CHM152 Quiz 9 25 Pts Spring 2017 Name: Key

$\Delta G° = \Delta H° - T\Delta S°$ $\Delta G = \Delta G° + RT\ln Q$ $\Delta G° = -RT\ln K$ $\Delta H° = \Sigma nH°_{(products)} - \Sigma nH°_{(reactants}$

$\Delta S° = \Sigma nS°_{(products)} - \Sigma nS°_{(reactants)}$ $\Delta G° = \Sigma nG°_{(products)} - \Sigma nG°_{(reactants)}$

R = 0.08205783 (L·atm)/(mol·K) = 8.314510 J/(mol·K)

1. (4 Pts) Calculate ΔS° at 25°C for the reduction of PbO(s), $2PbO(s) + C(s) \rightarrow 2Pb(s) + CO_2(g)$ given these absolute entropies:

	S° (J/K·mol)
PbO(s)	69.45
C(s)	5.7
Pb(s)	64.89
CO_2(g)	213.6

$\Delta S = (2(64.89) + 213.6) - (2(69.45) + 5.7)$ (Pb, CO_2, PbO, C)

$\Delta S = +198.8\ J/K$

2. (4 Pts) HI has a normal boiling point of –35.4°C, and its ΔH_{vap} is 21.16 kJ/mol. Calculate the molar entropy of vaporization (ΔS_{vap}). Show work to receive credit.
   A) 598 J/K·mol D) 0.068 J/K·mol
   B) 68.6 J/K·mol E) 89.0 J/K·mol
   C) 75.2 J/K·mol

@ Eq (Boiling) $\Delta G = 0 = \Delta H - T\Delta S$

$\Delta S = \frac{\Delta H}{T} = \frac{21.16 \times 10^3\ J/mol}{237.6\ K} = 89.1\ J/K \cdot mol$

3. (4 Pts) Calculate ΔG° for the reaction $3NO_2(g) + H_2O(l) \rightarrow 2HNO_3(l) + NO(g)$.

	$\Delta G°_f$ (kJ/mol)
H_2O(l)	–237.2
HNO_3(l)	–79.9
NO(g)	86.7
NO_2(g)	51.8

$\Delta G = [2(-79.9) + 86.7] - [3(51.8) + -237.2]$ (HNO_3, NO, NO_2, H_2O)

$\Delta G = 8.7\ kJ/mol$

4. (4 Pts) Hydrogen peroxide (H_2O_2) decomposes according to the equation (Show work to receive credit) $H_2O_2(l) \rightarrow H_2O(l) + \frac{1}{2}O_2(g)$.
   Calculate K_p for this reaction at 25°C. (ΔH° = –98.2 kJ/mol, ΔS° = 70.1 J/K·mol)

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

$= -98.2 \times 10^3\ J/mol - (298K \cdot 70.1\ J/K\,mol)$

$\Delta G = -119089.9\ J/mol$

$\Delta G = -RT\ln K$

$-119089.9 = -8.314(298)\ln K$

$\ln K = 48.067$

$K = 7.5 \times 10^{20}$

5. (4 Pts) At 1500°C the equilibrium constant for the reaction $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$ has the value $K_p = 1.4 \times 10^{-7}$. Calculate ΔG° for this reaction at 1500°C. Show work to receive credit.
   A) 105 kJ/mol B) 1.07 kJ/mol C) –233 kJ/mol D) –105 kJ/mol E) 233 kJ/mol

$\Delta G = -RT\ln K$

$= -8.314(1773\ K)\ln 1.4 \times 10^{-7}$

$= 232632\ J/mol = 232\ kJ/mol$

More on back.

6. (4 Pts) Sodium carbonate can be made by heating sodium bicarbonate:

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$$

Given that $\Delta H° = 128.9$ kJ/mol and $\Delta G° = 33.1$ kJ/mol at 25°C, above what minimum temperature will the reaction become spontaneous under standard state conditions?

$\Delta G° = \Delta H° - T\Delta S°$

$\Delta S° = \frac{\Delta H° - \Delta G°}{T}$

$\Delta S° = 321 \frac{J}{mol \cdot K}$

$\Delta G = 0 = \Delta H - T\Delta S$

$0 = 128.9 \times 10^3 \frac{J}{mol} - T(321 \frac{J}{mol \cdot K})$

$T = 401K$

above 401 K or > 128°C

7. (1 Pt) Which of these species would you expect to have the highest standard entropy (S°)?

A) $CH_4(g)$ B) $C_2H_2(g)$ C) $C_2H_4(g)$ D) $C_2H_6(g)$ E) $C_3H_8(g)$