

17 • Spontaneity, Entropy & Free Energy**STUDY QUESTIONS**

1. Imagine tossing two coins in the air.
- Predict the distribution of various combinations of heads and tails. *HH, HT, TH, TT*
 - What is the probability of the result being two heads? *1/4*
 - What is the most probable result? *1 head, 1 tail*

Now imagine tossing three coins in the air. *HHH, HHT, HTH, HTT, THH, THT, TTH, TTT*

- What is the probability of a three heads result? *1/8*
 - Which system has the highest entropy, the two-coin system or the three-coin system?
2. Which one of the following pairs of samples has the higher entropy?
- $\text{Br}_2(\text{l})$ or $\text{Br}_2(\text{g})$
 - $\text{C}_2\text{H}_6(\text{g})$ or $\text{C}_3\text{H}_8(\text{g})$
 - $\text{MgO}(\text{s})$ or $\text{NaCl}(\text{s})$ *← compare lattice energies: $K\left(\frac{Q_1 Q_2}{r}\right) = \text{L.E.}$*
 - $\text{KOH}(\text{s})$ or $\text{KOH}(\text{aq})$

3. Predict the entropy change for the following processes:

- $\text{O}_2(\text{g}) \rightarrow 2\text{O}(\text{g})$ *$\Delta S +$*
- $2\text{O}_3(\text{g}) \rightarrow 3\text{O}_2(\text{g})$ *$\Delta S +$*
- $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$ *ΔS not obvious. ($\Delta S^\circ_{\text{rxn}} = -7.10 \text{ J/K}$)*
- $\text{NaCl}(\text{s}) \rightarrow \text{Na}^+(\text{aq}) + \text{Cl}^-(\text{aq})$ *$\Delta S +$*
- $\text{C}_2\text{H}_5\text{OH}(\text{l}) \rightarrow \text{C}_2\text{H}_5\text{OH}(\text{g})$ *$\Delta S +$*
- $\text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{AgCl}(\text{s})$ *$\Delta S -$*

9. Of the following reactions,
 which are spontaneous at any temperature, *(a) (d)*
 which are never spontaneous regardless of the temperature, *(e)*
 which are spontaneous only at a high temperature, *(c)*
 and which are spontaneous only at low temperature? *(b)*

	ΔH	ΔS
a. $\text{C}_8\text{H}_{18}(\text{l}) + \frac{25}{2}\text{O}_2(\text{g}) \rightarrow 8\text{CO}_2(\text{g}) + 9\text{H}_2\text{O}(\text{g})$	-	+
b. $\text{N}_2(\text{g}) + 2\text{F}_2(\text{g}) \rightarrow \text{N}_2\text{F}_4(\text{g})$	-	-
c. $\text{Cl}_2(\text{g}) \rightarrow 2\text{Cl}(\text{g})$	+	+
d. $2\text{O}_3(\text{g}) \rightarrow 3\text{O}_2(\text{g})$	-	+
e. $2\text{C}(\text{s}) + 2\text{H}_2(\text{g}) \rightarrow \text{C}_2\text{H}_4(\text{g})$	+	-

$$\Delta G = \Delta H - T\Delta S$$