ENTHALPY OF HYDRATION AND SOLUTION (#1.3)

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Learning Objectives

- To qualitatively correlate the ΔH_{soln} of several compounds with their properties such as ionic charge, size, etc.
- To quantitatively determine the enthalpy of solvation of $MgSO_4$ and $MgSO_4 \cdot 7H_2O$.
- To quantitatively determine the enthalpy of the water of hydration in $MgSO_4 \cdot 7H_2O$.

Introduction:

Many ionic salts contain water molecules that are loosely bound to the salt ions. These water molecules can be driven off from the salt by heating the salt to the appropriate temperature. The energy of this process is difficult to measure experimentally, however, so we will approach it in a different manner. When such a substance is dissolved dilute solutions (less than 0.01 Molar) the amount of water molecules added by dissolving $MgSO_4 \cdot 7H_2O$ versus $MgSO_4$ is sufficiently small that it can be neglected.

This solvation process involves heat energy, either exo- or endothermic, and this heat is generally represented as "q", and when accomplished at atmospheric pressure, the heat is referred to as "enthalpy" and given the symbol ΔH. Generally, when ΔH is used, it usually also refers to the amount of heat involved per mole of the compound of interest, here, the solute.

The three energy processes involved are considered, i.e.,

1. The solvent molecules must be separated from each other, which requires energy, $+\Delta H_1$.
2. Solute molecules or ions must be separated from each other, $+\Delta H_2$.
3. An attractive interaction between the solute molecules or ions and the solvent molecules,$-\Delta H_3$.

The overall energy of the solution process is give by $\Delta H_{soln} = \Delta H_1 + \Delta H_2 + \Delta H_3$

Another factor that has an influence and is discussed is the charge to size ratio of the ions.

Experimental Procedure

Equipment Setup: The temperature probe is calibrated at a minimum of three temperatures between 0 °C and 60 °C, using a thermometer for calibration. **Remember**: your data can not be better than your calibration.

Qualitative Properties of Some Dissolving Compounds: Pea size amounts of ammonium nitrate, sodium chloride, lithium chloride, sodium hydroxide, sodium nitrate, sodium sulphate, and 0.50 mL of conc. sulphuric acid are added to 20 mL of water and the temperature change measured.

Quantitative Determination of $\Delta H_{solution}$ and $\Delta H_{hydration}$: Weigh approximately 2 g of $MgSO_4$ to the nearest 0.01 g into a plastic weighing boat and is added to 100.0 mL of distilled water while recording the temperature change. This is repeated for 4, 6 and 8 g of anhydrous $MgSO_4$, then 2, 4, 6 and 8 g of $MgSO_4 \cdot 7H_2O$.

Data Treatment: Guidance is given for obtaining the delta T, making the graphs drawing the conclusions.

Instructor Resources Provided

1. Sample Report Sheets providing the format to organize the data collection with sample data.
2. Questions to consider, answer and turn-in with suggested answers.
3. Tips and Traps section to assist the instructor with potential problems and solutions.
4. Sample ***MicroLAB*** screen shots and graphs.
5. Laboratory preparation per student station.

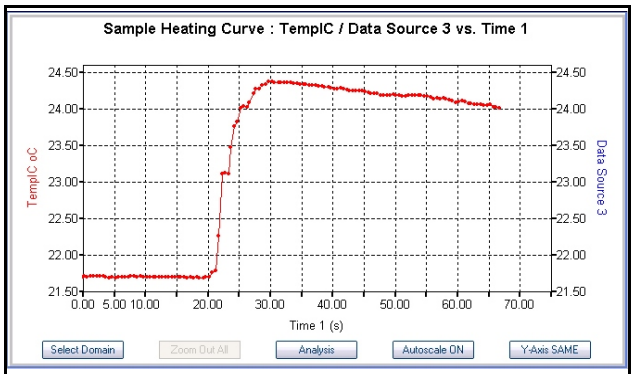

Figure 1. Sample MicroLAB heating curve.

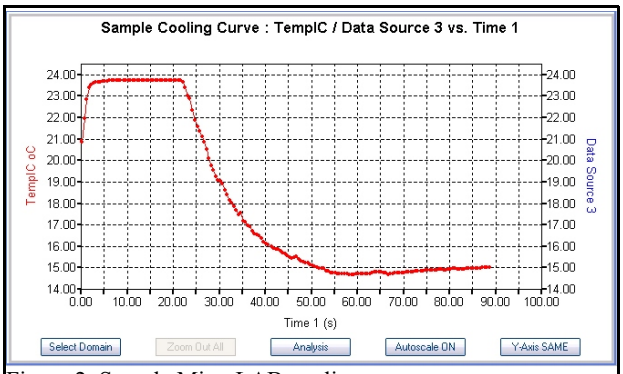

Figure 2. Sample MicroLAB coolingcurve.

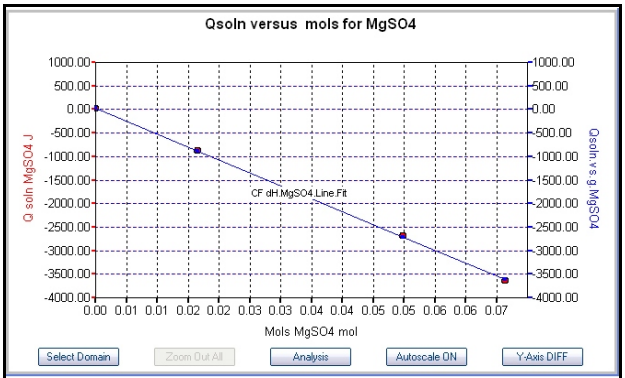

Figure 1. Graph showing the increasing negative enthalpy of solution per mol of $MgSO_4$.

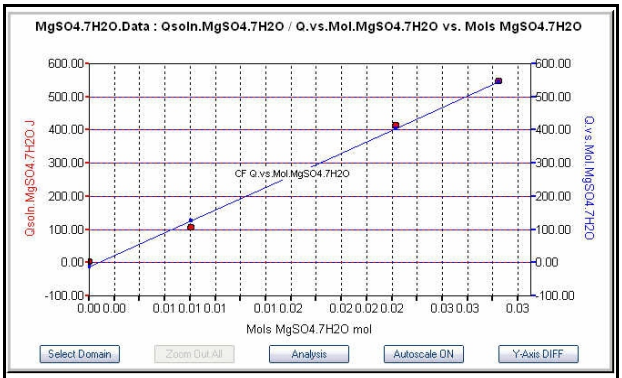

Figure 2. Graph showing the increasing positive enthalpy of solution per mol of $MgSO_4 \cdot 7H_2O$

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