KWANTLEN POLYTECHNIC UNIVERSITY

CHEMISTRY 1210 – SPRING 2017

EXAM 1

February 9th 2017

Name: _____

Student #: _____

_____ / **40**

Time allowed: 1h50

Only approved calculators are permitted
Cell phones and other electronics must be turned off
"What is 'HIJKLMNO'? – H_2O"
Good Luck – Bonne chance – Suerte

$T_k = T_c + 273.15$
$K_w = 1.0 \times 10^{-14}$ (at 25°C)

Assume all acid-base questions are at 25°C unless specified

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$ln\left(\frac{K_{eq1}}{K_{eq2}}\right) = \frac{\Delta H^o}{R}\left(\frac{T_1 - T_2}{T_1 T_2}\right)$$

$$k_p = k_c(RT)^{\Delta n}$$

1) ***(1 pt)*** What is a chemical equilibrium? It is a chemical reaction… *(circle one)*

   a) …that is balanced precariously on the edge of a lab bench, but somehow manages to not fall off
   b) …where the concentration of the products is equal to the concentrations of the reactants which is defined by a constant
   c) …where both the forward and reverse reaction are taking place at the same rate
   d) …where the concentration of the products is a constant when conditions are changed

2) **(1 pt)** Which of the following is the strongest acid: *(circle one)*

   a) H_3PO_4, phosphoric acid, ka = 7.1×10^{-3}
   b) H_2CO_3, carbonic acid, ka = 4.3×10^{-7}
   c) NH_3, ammonia, kb = 1.7×10^{-5}
   d) $C_7H_6O_2$, benzoic acid, ka = 6.3×10^{-5}

3) ***(1 pt)*** Which of the following salts would be acidic? (NH_3, kb =1.7×10^{-5}; H_2CO_3 ka1 = 4.3×10^{-7}, ka2 = 5.6×10^{-11}) *(circle one)*

   a) NaCl
   b) NH_4Cl
   c) $CaCO_3$
   d) $KClO_4$

4) ***(2 pts)*** What is a weak diprotic base, give one example and show its reactions with water.

5) ***(3 pts)*** The Haber reaction is used to produce ammonia

$$3H_2(g) + N_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta H^\circ = -92.4 \text{ kJ}$$

A mixture of $H_2(g)$, $N_2(g)$ and $NH_3(g)$ is brought to equilibrium at 3000°C. Describe how the reaction conditions, a-b-c, could be modified to increase the yield of $NH_3(g)$.

a) Concentration (reactants):

b) Pressure:

c) Temperature:

6) ***(2 pts)*** Based on the following two reactions and equilibrium constants, determine the value of K_3.

$NO(g) + \frac{1}{2}O_2(g) \rightleftharpoons NO_2(g)$ $\quad K_1 = 1.1\times10^{-3}$

$2NO(g) \rightleftharpoons N_2(g) + O_2(g)$ $\quad K_2 = 5.5\times10^{-1}$

$N_2(g) + 2O_2(g) \rightleftharpoons 2NO_2(g)$ $\quad K_3 = ?$

7) ***(4 pts)*** Consider the reaction: $2NO(g) \rightleftharpoons N_2(g) + O_2(g)$, for which $k_c = 10.0$ at 200 °C. A 5.00 L vessel if filled with 10.0 mol of $N_2(g)$ and 10.0 mol of $O_2(g)$

a) Determine the equilibrium concentration of NO

b) Determine the k_p for this reaction at 200°C? (use R=0.08314 L bar/mol K)

8) ***(2 pts)*** A solution is prepared as follows: 24.5 g of NaOH (40.0 g/mol) is dissolved in a 250.0 mL volumetric flask. A 15.00 mL sample of the first solution is diluted to 100.0 mL in a second volumetric flask. Determine the pH of the final solution.

9) ***(2 pts)*** Determine the pOH of a 0.45 M solution of HCl at 50.0°C. $K_w = 1.0 \times 10^{-14}$ at 25°C, and the autohydrolysis of water reaction has $\Delta H° = +55.8$ kJ/mol. (use R=8.314 J/mol K)

10) ***(4 pts)*** $H_3PO_4(aq)$ is an acid, with $K_{a1} = 6.9 \times 10^{-3}$; $K_{a2} = 6.3 \times 10^{-8}$; $K_{a3} = 4.8 \times 10^{-13}$.

Consider a 7.0 M solution of H_3PO_4.

a) Determine the pH of this solution

b) Determine the equilibrium concentration of PO_4^{3-} in this solution

11) ***(4 pts)*** Benzoic acid has a $k_a = 6.3 \times 10^{-5}$. Determine the pH of:

a) A 0.100 M benzoic acid solution

b) A 0.500 M sodium benzoate solution *(benzoate is the conjugate base of benzoic acid)*

12) ***(2 pts)*** Determine the mass of sodium fluoride NaF (42.0 g/mol) that needs to be added to 1.50 L of 0.100 M hydrofluoric acid HF ($k_a = 6.6\times10^{-4}$) to prepare a solution with a pH of 3.50.

13) ***(2 pts)*** Consider the following reaction:

$CO(g) + 3H_2(g) \rightleftharpoons CH_4(g) + H_2O(g)$

When 2.00 mol of CO(g) is mixed with 4.50 mol of $H_2(g)$ in a 2.0 L vessel at 250°C and the reaction is allowed to reach equilibrium, it is determined that 0.250 mol of $H_2O(g)$ are present at equilibrium. Determine K_c at 250°C.

14) ***(2 pts)*** Consider the following equilibrium:

$COCl_2(g) \rightleftharpoons CO(g) + Cl_2(g)$ $K_c = 4.6 \times 10^{-3}$ at 800 K

If a sample of 15.0 g of $COCl_2(g)$ (98.9 g/mol) is placed in a 1.00 L flask at 800 K and the reaction is allowed to reach an equilibrium, determine the equilibrium concentration of $COCl_2(g)$.

15) ***(4 pts)*** A 0.14 M HNO_2 solution is 5.75% ionized.

a) Calculate the pH of this solution

b) Determine the K_a of HNO_2

16) **(4 pts)** Consider the titration of 50.00 mL of 0.125 M benzoic acid ($k_a = 6.3\times10^{-5}$) with 0.125 M NaOH.

a) Determine the pH after 20.00 mL of NaOH has been added to the acid

b) Determine the volume required to reach the equivalence point and the pH at the equivalence point.