Thermochemistry Lab #1 Heat of Solution of a Solid

Pre-Lab (reference sections 6.1 and 6.2 in Zumdahl)
In your lab notebook, explain and relate the following terms:

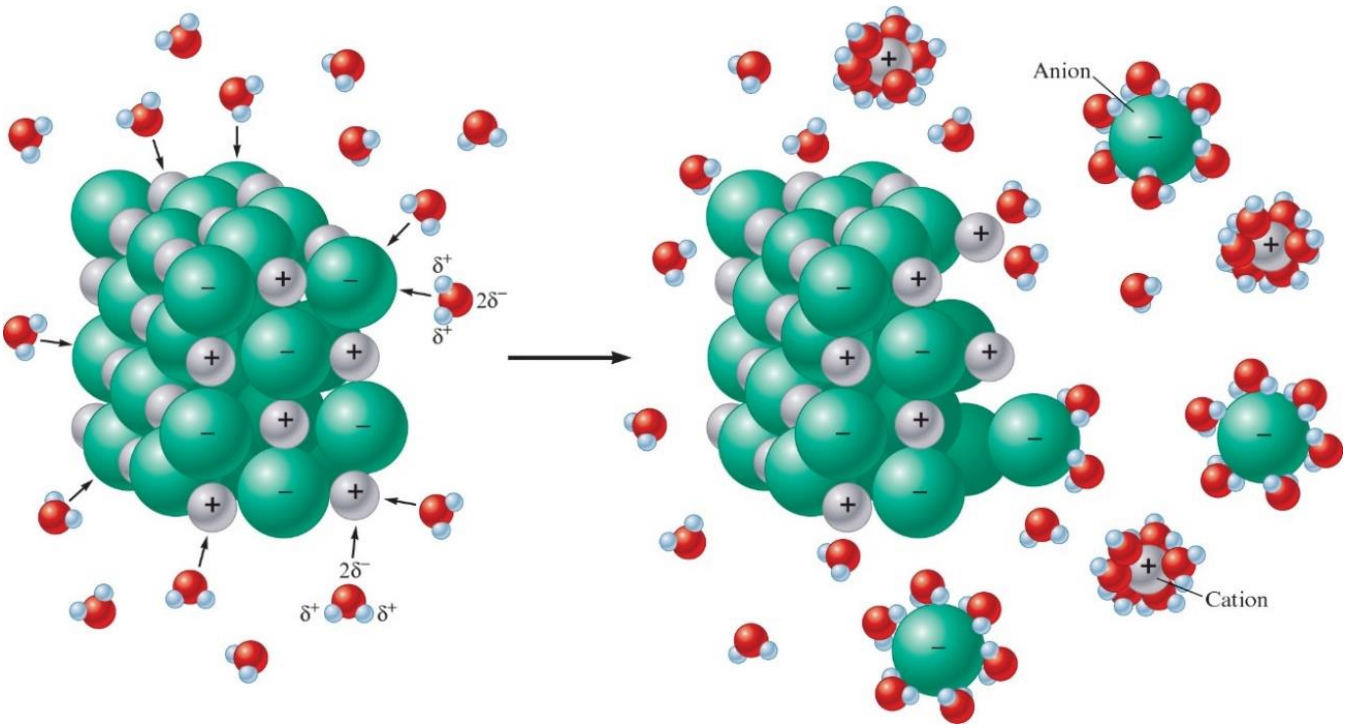
- energy
- heat
- temperature
- work
- system
- surroundings
- exothermic
- endothermic
- internal energy (include the equation)
- calorimetry
- specific heat capacity
- molar heat capacity
- heat transfer equation

Thermochemistry Lab #1 Heat of Solution of a Solid

http://www2.ucdsb.on.ca/tiss/stretton/chem2/labx.htm

Background:

When a solid dissolves in water, the process always has an energy change associated with it. Examples exist for both endothermic and exothermic heats of solution. However, the dissolving process itself is really a two-step process. The overall heat of solution depends on the relative amounts of energy involved in the two individual steps.



Hydration of ions. Hydration involves a complex redirection of forces of attraction and repulsion. Before this solution forms, water molecules are attracted only to each other; and Na^+ and Cl^- ions have only each other in the crystal to be attracted to. In the solution, the ions have water molecules to take the places of their oppositely charged counterparts; and water molecules find ions more attractive then even other water molecules.

