Gateway General Chemistry 125/126/130
Exam 3
December 5, 2006 (8:00-10:00pm)

Name_______________________

Section (*circle one*): 601 (Colin) 602 (Brannon) 603 (Mali) 604 (Xiaomu)

The exam has at total of 8 pages including the cover and a periodic table both of which you may remove. You do not need to turn the periodic table in with your exam. Please neatly show all of your work and apply significant figure rules.

Page	Questions	Possible points	Score
2	1-5	5	
3	6-8	11	
4	8	11	
5	9-11	8	
6	12-13	9	
7	14-15	6	

Total _______/50

Q1-5 *(1 point each) Please place the one correct letter in the box*

1) The value of K_c for the reaction $A \rightleftharpoons B$ is 2.21 at 25°C. At equilibrium

a. $[A] = [B]$
b. $[A] = [B]^2$
c. $[A] < [B]$
d. $[A] > [B]$
e. Need more information to determine relative concentrations.

1) C

2) To decide whether a reaction mixture is at equilibium, a student determines the value of Q, the reaction quotient, and finds that it is less than K. Therefore, the mixture is

a. at equilibrium, since there is as much reaction as required.
b. not at equilibrium, and will react to the right, to increase the amounts of products.
c. not at equilibrium, and will react to the left, to increase the amounts of reactants.
d. not at equilibrium, and will react to the right, to increase the amounts of reactants.
e. not at equilibrium, and will react to the left, to increase the amounts of products.

2) B

3) What volume of 0.1060 M NaOH is needed to neutralize a 50.00 mL sample of 0.0950 M HNO_3?

a. 55.79 mL
b. 55.19 mL
c. 50.00 mL
d. 44.81 mL
e. 5.19 mL

3) D

4) A buffer solution may result if K_3PO_4 is mixed with

a. HCl.
b. K_2HPO_4.
c. NaOH.
d. either HCl or K_2HPO_4.
e. either K_2HPO_4 or NaOH

4) D

5) The equilibrium constant for the reaction

$$NO(g) + 1/2\ O_2(g) \rightleftharpoons NO_2(g)$$

has a value of $K_c = 1.23$ at a certain temperature. What is the value of K_c for the reaction

$$2\ NO_2(g) \rightleftharpoons 2\ NO(g) + O_2(g) \quad ?$$

a. 2.46
b. 1.51
c. 0.66
d. 0.41
e. -1.51

5) C

6) (*6 points*) Given the equilibrium:

$$H_2O(g) + C(s) \rightleftharpoons CO(g) + H_2(g) \quad \Delta H > 0 \; ; \; K_{eq} < 1$$

What happens to the concentration of water $[H_2O_{(g)}]$ when the following stresses are placed on the system at equilibrium? (*Circle the correct description of the $[H_2O_{(g)}]$ as a result of the stress described*)

