Assumption University  
Faculty of Engineering  
Semester 1/2006  
Quiz II  

Date: September 15, 2006  
BG 1108 General Chemistry  
Time: 11:30 – 12:30 (1 Hour)  

Calcuators – CASIO fx-61F, SHARP EL556/506R and TEXASINSTRUMENT TI-36X are permitted.

Answer all questions:

Part I: Short Questions  5 marks

Part II: Solve the Problems  20 marks

Total  25 marks

Part I: Answer the following short questions.

1. Half-life for a reaction: 
   
   \[ t_{1/2} = \dfrac{\ln 2}{k} \]  
   (1 mark)

2. Write the rate expressions for the following reaction. (1 mark)

   \[ 4 \text{NH}_3(g) + 5 \text{O}_2(g) \rightarrow 4 \text{NO}(g) + 6 \text{H}_2\text{O}(g) \]

   \[ \begin{align*}
   \frac{\Delta [\text{NH}_3]}{\Delta t} &= -\frac{1}{4} \frac{\Delta [\text{O}_2]}{\Delta t} \\
   \frac{\Delta [\text{O}_2]}{\Delta t} &= -\frac{5}{4} \frac{\Delta [\text{NO}]}{\Delta t} \\
   \frac{\Delta [\text{NO}]}{\Delta t} &= \frac{5}{4} \frac{\Delta [\text{H}_2\text{O}]}{\Delta t} \\
   \frac{\Delta [\text{H}_2\text{O}]}{\Delta t} &= \frac{5}{4} \frac{\Delta [\text{NH}_3]}{\Delta t}
   \end{align*} \]

3. The effect of soluble substance on the freezing point of solvent. (1 mark)

   The freezing point of a solution is lower than that of the solvent.

   \[ \text{Solute} \rightarrow \text{Ice} \quad T_{f, s} < T_f \]

4. Give the relationship between \(K_p\) and \(K_c\) for each of the following reaction. (2 marks)

   a. \( 2\text{Br}_2(g) = 2\text{Br}_2(g) \)
      \[ \dfrac{K_p}{K_c(2T)} \]

   b. \( \text{N}_2\text{O}_4(g) = 2\text{NO}_2(g) \)
      \[ K_p ; K_c(2T) \]

   c. \( \text{NH}_4\text{HS}(s) = \text{NH}_3(g) + \text{H}_2\text{S}(g) \)
      \[ K_p ; K_c(2T) \]

   d. \( a\text{A}(g) + b\text{B}(l) = c\text{C}(g) + d\text{D}(g) \)
      \[ K_p ; K_c(2T)^{d-a} \]
Part II: Solve the following problems (4 questions: 20 marks)

Instruction:
1. Express your answers with significant figures.
2. Use the data of the elements as given below:
   \[ H = 1.008, \quad O = 16.00, \quad K = 39.10 \]
   \[ R = 0.0821 \text{ L atm K}^{-1} \text{ mol}^{-1} \]
3. \( K_w = 5.60 \times 10^{-14} \text{ m}^3 \text{ mol}^{-1} \)

   a. Find the pH of an aqueous solution which is prepared by dissolving 5.60 \( \times \) 10\(^{-2} \) g of KOH in 1.2 L water.

   b. How much water should be added to 250 mL of dilute KOH solution with pH 4.50 to change to pH 4.65.

   (5 marks)

\[
\text{pOH} = \log \frac{K_w}{[H^+]} = \log \frac{5.60 \times 10^{-14}}{[H^+]} = 10.24
\]

\[
\text{M}_\text{KOH} = \frac{5.60 \times 10^{-2} \text{ g KOH}}{39.10 \text{ g mol}^{-1}} = 1.42 \times 10^{-3} \text{ mol L}^{-1}
\]

\[
\text{pOH} = 4.50 \quad \rightarrow \quad [OH^-] = 8.32 \times 10^{-10} \text{ mol L}^{-1}
\]

\[
\text{pH} = 14.00 - 3.08 = 10.92
\]

---

(5)

