CHEM 5200 - Exam 3 - November 7, 2017

INFORMATION PAGE (Use for reference and for scratch paper)

Constants and Conversion Factors:

R = 8.31 J/mol-K = 8.31 kPa-L/mol-K = 0.00831 kJ/mol-K

1 L-atm = 101 J

1 L-bar = 100 J

1 kPa-L = 1 J

1 bar = 100 kPa

1 bar = 750 torr

1 atm = 760 torr

1 kPa = 7.50 torr

Molar Masses $C_{10}H_8$ - 128. C_6H_6 - 78. $C_{12}H_{22}O_{11}$ - 342.
$C_6H_5CH_3$ - 92.

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Name_____

(30) MULTIPLE CHOICE [3 points per question] (Circle the ONE correct answer)

1. When 0.90 moles of $Cl_2(g)$ are mixed with 0.40 moles of $O_2(g)$ at 150 ^oC, the Gibbs Energy of mixing, ΔG_{mix}, is approximately:

   (A) -1.6 kJ (B) -2.1 kJ (C) -2.2 kJ (D) -2.8 kJ

2. Consider a mixture of two liquids, A and B. When 6.0 moles of A and 4.0 moles of B are mixed together, the volume of the solution is 700 cm^3. The Partial Molar Volume of A is 80. cm^3/mol. Therefore, the Partial Molar Volume of B is approximately:

   (A) 55 cm^3/mol (B) 220 cm^3/mol (C) 63 cm^3/mol

   (D) Cannot be determined without the density of the solution

3. When 90 grams of napthalene, $C_{10}H_8$, is dissolved in 200 grams of benzene, C_6H_6 (T_b^o=80 ^oC, K_b=2.5 ^oC/m), the boiling point of the solution is

   (A) 88.8 ^oC (B) 71.2 ^oC (C) 81.8 ^oC (D) 108.8 ^oC

4. When 20 grams of an unknown compound is dissolved in 150 grams of water (K_f = 1.86 ^oC/m), the freezing point of the solution is -3.5 ^oC. What is the Molar Mass of the unknown compound?

   (A) 10.6 g/mol (B) 124 g/mol (C) 71. g/mol (D) 45 g/mol

5. When a sample of sucrose ($C_{12}H_{22}O_{11}$) is dissolved in 12.0 L of aqueous solution at 40 ^oC, the osmotic pressure of the solution is 80. torr. Aproximately how many grams of sucrose are dissolved in the solution?

   (A) 0.12 g (B) 16.8 g (C) 1.4 g (D) 52.3 g

For #6 - #9: Consider the equilibrium, $2\ PCl_3(g) + O_2(g) \rightleftharpoons 2\ POCl_3(g)$.

The enthalpy change for this reaction is -510 kJ.

The value of the equilibrium constant at 100 ^oC is 0.04 .

6. For the above reaction, if the temperature is **decreased**, then

   (A) the equilibrium will move to the left and K will decrease
   (B) the equilibrium will move to the right and K will increase
   (C) the equilibrium will move to the left and K will remain constant
   (D) the equilibrium will move to the right and K will remain constant

7. For the above reaction, if $N_2(g)$ is added at constant total pressure, then

   (A) the equilibrium will move to the left and K will decrease
   (B) the equilibrium will move to the right and K will increase
   (C) the equilibrium will move to the left and K will remain constant
   (D) the equilibrium will move to the right and K will remain constant

8. What is the approximate value of ΔG for the above reaction at 100 ^oC when $P_{PCl3} = P_{O2} = 2.0$ bar and $P_{POCl3} = 0.2$ bar?

   (A) -6.4 kJ (B) +10.0 kJ (C) -26.4 kJ (D) +16.4 kJ

9. What is the approximate value of the equilibrium constant for the above reaction at 120 ^oC?

   (A) 2.3×10^3 (B) 170 (C) 2.3×10^{-4} (D) 9.2×10^{-6}

10. Consider the gas phase equilibrium, $A(g) \overset{K}{\rightleftharpoons} 2\ B(g)$. When the pressures of A and B are each 0.10 bar at 100 ^oC, the Gibbs Energy change for the reaction is -5.0 kJ. What is the approximate value of the equilibrium constant?

    (A) 0.5 (B) 2.0 (C) 5.0 (D) 0.2

FIVE (5) problems follow: NOTE: You Must show all of your work to receive credit.

(12) 1. The Enthalpy of Vaporization, $\Delta_{vap}H$, of decane is 51. kJ/mol, and the vapor pressure of liquid decane is 50 torr at 100 ºC.

Calculate the normal boiling point of decane, in **ºC**

(15) 2. The vapor pressure of liquid toluene, $C_6H_5CH_3(l)$, is 85.5. torr at 40 ^oC A sample of solid napthalene, $C_{10}H_8(s)$, is added to 800 grams of liquid toluene. The vapor pressure of the mixture is 80.0 torr at 30 ^oC.

How many grams of napthalene are contained in the mixture.

(12) 3. Consider the gas-phase equilibrium, $3A \overset{K}{\rightleftharpoons} 2B + 2C$

If one starts with 4 moles of A and 3 moles of C (no B) in a vessel, and the reaction is allowed to come to equilibrium, the mixture contains 1.3 mol of A at a total pressure of 4.0 bar.

Calculate the equilibrium constant, K, for this reaction.

(14) 4. Consider the gas-phase dissociation equilibrium, $A(g) \overset{K}{\rightleftharpoons} 2B(g) + 2C(g)$
The equilibrium constant for this dissociation is 5.0×10^{-8}.

Calculate the fraction dissociation, α, at a total pressure of 5. bar.

Note: You may assume that $\alpha << 1$

(17) 5. Consider the gas phase equilibrium reaction: $PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$.
The equilibrium constant for this reaction is K = 100. at 150 ^oC.
The Enthalpy Change for this reaction is $\Delta_r H^o$ = -88 kJ/mol at 150 ^oC

(8) (a) Calculate the $\Delta_r S^o$ at 150 ^oC , in J/mol-K.

5. **(Cont'd)**

Consider the gas phase equilibrium reaction: $PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$.
The equilibrium constant for this reaction is K = 100. at 150 ^oC.

(9) (b) The Enthalpy change for this reaction is temperature dependent, and is given by

$\Delta_r H^o$ = a + b/T, where a = -272 kJ/mol, b = +7.8x10^4 kJ-K/mol.

Calculate the value of the equilibrium constant, K, at 300 ^oC