CHM152
SP09

Name:KEY

Exam II – Chapters 13 & 14

For multiple choice questions, there is only one correct answer!

Some K_a values:

Acetic acid (CH_3COOH)	**1.8×10^{-5}**
Nitrous acid (HNO_2)	**4.5×10^{-4}**
Formic acid (HCO_2H)	**1.8×10^{-4}**
Hydrocyanic acid (HCN)	**4.9×10^{-10}**
Ammonia (NH_3)	**5.6×10^{-10}**
Methylamine (CH_3NH_2)	**2.7×10^{-11}**

1. (8 pts) A student mixed together two reactants, a reaction occurred forming two new products, and equilibrium was reached. The student found the equilibrium constant to be 50. What would happen if the student took the two product chemicals and mixed them together?
   a. Equilibrium will be reached when the concentration of the reactants equals the products.
   b. The reaction stops once equilibrium is achieved.
   c. The products will react and reach equilibrium with an equilibrium constant equal to 50.
   d. The products will react and reach equilibrium with an equilibrium constant equal to 1/50.
   e. Nothing will happen, only reactants can react together to form the products.

2. (8 pts) The correct equilibrium expression for the formation of ammonia is:
   a. $\frac{[NH_3]}{[H_2][N_2]}$ b. $\frac{[H_2][N_2]}{[NH_3]}$ c. $\frac{[NH_3]^2}{[H_2]^3[N_2]}$ d. $\frac{[H_2]^3[N_2]}{[NH_3]^2}$

3. (8 pts) A student is running the reaction for the formation of ammonia in lab. The student wanted to know where her reaction was at regarding equilibrium so she sampled the mixture and found Q_C to be 2.3×10^{-2}. The value of K_C for the formation of ammonia at 500 K is 168. What is true about the student's reaction?
   a. The reaction is at equilibrium.
   b. The reaction needs to proceed in the forward direction to reach equilibrium.
   c. The reaction needs to proceed in the reverse direction to reach equilibrium.
   d. The reaction is past the point of equilibrium and stopped.

4. (10 pts) When studying carbon oxidation, the following reaction is often used:

   $$CO_2\,(g) + C\,(s) \leftrightarrow 2\,CO\,(g) \qquad \Delta H = -55.6\ kJ/mol$$

   Determine the shift in the equilibrium for the reaction if the following changes are applied:

a.	Carbon is added	**shift left**	**shift right**	**no affect**
b.	Carbon dioxide is added	**shift left**	**shift right**	**no affect**
c.	Helium gas is added	**shift left**	**shift right**	**no affect**
d.	The temperature is decreased	**shift left**	**shift right**	**no affect**
e.	The pressure is increased	**shift left**	**shift right**	**no affect**

5. (9 pts) If the pH of a solution is 5.923, calculate the
   a. $[H_3O^+]$ = 1.19×10^{-6} M
   b. $[OH^-]$ = 8.38×10^{-9} M
   c. pOH = 8.077

6. (8 pts) Circle all of the following salts that would be **basic**:

KBr $LiClO_4$ NaF NH_4NO_3 $Sr(CH_3COO)_2$

7. (8 pts) A student placed 0.025 M hydrobromic acid in water. Write the balanced equation for this reaction and calculate the pH of the resulting solution.

$HBr\ (aq) + H_20\ (l) \rightarrow Br^-\ (aq) + H_3O^+\ (aq)$

pH = -log [H3O+] = - log (0.025 M) = **1.60** (2 sig figs in concentration so 2 past the decimal for pH)

8. (9 pts) Place the following acids in order of ***increasing*** acid strength: PO_4^{3-}, H_3PO_4, HPO_4^{2-}, $H_2PO_4^-$

For polyprotic acids, the first H is the easiest to pull off so the K_a is the largest and it is the most acidic.

least acidic PO_4^{3-} , HPO_4^{2-} , $H_2PO_4^-$, H_3PO_4 most acidic

9. (8 pts) Calculate the values for K_C and K_P for the combustion of ethanol (C_2H_5OH) at 225°C if the equilibrium partial pressure of ethanol is 0.123 atm, O_2 (g) is 0.075 atm, CO_2 (g) is 0.112 atm, and H_2O (g) is 0.050 atm.

Show ALL Work **$C_2H_5OH\ (g) + 3\ O_2\ (g) \leftrightarrow 2\ CO_2\ (g) + 3\ H_2O\ (g)$**

$$K_P = \frac{(P_{H2O})^3(P_{CO2})^2}{(P_{C2H5OH})(P_{O2})^3} = \frac{(0.050\ atm)^3(0.112\ atm)^2}{(0.123\ atm)(0.075\ atm)^3} = 0.030$$

$$K_C = \frac{K_P}{(RT)^{\Delta n}} = \frac{0.030}{((0.08206\ Latm/molK)(498K))^{((2+3)-(3+1))}} = 7.3 \times 10^{-4}$$

K_C = 7.3×10^{-4} **K_P = 0.030**

10. (8 pts) What is the equilibrium concentration of all species when 0.25 M I_2, 0.25 M Cl_2 and 0.10 M ICl are mixed together in a flask?