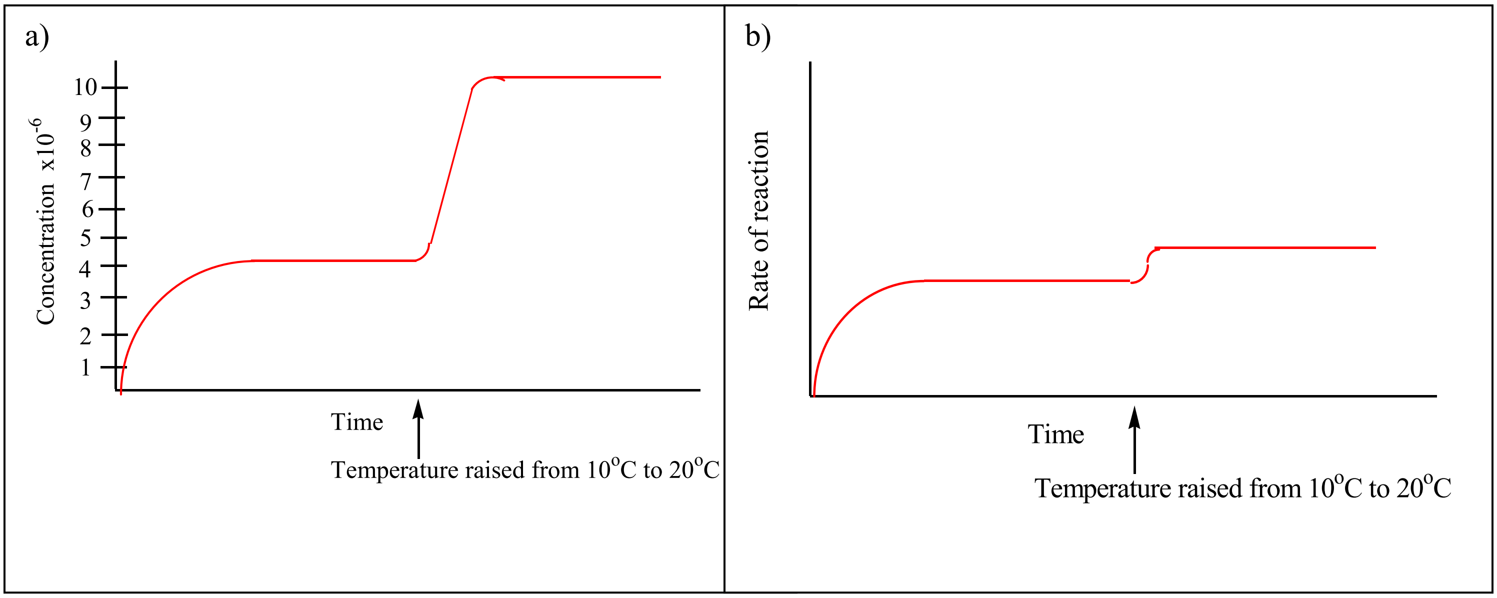
	$[H_2O_{(g)}]$		
a) Temperature is lowered	[✓ increases]	decreases	stays the same
b) $C_{(s)}$ is added	increases	decreases	[✓ stays the same]
c) $C_{(s)}$ is removed; but some $C_{(s)}$ visible in reaction flask	increases	decreases	[✓ stays the same]
d) $CO_{(g)}$ is added	[✓ increases]	decreases	stays the same
e) The volume of the container is doubled	increases	[✓ decreases]	stays the same
f) H_2 is removed	increases	[✓ decreases]	stays the same

7) (*5 points*) Suppose that you constructed an iodine thermometer by placing 1 g of $I_{2(s)}$ in a 1L glass ball at 10.0°C.

a) On the graph of concentration vs. time, sketch the concentration of $I_{2(g)}$ as the system is allowed to come to equilibrium. Then, add any change in concentration expected when the ball is warmed to 20°C and a new equilibrium is established.

b) Sketch the rate of reaction $I_{2\,(g)} \rightarrow I_{2\,(s)}$ as the system initially comes to equilibrium at 10°C and then after the temperature has been raised to 20°C.

The equilibrium constants for the reaction are: K_c (10.0°C) = 4.1×10^{-6}; K_c (20.0°C) = 9.9×10^{-6}.



8) (*11 points*) 0.46 moles of cyanic acid (HOCN) is added to 1 L of water.

a) *(2 points*) Write out the chemical equilibrium that occurs. Identify the acid, base, conjugate acid, and conjugate base.

$HOCN_{(aq)} + H_2O_{(l)} \leftrightarrow H_3O^+_{(aq)} + {}^-OCN_{(aq)}$

Acid base conj acid conj base

b) (*1 point*) Write out the expression for K_a:

$$K_a = \frac{[^-OCN][H_3O^+]}{[HOCN]}$$

c) (*3 points*) Given that $K_a = 3.5 \text{ x}10^{-4}$, find the concentrations of the three aqueous species at equilibrium.

	HOCN	$\leftrightarrow H_3O^+$	^-OCN
I	0.46M	0	0
C	-x	+x	+x
E	0.46-x	x	x

$$3.5\text{x}10^{-4} = \frac{x^2}{0.46}$$

$1.269 \text{ x}10^{-2} = x$ (2.76% of 0.46, assumption valid)

By quadratic $x = 1.25 \text{ x}10^{-2}$

HOCN = 0.5 M

$H_3O^+ = 1 \text{ x}10^{-2}$

$^-OCN = 1 \text{ x}10^{-2}$

d) (*1 point*) What is the pH of the solution?

