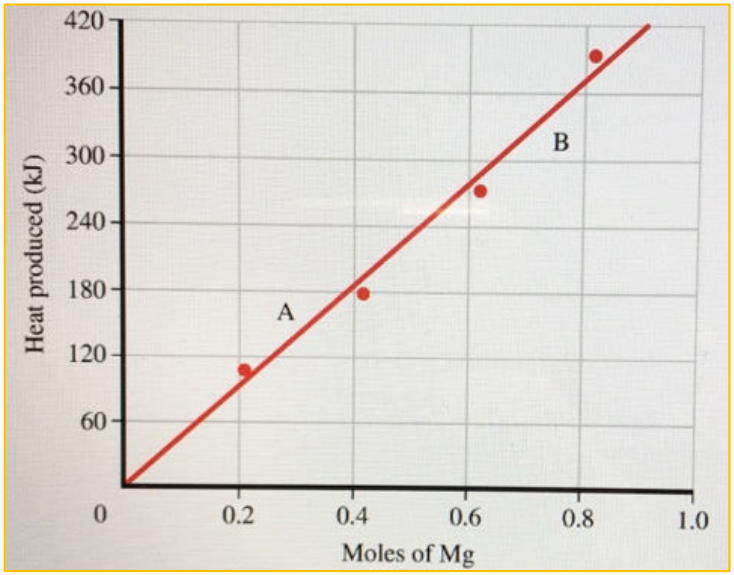
DATA COLLECTION:

3. Plot the collected data as moles, n vs. heat, 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. (5 points)

Molar mass of $MgSO_4$ = 120.366 g/mol

Here, n_1 = m/M = 0.5 g/120.366 g/mol = 4.16×10^{-3} mol

1. Similarly we will determination of n_2, n_3 and n_4.



The slope of the best fit line gives the heat produced per mole of Mg. Use the two points indicated on the line to determine the slope.

$m = (y_2 - y_1)/(x_2 - x_1)$

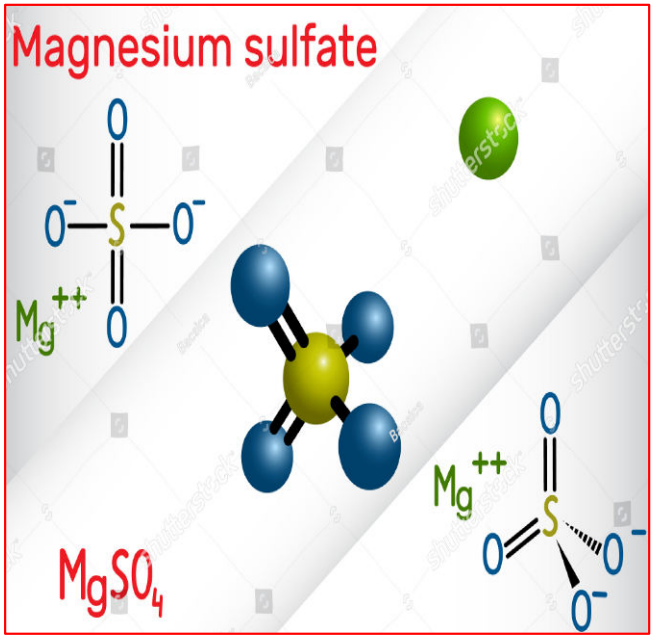
Equation: $y = mx + c$

PART II. QUANTITATIVE

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)**

BEFORE REACTION:

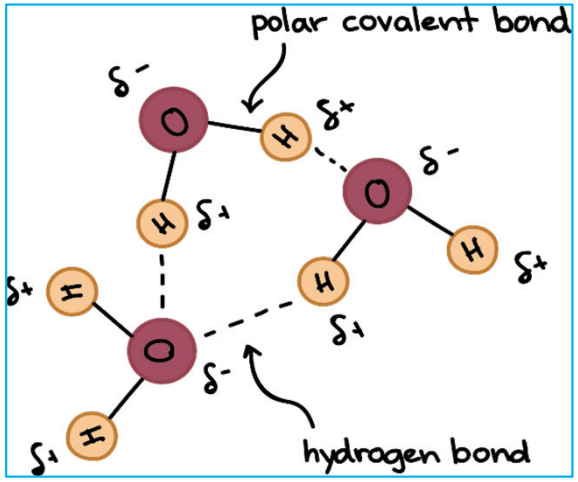
- Here, there is strong electrostatic force of attraction between ions (Mg^{2+} and SO_4^{2-}) and energy required to break this force is called lattice energy. Breaking this structure is endothermic process since it absorbs heat energy.



