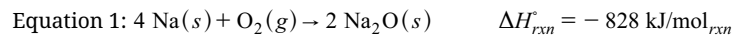


Question 7

The following information applies to parts A and B.

7. Sodium metal reacts with oxygen gas according to Equation 1.



Standard enthalpies of formation are provided in Table 1.

Table 1

Substance	ΔH_f° (kJ/mol)
Na(s)	0
O ₂ (g)	0
Na ₂ O(s)	?

Part A

Based on the information given, **calculate** the value of ΔH_f° for Na₂O(s). Show the work that leads to your answer.

Part B

An 18.4 g sample of Na(s) reacts with 12.8 g of O₂(g) according to Equation 1. **Calculate** the total amount of heat, in kilojoules, released during this process. Show the work that leads to your answer.

Part C

Lattice enthalpy can be defined as the energy required to separate an ionic crystal into gaseous ions. Rb₂O(s) and Na₂O(s) have similar crystal structures, and their lattice enthalpies are given in Table 2.

Table 2

Compound	Lattice Enthalpy (kJ/mol)
Na ₂ O(s)	2481
Rb ₂ O(s)	2163

Using Coulomb's law, **explain** why the lattice enthalpy of Rb₂O(s) is smaller than that of Na₂O(s).

STOP
END OF EXAM

6. A student is studying the properties of CaSO_4 and PbSO_4 . The student has samples of both compounds, which are white powders.

(a) The student tests the electrical conductivity of each solid and observes that neither solid conducts electricity. Describe the structures of the solids that account for their inability to conduct electricity.

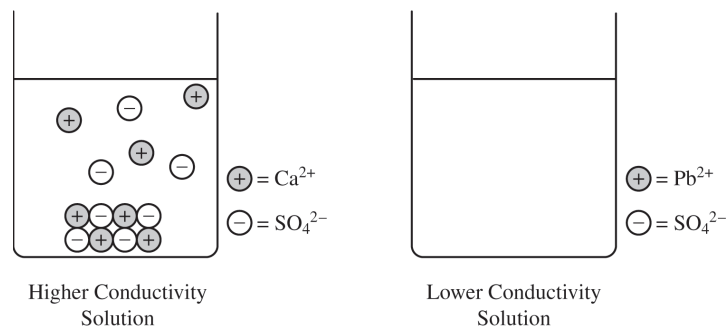
The student places excess $\text{CaSO}_4(s)$ in a beaker containing 100 mL of water and places excess $\text{PbSO}_4(s)$ in another beaker containing 100 mL of water. The student stirs the contents of the beakers and then measures the electrical conductivity of the solution in each beaker. The student observes that the conductivity of the solution in the beaker containing the $\text{CaSO}_4(s)$ is higher than the conductivity of the solution in the beaker containing the $\text{PbSO}_4(s)$.

(b) Which compound is more soluble in water, $\text{CaSO}_4(s)$ or $\text{PbSO}_4(s)$? Justify your answer based on the results of the conductivity test.

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Use a pencil or pen with black or dark blue ink only. Do NOT write your name. Do NOT write outside the box.

The left side of the diagram below shows a particulate representation of the contents of the beaker containing the $\text{CaSO}_4(s)$ from the solution conductivity experiment.



(c) Draw a particulate representation of $\text{PbSO}_4(s)$ and the ions dissolved in the solution in the beaker on the right in the diagram. Draw the particles to look like those shown to the right of the beaker. Draw an appropriate number of dissolved ions relative to the number of dissolved ions in the beaker on the left.

(d) The student attempts to increase the solubility of $\text{CaSO}_4(s)$ by adding 10.0 mL of 2 M $\text{H}_2\text{SO}_4(aq)$ to the beaker, and observes that additional precipitate forms in the beaker. Explain this observation.

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Use a pencil or pen with black or dark blue ink only. Do NOT write your name. Do NOT write outside the box.

6. Answer the following questions about $\text{Mg}(\text{OH})_2$. At 25°C , the value of the solubility product constant, K_{sp} , for $\text{Mg}(\text{OH})_2(s)$ is 1.8×10^{-11} .

- (a) Calculate the number of grams of $\text{Mg}(\text{OH})_2$ (molar mass 58.32 g/mol) that is dissolved in 100. mL of a saturated solution of $\text{Mg}(\text{OH})_2$ at 25°C .
- (b) The energy required to separate the ions in the $\text{Mg}(\text{OH})_2$ crystal lattice into individual $\text{Mg}^{2+}(g)$ and $\text{OH}^-(g)$ ions, as represented in the table below, is known as the lattice energy of $\text{Mg}(\text{OH})_2(s)$. As shown in the table, the lattice energy of $\text{Sr}(\text{OH})_2(s)$ is less than the lattice energy of $\text{Mg}(\text{OH})_2(s)$. Explain why in terms of periodic properties and Coulomb's law.

Reaction	Lattice Energy (kJ/mol)
$\text{Mg}(\text{OH})_2(s) \rightarrow \text{Mg}^{2+}(g) + 2 \text{OH}^-(g)$	2900
$\text{Sr}(\text{OH})_2(s) \rightarrow \text{Sr}^{2+}(g) + 2 \text{OH}^-(g)$	2300

CHEMISTRY

Section II

7 Questions

Time—1 hour and 45 minutes

YOU MAY USE YOUR CALCULATOR FOR THIS SECTION.

Directions: Questions 1–3 are long free-response questions that require about 23 minutes each to answer and are worth 10 points each. Questions 4–7 are short free-response questions that require about 9 minutes each to answer and are worth 4 points each.

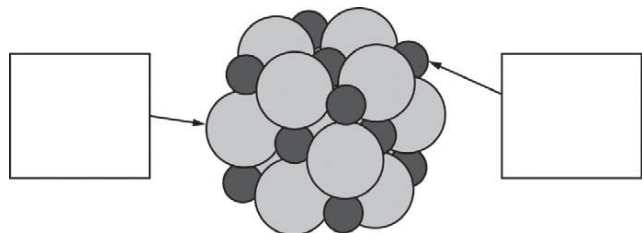
Write your response in the space provided following each question. Examples and equations may be included in your responses where appropriate. For calculations, clearly show the method used and the steps involved in arriving at your answers. You must show your work to receive credit for your answer. Pay attention to significant figures.

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 $4.18 \text{ J/(g}\cdot^\circ\text{C)}$. Include units with your answer.
- (ii) Determine the value of ΔH_{soln} for LiCl in kJ/mol_{rxn} .

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.
- (c) Using principles of atomic structure, explain why the Na^+ ion is larger than the Li^+ ion.
- (d) Which salt, LiCl or NaCl , has the greater lattice enthalpy? Justify your answer.
- (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.



- (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 dissolution process being exothermic. For each interaction, include the particles that interact and the specific type of intermolecular force between those particles.