$pH = -\log[H_3O^+] = ;\log[1.3\text{x}10^{-2}] = 1.88 = 2$

e) (*4 points*) A 0.50 M solution of NaOCN is prepared. Find the pH of this solution.

$^-OCN_{(aq)} + H_2O_{(l)} \leftrightarrow HOCN_{(aq)} + OH^-$

	^-OCN	$\leftrightarrow$ HOCN	OH^-
I	0.50M	0	0
C	-x	+x	+x
E	0.50-x	x	x

$K_a{*}K_b = 1\text{x}10^{-14}$

$K_b = 1\text{x}10^{-14}/3.5\text{x}10^{-4} = 2.8\text{x}10^{-11}$

$$K_b = \frac{[HOCN][OH^-]}{[^-OCN]}$$

$$2.8\text{x}10^{-11} = \frac{x^2}{0.50}$$

$2.86 \text{ x}10^{-6} = x = [OH^-]$

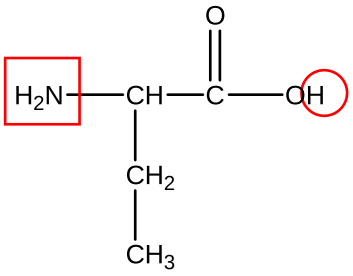
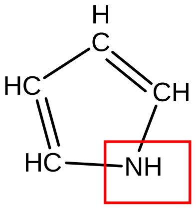
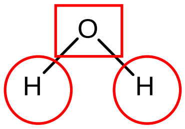
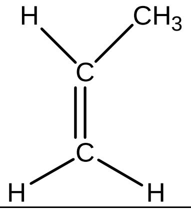
$pOH = -\log[OH^-] = -\log[2.86 \text{ x}10^{-6}] = 5.42$

$pH = 14\text{-}pOH = 8.6$

9) (*3 points*)

	Each of the compounds on the left are dissolved in water. Circle the approximate pH of the resulting solution
$NaHSO_4$	[✓ pH <7] pH~7 pH >7
NaF	pH <7 pH~7 [✓ pH >7]
HNO_2	[✓ pH <7] pH~7 pH >7
$Ca(CN)_2$	pH <7 pH~7 [✓ pH >7]
KBr	pH <7 [✓ pH~7] pH >7
HIO_3	[✓ pH <7] pH~7 pH >7

10) (*4 points*) Identify the following molecules as acids, bases, neither, or both. Circle any acidic protons and box in the sites of proton acceptors

	Acid base neither [✓ both]
	Acid [✓ base] neither both
	Acid base neither [✓ both]
	Acid base [✓ neither] both

11) *(1 point)* Name one of the two indicators you used in lab while working with acids and bases:

Phenolphthalein OR bromocresol green

12) (*5 points*) Consider these reactions:

$AgCl_{(s)} \leftrightarrow Ag^{+}_{(aq)} + Cl^{-}_{(aq)}$ $K_c = 1.8 \times 10^{-10}$

$AuCl_{(s)} \leftrightarrow Au^{+}_{(aq)} + Cl^{-}_{(aq)}$ $K_c = 1.8 \times 10^{-12}$

a) What is the solubility of AgCl in water?

	Ag^{+}	Cl^{-}
I	0	0
C	+x	+x
E	x	x

$K_c = 1.8\text{x}10^{-10} = [Ag^{+}][Cl^{-}] = x^2$

$1.3 \text{ x } 10^{-5}M = x =$ solubility

b) What is the solubility of AuCl in a 0.1 M solution of Cl^{-}?

	Au^{+}	Cl^{-}
I	0	0.1
C	+x	+x
E	x	0.1+x

$K_c = 1.8\text{x}10^{-12} = [Au^{+}]\,[Cl^{-}] = [x][0.1\cancel{+x}]$

$1.8\text{x}10^{-12} = x * 0.1$

$1.8\text{x}10^{-11}$ M = x

solubility = $2\text{x}10^{-11}$M

13) (*4 points*) Explain why the solubilities of $PbCO_3$ and $Pb_3(PO_4)_2$ (and phosphates and carbonates in general) are increased in water by lowering the pH, but the solubility of $PbCl_2$ (and chlorides in general) in water are unaffected by lowering the pH. Write out any chemical equilibria that are relevant to your answer.