In this experiment, you will determine the heats of solution for the dissolving of ammonium nitrate and of sodium acetate in water, using simple styrofoam cups as a calorimeter.

Objectives:
To measure experimentally the amount of heat involved in the dissolving of ammonium nitrate and of sodium acetate in water.

To relate the heat of solution involved to the two-step process of dissolving.

Apparatus and Materials:
2 styrofoam cups, nesting
cardboard lid with hole for temperature probe
temperature probe connected to Vernier Logger Pro
100 mL graduated cylinder
balance
sodium acetate, $NaCH_3COO$, **ANHYDROUS**
ammonium nitrate, NH_4NO_3

Procedure:
1. Find the data table included with this lab and familiarize yourself with its layout.

2. Accurately find the mass of a sample of solid ammonium nitrate of approximately 15 grams.

3. Find the mass of the pair of <u>dry</u> styrofoam cups.

4. Add about 150 mL of distilled water to the nesting cups and find the mass of the cups and water.

5. Stir the water briefly with the temperature probe and record the temperature to the nearest 0.2ºC.

6. Dissolve the solid in the water, put on the cardboard lid, stir with the temperature probe, and record the maximum temperature of the solution.

7. Rinse out the cup, dry it thoroughly, and repeat the experiment using a sample of about 15 grams of solid sodium acetate in place of the ammonium nitrate.

Calculations:
1. From your data, calculate the following for each part of the experiment.
   a) the temperature change of the water.
   b) the mass of water.
   c) the quantity of heat absorbed (or given off) by the water during the dissolving.
   d) the number of moles of solid used.
   e) the quantity of heat involved per mole of solid dissolved. This is called the molar heat of solution.

2. Find the accepted values for the molar heats of solution for these solids and record these data in your lab notebook.

3. Use these accepted values to calculate the percentage error of your experimental values.

Tables

Data

	Ammonium nitrate	Sodium acetate
Mass of empty styrofoam cups	g	g
Mass of cups and water	g	g
Mass of solid used	g	g
Initial temperature of H_2O	^oC	^oC
Final temperature of H_2O	^oC	^oC

Calculations

	Ammonium nitrate	Sodium acetate
Mass of H_2O used	g	g
Formula of solid		
Molecular mass of solid	g/mol	g/mol
Moles of solid used	mol	mol
Temperature change	^oC	^oC
Energy released in reaction	kJ	kJ
ΔH_{soln}	kJ/mol	kJ/mol
Percentage error		

In your lab notebook, show the work for all calculations.
Work needs to be organized, sequential, and clearly written.
Include units with all quantities used in calculations.

Questions:

1. Write an equation for the dissolving process for each solid. Include the heat term in each equation.

2. Consider the fact that dissolving is actually a two-step process. Describe each step using both words and a diagram. Designate each step as endothermic or exothermic.

3. How does the nature of these individual steps combine to determine whether the overall process will be endothermic or exothermic?

https://chem.libretexts.org/LibreTexts/Howard_University/General_Chemistry%3A_An_Atoms_First_Approach/Unit_4%3A__Thermochemistry/09%3A_Thermochemistry/Chapter_9.05%3A_Enthalpies_of_Solution

When substances dissolve, the process can be either exothermic ($\Delta H_{soln} < 0$) or endothermic ($\Delta H_{soln} > 0$), as you can see from the data in Table 9.5.1.

Table 9.5.1 Enthalpies of Solution at 25°C of Selected Ionic Compounds in Water (in kJ/mol)

	Anion				
Cation	**Fluoride**	**Chloride**	**Bromide**	**Iodide**	**Hydroxide**
lithium	4.7	−37.0	−48.8	−63.3	−23.6
sodium	0.9	3.9	−0.6	−7.5	−44.5
potassium	−17.7	17.2	19.9	20.3	−57.6
ammonium	−1.2	14.8	16.8	13.7	—
silver	−22.5	65.5	84.4	112.2	—
magnesium	−17.7	−160.0	−185.6	−213.2	2.3
calcium	11.5	−81.3	−103.1	−119.7	−16.7
	Nitrate	**Acetate**	**Carbonate**	**Sulfate**	
lithium	−2.5	—	−18.2	−29.8	
sodium	20.5	−17.3	−26.7	2.4	
potassium	34.9	−15.3	−30.9	23.8	
ammonium	25.7	−2.4	—	6.6	
silver	22.6	—	22.6	17.8	