**Review**

**Name:** **Period:** **Seat#:**

### STATION 1: ENTROPY CHANGE

For each of the following examples, decide whether the entropy is increasing or decreasing. Is ΔS + or –?

ΔS is _____ The electrolytic decomposition of water. $2H_2O(l) \rightarrow 2\ H_2(g) + O_2(g)$

ΔS is _____ The freezing of water. $H_2O(l) \rightarrow H_2O(s)$

ΔS is _____ The reaction of sodium metal with water. $2Na(s) + 2H_2O(l) \rightarrow H_2(g) + 2Na^+(aq) + 2\ OH^-(aq)$

ΔS is _____ The boiling of water. $H_2O(l) \rightarrow H_2O(g)$

ΔS is _____ The reaction of $OF_2$ and water. $OF_2(g) + H_2O(g) \rightarrow O_2(g) + 2HF(g)$

# Entropy and Free Energy

### STATION 2: ΔH, ΔS, ΔG, GIBB'S FREE ENERGY

$$C_2H_{2(g)} + 2\ H_{2(g)} \rightarrow C_2H_{6(g)}$$

| Substance | $S°$ (J/mol·K) | $\Delta H°_f$ (kJ/mol) |
|---|---|---|
| $C_2H_{2(g)}$ | 200.9 | 226.7 |
| $H_{2(g)}$ | 130.7 | 0 |
| $C_2H_{6(g)}$ | 229.6 | -84.7 |

Calculate ΔS, ΔH, and ΔG for this reaction at 298 K.

# Entropy and Free Energy

**STATION 3: EQUILIBRIUM**

Consider the boiling of liquid bromine: $Br_{2(l)} \leftrightarrows Br_{2(g)}$

At 25°C, $\Delta H°$ = 30.84 kJ/mol and $\Delta S°$ = 92.9 J/mol·K for this reaction.
Calculate the value of $\Delta G°$.

Assuming that $\Delta H$ and $\Delta S$ do not change at different temperatures, calculate the normal boiling point of liquid bromine.

# Entropy and Free Energy

**STATION 4: PREDICTING SPONTANEITY**

Consider the reaction: $MgO(s) + SO_2(g) \rightarrow MgSO_3(s)$

What is the sign of $\Delta H$ for this reaction? _____ Justify your answer.

What is the sign of $\Delta S$ for this reaction? _____ Justify your answer.

This reaction will be:

a) spontaneous at all temperatures
b) spontaneous at high temperatures
c) spontaneous at low temperatures
d) non-spontaneous at all temperatures

# Entropy and Free Energy

**STATION 5: $K_{eq}$ & $\Delta G$**

Consider the reaction: $C_2H_5Cl_{(g)} + Cl_{2(g)} \rightarrow C_2H_4Cl_{2(g)} + HCl_{(g)}$

**Standard Free Energies of Formation at 298 K**

| Substance | $\Delta G°_f$ kJ·mol$^{-1}$ |
|---|---|
| $C_2H_4Cl_{2(g)}$ | -80.3 |
| $C_2H_5Cl_{(g)}$ | -60.5 |
| $HCl_{(g)}$ | -95.3 |
| $Cl_{2(g)}$ | 0 |

Calculate the value of ΔG° for this reaction.

Calculate the value of $K_{eq}$ for the reaction at 298 K. [ΔG° = -RT *ln*K; R = 8.31 J·mol$^{-1}$·K$^{-1}$]

From the AP Exam:

**THERMOCHEMISTRY/KINETICS**

$$\Delta S^\circ = \sum S^\circ \text{ products} - \sum S^\circ \text{ reactants}$$

$$\Delta H^\circ = \sum \Delta H_f^\circ \text{ products} - \sum \Delta H_f^\circ \text{ reactants}$$

$$\Delta G^\circ = \sum \Delta G_f^\circ \text{ products} - \sum \Delta G_f^\circ \text{ reactants}$$

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$
$$= -RT \ln K = -2.303\, RT \log K$$
$$= -n\mathcal{F}E^\circ$$

$$\Delta G = \Delta G^\circ + RT \ln Q = \Delta G^\circ + 2.303\, RT \log Q$$

$$q = mc\Delta T$$

$$C_p = \frac{\Delta H}{\Delta T}$$

$$\ln[\mathrm{A}]_t - \ln[\mathrm{A}]_0 = -kt$$

$$\frac{1}{[\mathrm{A}]_t} - \frac{1}{[\mathrm{A}]_0} = kt$$

$$\ln k = \frac{-E_a}{R}\left(\frac{1}{T}\right) + \ln A$$

Gas constant, $R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$
$= 0.0821 \text{ L atm mol}^{-1} \text{ K}^{-1}$
$= 62.4 \text{ L torr mol}^{-1} \text{ K}^{-1}$
$= 8.31 \text{ volt coulomb mol}^{-1} \text{ K}^{-1}$