$2\ ICl\ (g) \leftrightarrow I_2\ (g) + Cl_2\ (g)$ **K_C = 0.11 @ 25°C**

I	0.10	0.25	0.25	Since all three are given at the start, Q_C needs to be calculated. This will show what is going down *vs.* up!
C	+2x	-x	-x	$Q_C = \frac{(0.25)(0.25)}{(0.10)^2} = 6.25$
E	0.10 + 2x	0.25 – x	0.25 – x	6.25 > 0.11 (K_C given) so the reaction shifts to make Q_C smaller towards the reactants.

$$0.11 = \frac{(0.25 - x)^2}{(0.10 + 2x)^2}$$ Since both the top and bottom are squared, you can take the square root of both sides!!

(*You could also solve using the quadratic formula!*)

$$\sqrt{(0.11)} = \frac{\sqrt{(0.25 - x)^2}}{\sqrt{(0.10 + 2x)^2}}$$ 0.33 (0.10 + 2x) = 0.25 – x x = 0.13 M

[ICl] = 0.10 + 2(0.13) = 0.36 M **[I_2] =0.25 – 0.13 = 0.12M** **[Cl_2] =0.25 – 0.13 = 0.12M**

11. (8 pts) A student placed 25.0 mL of 0.500 M acetic acid in a volumetric flask and diluted the sample to 100.0 mL. Write the balanced equation and calculate the pH, pOH, $[H_3O^+]$, $[OH^-]$ of the resulting solution.

Dilution calculation first: $C_1V_1 = C_2V_2$ = 25.0 mL x 0.500 M = 100.0 mL x ___M = 0.125 M

$CH_3COOH\ (aq) + H_2O\ (l) \leftrightarrow CH_3COO^-\ (aq) + H_3O^+\ (aq)$

0.125 M	0	0
-x	+x	+x
0.125 – x	x	x

From the first page: Ka (acetic acid) = $1.8 \times 10^{-5} = \frac{x^2}{(0.125 - x)}$ Assume x is negligible

$x = 0.0015\ M = [H_3O^+]$

pH = - log (0.0015 M) = 2.82 pH + pOH = 14 so pOH = 14 – 2.82 = 11.18

$[OH^-] = 10^{-pOH} = 10^{-11.18} = 6.6 \times 10^{-12}$ M

pH = **2.82** pOH = **11.18** $[H_3O^+]$ = **0.0015 M** $[OH^-]$ = **6.6×10^{-12} M**

12. (8 pts) A student placed 4.25 g of potassium nitrite in 200.0 mL of water.

a. Show the equation(s) of what happens when potassium nitrite is placed in water:

$KNO_2\ (s) \rightarrow K+\ (aq) + NO_2^-\ (aq)$

$NO_2^-\ (aq) + H_2O\ (l) \leftrightarrow HNO_2\ (aq) + OH^-\ (aq)$

b. What is the pH of the resulting solution?

Since hydroxide is formed, K_b is used! $K_a \times K_b = K_w$ so $K_b = K_w/K_a = 2.2 \times 10^{-11}$

4.25 g KNO_2 (1 mol/82.11 g KNO_2) = 0.0499 mol KNO_2 / 0.2000 L = 0.250 M NO_2^-

$NO_2^-\ (aq) + H_2O\ (l) \leftrightarrow HNO_2\ (aq) + OH^-\ (aq)$

0.250 M	0	0
-x	+x	+x
0.250 – x	x	x

$2.2 \times 10^{-11} = x2 / (0.250 - x)$ assume x small

$x = 2.4 \times 10^{-6}$ M OH^-

pOH = -log (2.4×10^{-6} M) = 5.63

pH + pOH = 14 *SO* 14 – 5.63 = **8.37 = pH**

Extra Credit

(8 pts) Please finish each reaction by writing the correct arrow and products. Then determine whether the following reactions would result in an acidic, basic, or neutral solution:

a. $NaOH\ (aq) + HCO_2H\ (aq)$

The resulting solution is: acidic basic neutral

b. $NH_3\ (aq) + HClO_4\ (aq)$

The resulting solution is: acidic basic neutral

c. $KOH\ (aq) + HBr\ (aq)$

The resulting solution is: acidic basic neutral

d. $CH_3NH_2\ (aq) + HCO_2H$

The resulting solution is: acidic basic neutral