IB Chemistry II Study Worksheet 15.2.4 and all of 15.3

1. State with a reason whether the following steps in the Born Haber cycle of potassium chloride are exothermic or endothermic.
   a) \( \text{Cl}_2 (g) \rightarrow \text{Cl} (g) \)
   b) \( \text{Cl} (g) \rightarrow \text{Cl}^- (g) \)
   c) \( \text{K} (s) \rightarrow \text{K} (g) \)
   d) \( \text{K} (g) \rightarrow \text{K}^+ (g) \)
   e) \( \text{K}^+ (g) + \text{Cl}^- (g) \rightarrow \text{KCl} (s) \)

2. Explain why the melting points of the group 1 metal chlorides decreases down the group.

3. Of what use are theoretical values produced using mathematical models for helping chemists understand the nature of ionic and covalent bonds?

4. Consider the following theoretical and experimental lattice enthalpies and then deduce the order of increasing covalent character.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Lattice enthalpy (kJ mol(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Experimental</td>
</tr>
<tr>
<td>KF</td>
<td>801</td>
</tr>
<tr>
<td>CaO</td>
<td>3513</td>
</tr>
<tr>
<td>LiO</td>
<td>744</td>
</tr>
</tbody>
</table>

15.3 Entropy

1. State and explain the factors that increase the entropy in a system. Address: phase changes, changes in pressure (acting on a gas), a solution forming from a solid and liquid, comparing characteristics of solids (i.e. graphite versus diamond), chemical reactions, changes in temperature of a system.

2. Which one of the following does not generally lead to an increase in the entropy of a system?
   - A. An increase in the total number of moles of particles.
   - B. The formation of a solution.
   - C. The formation of a gaseous product.
   - D. The formation of solid products.

3. A short length of magnesium ribbon burns in a crucible over a Bunsen burner.
   a) Write a balanced equation for the reaction. b) Is the reaction exothermic or endothermic?
   c) Do you think the product, MgO, can be classified as more or less ordered than the reactants, metallic magnesium and gaseous oxygen?
   d) Give the sign of the enthalpy and entropy change in this reaction.

4. For each of the following reactions, state with a reason whether you would expect the entropy of the products to be greater or less than that of the reactants.
5. 5 cm³ of hydrochloric acid is put in a test tube and the temperature of the acid recorded. 3 g of solid ammonium carbonate was added and the mixture stirred. The temperature of the reaction decreased.
   a) Write a balanced equation for the reaction.
   b) Consider the surroundings. Would the surroundings gain or lose energy as the chemicals returned to room temperature.
   c) Comment on the relative change in the magnitude of the entropy and enthalpy and their sign.

6. From an entropy point of view, in which of the following reactions are the products more stable than the reactants.
   A. 2C(s) + O₂(g) → 2CO(g)
   B. CaO(s) + CO₂(g) → CaCO₃(s)
   C. H₂(g) + Cl₂(g) → 2HCl(g)
   D. 2SO₂(g) + O₂(g) → 2SO₃(g)

7. Consider each of the following reactions and determine which would have the most positive value of ∆S.
   A. CH₄ (g) + 2 O₂(g) → CO₂(g) + 2 H₂O(g)
   B. CO₂ (g) + 3 H₂(g) → CH₃OH(g) + H₂O(g)
   C. 2 Al (s) + 3 S(s) → Al₂S₃ (s)
   D. CH₄ (g) + H₂O(g) → 3 H₂(g) + CO₂(g)

8. Calculate the standard entropy change for the following reactions at 25°C.
   A. CH₄ (g) + 2 O₂(g) → CO₂(g) + 2 H₂O(g)
   B. CO₂ (g) + 3 H₂(g) → CH₃OH(g) + H₂O(g)

9. a) Write the balanced equation for the formation of butanoic acid, C₃H₇COOH from its elements.
   b) Calculate the standard entropy change, ∆S°ₚ for the formation of butanoic acid at 25°C.

10. Define standard entropy, S° and explain why the symbol Δ is not included.