

AP[®] CHEMISTRY
2016 SCORING GUIDELINES

Question 1

A student investigates the enthalpy of solution, ΔH_{soln} , for two alkali metal halides, LiCl and NaCl. In addition to the salts, the student has access to a calorimeter, a balance with a precision of ± 0.1 g, and a thermometer with a precision of $\pm 0.1^\circ\text{C}$.

(a) To measure ΔH_{soln} for LiCl, the student adds 100.0 g of water initially at 15.0°C to a calorimeter and adds 10.0 g of LiCl(s), stirring to dissolve. After the LiCl dissolves completely, the maximum temperature reached by the solution is 35.6°C .

(i) Calculate the magnitude of the heat absorbed by the solution during the dissolution process, assuming that the specific heat capacity of the solution is $4.18 \text{ J}/(\text{g}\cdot^\circ\text{C})$. Include units with your answer.

$q = mc\Delta T = (110.0 \text{ g})(4.18 \text{ J}/(\text{g}\cdot^\circ\text{C}))(35.6^\circ\text{C} - 15.0^\circ\text{C})$ $= 9,470 \text{ J} = 9.47 \text{ kJ}$	<p>1 point is earned for the correct setup.</p> <p>1 point is earned for the correct answer with units.</p>
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(ii) Determine the value of ΔH_{soln} for LiCl in $\text{kJ}/\text{mol}_{rxn}$.

$10.0 \text{ g LiCl} \times \frac{1 \text{ mol LiCl}}{42.39 \text{ g LiCl}} = 0.236 \text{ mol LiCl}$ $\frac{-9.47 \text{ kJ}}{0.236 \text{ mol LiCl}} = -40.1 \text{ kJ}/\text{mol}_{rxn}$	<p>1 point is earned for the number of moles of LiCl.</p> <p>1 point is earned for the correct ΔH_{soln} <u>and</u> the correct sign.</p>
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To explain why ΔH_{soln} for NaCl is different than that for LiCl, the student investigates factors that affect ΔH_{soln} and finds that ionic radius and lattice enthalpy (which can be defined as the ΔH associated with the separation of a solid crystal into gaseous ions) contribute to the process. The student consults references and collects the data shown in the table below.

Ion	Ionic Radius (pm)
Li ⁺	76
Na ⁺	102

(b) Write the complete electron configuration for the Na⁺ ion in the ground state.

$1s^2 2s^2 2p^6$	1 point is earned for the complete correct configuration.
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Question 1 (continued)

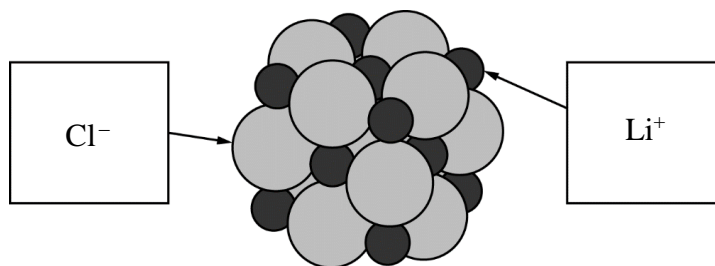
- (c) Using principles of atomic structure, explain why the Na^+ ion is larger than the Li^+ ion.

<p>The valence electrons in the Na^+ ion are in a higher principal energy level than the valence electrons in the Li^+ ion. Electrons in higher principal energy levels are, on average, farther from the nucleus.</p>	<p>1 point is earned for a correct explanation based on occupied principal energy levels.</p>
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- (d) Which salt, LiCl or NaCl , has the greater lattice enthalpy? Justify your answer.

<p>LiCl. Because the Li^+ ion is smaller than the Na^+ ion, the Coulombic attractions between ions in LiCl are stronger than in NaCl. This results in a greater lattice enthalpy.</p>	<p>1 point is earned for the correct choice and justification.</p>
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- (e) Below is a representation of a portion of a crystal of LiCl . Identify the ions in the representation by writing the appropriate formulas (Li^+ or Cl^-) in the boxes below.



<p>See diagram above.</p>	<p>1 point is earned for both identifications.</p>
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- (f) The lattice enthalpy of LiCl is positive, indicating that it takes energy to break the ions apart. in LiCl . However, the dissolution of LiCl in water is an exothermic process. Identify all particle-particle interactions that contribute significantly to the exothermic dissolution process being exothermic. For each interaction, include the particles that interact and the specific type of intermolecular force between those particles.

<p>There are interactions between Li^+ ions and polar water molecules and between Cl^- ions and polar water molecules. These are ion-dipole interactions.</p>	<p>1 point is earned for identifying the particles that interact. 1 point is earned for correctly identifying the type of interaction.</p>
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