

Part I: Preliminary Ideas and the Simulation

- 1) In this simulated experiment, you'll focus on the temperature change that occurs when dissolving a chloride salt in water. There are five chloride salts listed in the animation. On the back of this page, calculate the number of moles the given mass corresponds to for each compound. Fill in the table with each value. Watch sig figs!

	Mass (g)	# moles	ΔT
LiCl	0.80		
KCl	1.5		
NH ₄ Cl	1.1		
NaCl	1.2		
CaCl ₂	1.1		
CaCl ₂	2.2		
CaCl ₂	4.4		

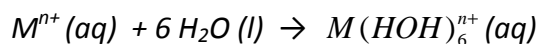
- 2) Now, run the simulation for each of these chlorides for the mass given in the table. Use the 20mL of water that is automatically set for each trial. After each trial, fill in the change in temperature column (ΔT) of the table. *Note: you'll need to hit the reset button after each trial.*
- 3) Questions to ponder...
- Is there a consistent trend in the data concerning chloride salts dissolving in water?
 - Rationalize any behaviors you do see in terms of bond enthalpies (bond strengths) for these reactions at constant V and P. For example, if the overall process is exothermic, what does that tell you?

Part II: The Dissolution Process

When a strong electrolyte (strong acid, strong base, or soluble salt) dissolves in water, it undergoes dissociation and hydration resulting in the formation of stable ions in solution. We can imagine the entire process occurring in steps, as follows:



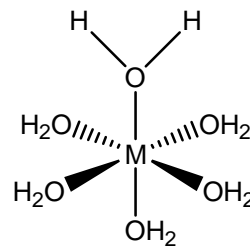
Here the first step involves separating the substance into individual particles. For example, if the strong electrolyte were sodium nitrate, we could imagine dissolution occurring as the 3-dimensional lattice separates into individual particles, which then dissociate further to sodium ions and nitrate ions. But the process is more complex than that because the ions formed actually interact with the water molecules (hydration). That is, labile ion-dipole interactions form due to the charges on the ions. *Labile* is a term that describes any interaction that is short-lived and allows for the fact that a particular water molecule is unlikely to interact with a particular anion or cation for any lengthy period of time. There are often 6 waters surrounding a cation in an octahedral geometry:



where the complex looks like the figure to the right. Note that all the waters are actually configured like the top water.

Some Questions to Ponder:

- 1) Based upon the physical properties and structure of water, how many water molecules are most likely involved in the "sphere of hydration" around an anion? Justify your response with a diagram/picture similar to the figure to the right.



- 2) For the salt $\text{MX}(s)$, what type of bond is broken in the separation/dissociation process? Will this require energy or evolve energy? If this were the only process (dissociation without hydration), how would the water temperature change?

- 3) For the $M^+(aq)$ ion, what type of bonds are created in the hydration process? Will this require energy or evolve energy? If hydration were the only process (no dissociation occurred), how would the water temperature change?
- 4) For the $X^-(aq)$ ion, what type of bond is created in the hydration process? Will this require energy or evolve energy? If hydration were the only process, how would the water temperature change?
- 5) Predict the relative bond strengths of the crystalline salts in Part I **based upon Coulomb's Law**. Which salt requires the most energy to break apart? Now, return to your results from the simulation in Part I. Does the order based on Coulomb's Law agree with the order given by your data? If not, what is going on? Explain!!!! What can you say about the energy of dissociation versus the energy of hydration for each of the salts **based upon your data?**

- 6) In the case of calcium chloride, you have run three trials with different starting masses of the salt. Do the results show any trend? Explain the results using the information described in Part II.
- 7) If we are looking at ΔH for any process, is it reasonable to consider only the new bonds that are being formed? Why or why not? Use your data to justify your response and explain your answer.