Before dilution

\[
\text{pOH} = 4.50
\]

\[
\left[\text{OH}^{-}\right] = 10^{-4.50} = 3.16 \times 10^{-5} \text{ mol L}^{-1}
\]

\[ V_1 = 250 \text{ mL} \]

\[
V_f = \frac{M_0 V_0}{M_f} = \frac{3.16 \times 10^{-5} \text{ mol L}^{-1} \times 250 \text{ mL}}{3.20 \times 10^{-5} \text{ mol L}^{-1}} = 352.7 \text{ mL}
\]

\[
\text{Vol. of water to be added} = (352.7 - 250) \text{ mL} = 102.7 \text{ mL}
\]
2. If a benzene solution boils at 86.5°C, what temperature does it freeze? 

\[ T_{BP} \text{ & } T_{FP} \text{ for benzene at } 80.1^\circ C \text{ and } 5.5^\circ C \]

\[ k_B \text{ & } k_F \text{ for benzene are } 2.53^\circ C \text{ m}^{-1} \text{ and } 5.12^\circ C \text{ m}^{-1} \text{ respectively.} \] (5 marks)

\[ \text{Given: } T_{BP} = 86.5^\circ C \]

\[ \Delta T_{BP} = (86.5 - 80.1)^\circ C = 6.4^\circ C \]

\[ m = \frac{\Delta T_{BP}}{k_B} = \frac{6.4^\circ C}{2.53^\circ C \text{ m}^{-1}} \]

\[ \Delta T_{FP} = k_F m = 5.12^\circ C \text{ m}^{-1} \times \frac{6.4^\circ C}{2.53^\circ C \text{ m}^{-1}} \]

\[ T_{FP} = (5.5 - 13)^\circ C = -7.5^\circ C \]
3. The thermal decomposition of phosphine, \( \text{PH}_3 \), is a first-order reaction: \( 4\text{PH}_3(\text{g}) \rightarrow \text{P}_4(\text{g}) + 6\text{H}_2(\text{g}) \).

The half-life of the reaction is 50.0 seconds at 650°C.

Calculate (a) the first-order rate constant for the reaction, and (b) the time required for 90% of the phosphine to decompose. (5 marks)

\[ t_{1/2} = \frac{0.693}{k} \]

\[ k = \frac{0.693}{t_{1/2}} = \frac{0.693}{50.0 \text{ s}} = 1.39 \times 10^{-2} \text{ s}^{-1} \]

(b) 90% decomposition

\[ [A]_0 = 1.0 \text{ mol} \]
\[ [A] = 0.10 \text{ mol} \]

\[ t = \frac{1}{k} \ln \frac{[A]_0}{[A]} = \frac{1}{1.39 \times 10^{-2} \text{ s}^{-1}} \ln \frac{1.0}{0.10} \]

\[ t = 3.30 \times 10^{2} \text{ s} = 1.65 \times 10^{2} \text{ s} \]

\[ t = \frac{1.65 \times 10^{2} \times 1.0 \text{ min}}{60} = 2.75 \text{ min} \]
4. A 2.50 moles of NOCl was initially in a 2.0 L reaction chamber at 400°C. At the equilibrium, it was found that 26.0% of NOCl had dissociated:

\[ 2 \text{NOCl}(g) \rightarrow 2 \text{NO}(g) + \text{Cl}_2(g) \]

Calculate \( K_c \), \( K_p \) and partial pressure of NOCl at the equilibrium. (5 marks)

\[
\begin{array}{c|c|c|c}
\text{React. mol} & \text{Dist. mol} & \\
\hline
\text{NOCl} & 2.50 & 0.65 \times 0.33 \\
\text{NO} & 0.65 \times 0.33 & 0.33 & 0.82 \times 0.82 \\
\text{Cl}_2 & 0.33 & 0.33 & 0.33 \\
\end{array}
\]

\[
K_c = \frac{[\text{NO}]^2[\text{Cl}_2]}{[\text{NOCl}]^2} = \frac{(0.33)^2(0.33)}{(0.82)^2} = 2.1 \times 10^{-3}
\]

\[
K_p = K_c (RT)^1 = 2.1 \times 10^{-3} \times 0.0821 \times 623 \approx 1.2
\]

\[
P_{\text{NOCl}} = 0.92 \text{ atm} \times 0.0821 \text{ L atm}^{-1} \text{ mol}^{-1} \times 623 \text{ K} = 51 \text{ atm}
\]

***************

5