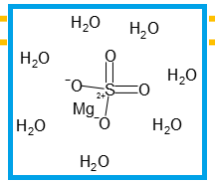
PART II. QUANTITATIVE

BEFORE REACTION:

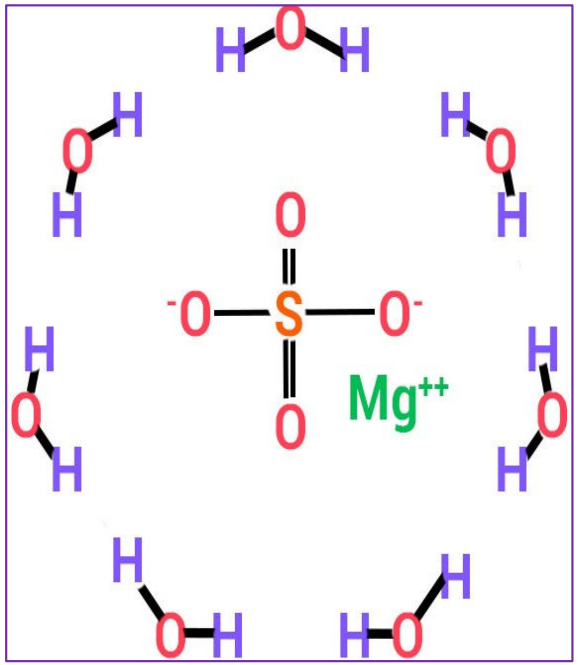
- On the other hand, water molecule are held together by hydrogen bond. When this hydrogen bonding is broken, it requires energy. So, it is an endothermic process.



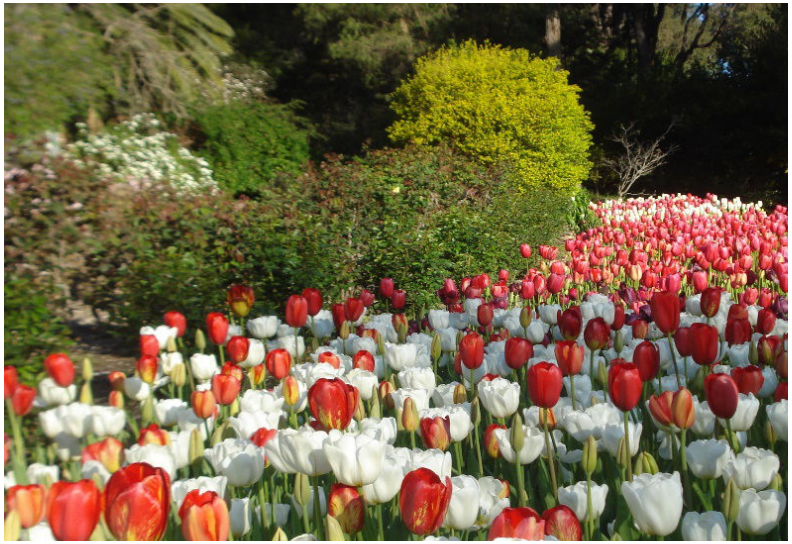
AFTER REACTION:



- When $MgSO_4$ is added in water, the negative dipole of oxygen ($O^{\delta-}$) get surrounded to the positive ion (Mg^{2+}). The ordered arrangement of water releases energy called hydration enthalpy and this process is exhaustive.
- The positive dipole of hydration ($H^{\delta+}$) surrounds the negative ion (SO_4^{2-}) and release energy. Here, the hydration enthalpy is greater than the lattice energy. So the solid structure breaks and gets dissolved to showing increasing temperature (Exothermic reaction occurs).



Thank You for Listening



Any Questio