

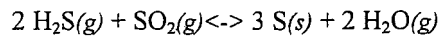
# $\Delta G, \Delta H, \Delta S$

## Advanced QUIZ Entropy and Free Energy

1. Hydrogen sulfide can be removed from natural gas by the reaction  
pts  $2\text{H}_2\text{S}(\text{g}) + \text{SO}_2(\text{g}) \rightarrow 3\text{S}(\text{s}) + 2\text{H}_2\text{O}(\text{g})$   
Determine  $\Delta S$  for this reaction at standard conditions.
2. Determine  $\Delta G$  for the following reaction using the information given below.  
pts  $2\text{CO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g})$   
 $2\text{CH}_4(\text{g}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{CO}(\text{g}) + 4\text{H}_2\text{O}(\text{g}) \quad \Delta G^\circ = -1088 \text{ kJ}$   
 $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g}) \quad \Delta G^\circ = -801 \text{ kJ}$
3. One of the reactions that destroys ozone in the upper atmosphere is  
pts  $\text{NO}(\text{g}) + \text{O}_3(\text{g}) \rightarrow \text{NO}_2(\text{g}) + \text{O}_2(\text{g})$   
Determine  $\Delta G$  for this reaction at  $-35^\circ\text{C}$  (this is the average temperature of the upper atmosphere)  
(Assume  $\Delta H$  and  $\Delta S$  vary only slightly with temperature change)  
Will this reaction occur spontaneously under these conditions?
4. Determine  $\Delta G$  for the following reaction at standard conditions.  
pts  $6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l}) \rightarrow \text{C}_6\text{H}_{12}\text{O}_6(\text{s}) + 6\text{O}_2(\text{g})$   
+1pt Extra credit? Can you name this very common reaction?

5. Determine the temperature at which the following reaction will not proceed spontaneously in either direction. At what temperatures will the forward reaction be spontaneous.  
pts  $2\text{Al}(\text{s}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{Al}_2\text{O}_3(\text{s})$

6.



At 298 K, the standard enthalpy change,  $\Delta H$ , for the reaction represented above is  $-145$  kilojoules.

2pts

(a) Predict the sign of the standard entropy change,  $\Delta S$ , for the reaction. Explain the basis for your prediction.

2pts

(b) At 298 K, the forward reaction (*i.e.*, toward the right) is spontaneous. What change, if any, would occur in the value of  $\Delta G$  for this reaction as the temperature is increased? Explain your reasoning using thermodynamic principles.

2pts

(c) The absolute temperature at which the forward reaction becomes nonspontaneous can be predicted. Write the equation that is used to make the prediction. Why does this equation predict only an approximate value for the temperature?

7. When solid  $\text{NH}_4\text{SCN}$  is mixed with solid  $\text{Ba}(\text{OH})_2$  in a closed container, the temperature drops and a gas is produced. Which of the following indicates the correct signs for  $\Delta G$ ,  $\Delta H$ , and  $\Delta S$  for the process? Explain your answer.

2pts

	$\Delta G$	$\Delta H$	$\Delta S$
(A)	-	-	-
(B)	-	+	-
(C)	-	+	+
(D)	+	-	+
(E)	+	-	-

## Chemistry, 3e

Name \_\_\_\_\_ Date \_\_\_\_\_ Section \_\_\_\_\_

1. Substance	$\Delta H_f^\circ$ kJ/mole	$\Delta G_f^\circ$ kJ/mole	$S^\circ$ J/K mole
CO <sub>2</sub> (g)	-393.5	-394	214
C <sub>6</sub> H <sub>12</sub> O <sub>6</sub> (s)	-1275	-911	212
HNO <sub>3</sub> (l)	-174	-81	156
H <sub>2</sub> O (g)	-242	-229	189
H <sub>2</sub> O (l)	-286	-237	70
H <sub>2</sub> S (g)	-21	-34	206
NO (g)	90		211
NO <sub>2</sub> (g)	34		240
O <sub>2</sub> (g)		0	205
O <sub>3</sub> (g)	143		239
S (s)			32
SO <sub>2</sub> (g)	-297	-300	248
Al (s)			28
Al <sub>2</sub> O <sub>3</sub> (s)	-1676		51