

**Chemistry**  
**Higher level**  
**Paper 2**

Practice paper

**Topic: Thermodynamics**

1. Construct a Born-Haber cycle for the formation of  $\text{CaCl}_2$  and calculate its enthalpy of formation using the data below:

[5]

$$\Delta H_{\text{at}}(\text{Ca}) = +178 \text{ kJ mol}^{-1}$$

$$\text{IE}_1(\text{Ca}) = +590 \text{ kJ mol}^{-1}$$

$$\text{IE}_2(\text{Ca}) = +1145 \text{ kJ mol}^{-1}$$

$$\Delta H_{\text{at}}(\text{Cl}) = +121 \text{ kJ mol}^{-1}$$

$$\text{EA}_1(\text{Cl}) = -349 \text{ kJ mol}^{-1}$$

$$\Delta H_{\text{latt}}(\text{CaCl}_2) = +2258 \text{ kJ mol}^{-1}$$

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2. The theoretical lattice enthalpy for  $\text{AlBr}_3$  is  $+5000 \text{ kJ mol}^{-1}$ . The experimental value from a Born-Haber cycle is  $+5450 \text{ kJ mol}^{-1}$ . Explain the reason for this discrepancy.

[2]

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3. Calculate  $\Delta S^\ominus$  for the Haber process:  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$

[3]

$$S^\ominus \text{ (J K}^{-1} \text{ mol}^{-1}\text{): } \text{N}_2=192, \text{H}_2=131, \text{NH}_3=193$$

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4. Using your answer from Q3 and given  $\Delta H^\ominus = -92 \text{ kJ mol}^{-1}$ , determine  $\Delta G^\ominus$  at 298 K. [2]

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5. Determine the temperature above / below which the Haber process becomes non-spontaneous. [2]

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6. At a certain temperature,  $\Delta G^\ominus = -10.0 \text{ kJ mol}^{-1}$ . Calculate the value of the equilibrium constant K at 500 K. [2]

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7. Sketch a graph of  $\Delta G$  against Temperature (T) for an endothermic reaction where entropy increases. Label the crossover point. [3]

8. Enthalpy of hydration is affected by ionic radius and ionic charge.

(a) Compare the hydration enthalpy of  $\text{Mg}^{2+}$  and  $\text{Ba}^{2+}$ . Justify your answer.

[2]

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9. Complete the table below describing the effect of temperature on spontaneity based on the signs of enthalpy and entropy changes:

[4]

$\Delta H$ sign	$\Delta S$ sign	Spontaneity
-	+	
+	-	
-	-	
+	+	

10. Lattice enthalpy values are determined by the characteristics of the constituent ions. Predict, with a reason, whether NaF or MgO will have a higher lattice enthalpy of dissociation.

[2]

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