1. Predict the sign of ΔS_{sys} for each reaction: I

   (a) $Mg(s) + Cl_2(g) \longrightarrow MgCl_2(s)$ (Negative)

   (b) $2\,H_2S(g) + 3\,O_2(g) \longrightarrow 2\,H_2O(g) + 2\,SO_2(g)$ (Negative)

   (c) $N_2(g) + 3\,H_2(g) \longrightarrow 2\,NH_3(g)$ (Negative)

   (d) $2\,KClO_3(s) \longrightarrow 2\,KCl(s) + 3\,O_2(g)$ (Positive)

2. Predict the sign of ΔH_{sys} and ΔS_{sys} for each process.

   (a) Evaporation ($\Delta H_{sys} = Positive\ \Delta S_{sys} = Positive$)

   (b) Condensation ($\Delta H_{sys} = Negative\ \Delta S_{sys} = Negative$)

   (c) Melting ($\Delta H_{sys} = Positive\ \Delta S_{sys} = Positive$)

   (d) Freezing (fusion) ($\Delta H_{sys} = Negative\ \Delta S_{sys} = Negative$)

   (e) Sublimation (solid to gas) ($\Delta H_{sys} = Positive\ \Delta S_{sys} = Positive$)

3. Calculate ΔG_{rxn} at the indicated temperature for each reaction and determine if the reaction is spontaneous under those conditions.

   (a) $\Delta H_{rxn} = -385\ kJ/mol;\ \Delta S_{rxn} = +25\ J/(Kmol);\ 298\ K$
   $\Delta G_{rxn} = \Delta H_{rxn} - T\Delta S_{rxn} = -385\,kJ/mol - (298\,K)(0.025\,kJ/(Kmol)) = -392.45\,kJ/mol$
   (spontaneous)

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

Useful information:

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

Compound	$\Delta H_f^\circ\ (kJ/mol)$	$\Delta G_f^\circ\ (kJ/mol)$	$\Delta S_f^\circ\ (J/mol \cdot K)$
NO_2(g)	33.2	51.3	240.1
$H_2O(\ell)$	-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.

$3\,NO_2(g) + H_2O(\ell) \longrightarrow 2\,HNO_3(aq) + NO(g)$

$\Delta H^\circ_{rxn} = \sum(n_p \Delta H^\circ_f(products)) - \sum(n_r \Delta H^\circ_f(reactants))$

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

Similarly: $\Delta S^\circ_{rxn} = -287.5\ J/(Kmol) = -0.2875\ kJ/(Kmol)$

ΔG°_{rxn} can be calculated from the formation values in the table, which gives $-49.2\ kJ/mol$ or from $\Delta G^\circ_{rxn} = \Delta H^\circ_{rxn} - T\Delta S^\circ_{rxn} = -50.8\ kJ/mol$. The slight difference is from rounding, etc.