

1. Predict the sign of ΔS_{sys} for each reaction: I
 - (a) $\text{Mg(s)} + \text{Cl}_2\text{(g)} \longrightarrow \text{MgCl}_2\text{(s)}$ (Negative)
 - (b) $2\text{H}_2\text{S(g)} + 3\text{O}_2\text{(g)} \longrightarrow 2\text{H}_2\text{O(g)} + 2\text{SO}_2\text{(g)}$ (Negative)
 - (c) $\text{N}_2\text{(g)} + 3\text{H}_2\text{(g)} \longrightarrow 2\text{NH}_3\text{(g)}$ (Negative)
 - (d) $2\text{KClO}_3\text{(s)} \longrightarrow 2\text{KCl(s)} + 3\text{O}_2\text{(g)}$ (Positive)
2. Predict the sign of ΔH_{sys} and ΔS_{sys} for each process.
 - (a) Evaporation ($\Delta H_{sys} = \text{Positive}$ $\Delta S_{sys} = \text{Positive}$)
 - (b) Condensation ($\Delta H_{sys} = \text{Negative}$ $\Delta S_{sys} = \text{Negative}$)
 - (c) Melting ($\Delta H_{sys} = \text{Positive}$ $\Delta S_{sys} = \text{Positive}$)
 - (d) Freezing (fusion) ($\Delta H_{sys} = \text{Negative}$ $\Delta S_{sys} = \text{Negative}$)
 - (e) Sublimation (solid to gas) ($\Delta H_{sys} = \text{Positive}$ $\Delta S_{sys} = \text{Positive}$)
3. Calculate ΔG_{rxn} at the indicated temperature for each reaction and determine if the reaction is spontaneous under those conditions.
 - (a) $\Delta H_{rxn} = -385 \text{ kJ/mol}$; $\Delta S_{rxn} = +25 \text{ J/(Kmol)}$; 298 K
$$\Delta G_{rxn} = \Delta H_{rxn} - T\Delta S_{rxn} = -385 \text{ kJ/mol} - (298 \text{ K})(0.025 \text{ kJ/(Kmol)}) = -392.45 \text{ kJ/mol}$$

(spontaneous)
 - (b) $\Delta H_{rxn} = +114 \text{ kJ/mol}$; $\Delta S_{rxn} = +21 \text{ J/(Kmol)}$; 225 K
$$\Delta G_{rxn} = \Delta H_{rxn} - T\Delta S_{rxn} = +114 \text{ kJ/mol} - (225 \text{ K})(+0.021 \text{ kJ/(Kmol)}) = +109.3 \text{ kJ/mol}$$

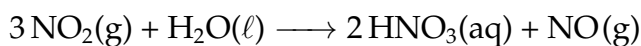
(non-spontaneous)

Useful information:

$$R = 8.314 \text{ J}/(\text{mol} \cdot \text{K})$$

Compound	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	ΔS_f° (J/mol · K)
NO ₂ (g)	33.2	51.3	240.1
H ₂ O(l)	-285.8	-237.1	70.0
HNO ₃ (aq)	-207	-110.9	146
NO (g)	91.3	87.6	210.8

4. Calculate ΔH_{rxn}° , ΔS_{rxn}° , and ΔG_{rxn}° for the following reaction at 25°C.



$$\Delta H_{rxn}^\circ = \sum(n_p \Delta H_f^\circ(\text{products})) - \sum(n_r \Delta H_f^\circ(\text{reactants}))$$

$$\Delta H_{rxn}^\circ = ((2 \times (-207 \text{ kJ/mol})) + (1 \times 91.3 \text{ kJ/mol})) - ((3 \times 33.2 \text{ kJ/mol}) + (1 \times (-285.8 \text{ kJ/mol}))) = -136.5 \text{ kJ/mol}$$

$$\text{Similarly: } \Delta S_{rxn}^\circ = -287.5 \text{ J}/(\text{Kmol}) = -0.2875 \text{ kJ}/(\text{Kmol})$$

ΔG_{rxn}° can be calculated from the formation values in the table, which gives -49.2 kJ/mol or from $\Delta G_{rxn}^\circ = \Delta H_{rxn}^\circ - T\Delta S_{rxn}^\circ = -50.8 \text{ kJ/mol}$. The slight difference is from rounding, etc.