$PbCO_{3(s)} \leftrightarrow Pb^{+2}_{(aq)} + CO_3^{-2}{}_{(aq)}$

$Pb_3(PO_4)_{2(s)} \leftrightarrow 3Pb^{+2}_{(aq)} + 2\,PO_4^{-3}{}_{(aq)}$

$CO_3^{-2}{}_{(aq)} + H_2O_{(l)} \leftrightarrow HCO_3^{-}{}_{(aq)} + OH^{-}_{(aq)}$

$PO_4^{-3}{}_{(aq)} + H_2O_{(l)} \leftrightarrow HPO_4^{-2}{}_{(aq)} + OH^{-}_{(aq)}$

$PbCl_{2(s)} \leftrightarrow Pb^{+2}_{(aq)} + 2Cl^{-}_{(aq)}$

Both carbonate and phosphate are bases as shown in the equilibria on the right. (They react with water, accepting a proton to form hydroxide). Lowering the pH, adds H_3O^{+} which reacts with OH^{-} (to form water) and shifts the equilibria on the right towards the right, consuming carbonate or phosphate which shifts the solubility equilibria on the left leading to a higher solubility of phosphate and carbonate salts. Chloride does not act as a base and therefore the solubility of chloride salts is not affected by the pH.

14) (*6 points*) The Henderson Hasslebach equation is: $pH = pK_a + \log([A^-]/[HA])$. A buffer made for use with a fluoride ion selective probe is made from acetic acid (CH_3COOH) and potassium acetate (CH_3COOK). The buffer needs to have total molarity of 1.0 M (including both acetic acid and potassium acetate) and have a pH of 5.22. The Ka of acetic acid is 1.8 x10^{-5}.

a) (*3 points*) What are the initial concentrations of acetic acid and potassium acetate in the buffer?

$$[A^-] + [HA] = 1\text{ M}$$
$$x + y = 1$$
$$y = 1 - x$$

$$pH = pK_a + \log\frac{[A^-]}{[HA]}$$
$$5.22 = -\log(1.8\times10^{-5}) + \log\frac{[x]}{[1-x]}$$
$$5.22 = 4.74 + \log[x/(1-x)]$$
$$0.48 = \log[x/(1-x)]$$
$$3.02 = x/(1-x)$$
$$3.02 = 4.02x;\ 0.75 = x$$

$[CH_3COOH]$ = 0.25

$[CH_3COOK]$ = 0.75

b) (*1 point*) If you have a 5.0 M solution of acetic acid, how many milliliters of this solution would you use in order to prepare 1.0 L of the buffer?

$$5\text{ M }(V_1) = 0.25\text{M }(1\text{ L})$$
$$V_1 = 0.05\text{ L} = 50\text{ mL} = 5.0\times10^1\text{ mL}$$

c) (*1 point*) How much potassium acetate would you weigh out in order to prepare 1.0 L of the buffer?

$$0.75\text{ mol }CH_3COOK * \frac{(98\text{ g }CH_3COOK)}{1\text{ mol }CH_3COOK} = 74.25\text{ g} = 74\text{ g }CH_3COOK$$

d) (*1 point*) Will the buffer have a higher buffering capacity for acid or for base? Please explain.

Acid; The buffer starts with more conjugate base (CH_3COO^-).

PERIODIC CHART OF THE ELEMENTS

1	1 H 1.00794																		2 He 4.00260
2	3 Li 6.941	4 Be 9.01218												5 B 10.81	6 C 12.011	7 N 14.0067	8 O 15.9994	9 F 18.998403	10 Ne 20.179
3	11 Na 22.98977	12 Mg 24.305												13 Al 26.98154	14 Si 28.0855	15 P 30.9376	16 S 32.06	17 Cl 35.453	18 Ar 39.948
4	19 K 39.0983	20 Ca 40.08	21 Sc 44.9559		22 Ti 47.88	23 V 50.9415	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.69	29 Cu 63.546	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.80
5	37 Rb 85.4678	38 Sr 87.62	39 Y 88.9059		40 Zr 91.22	41 Nb 92.9064	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.9055	46 Pd 106.42	47 Ag 107.8682	48 Cd 112.41	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.9045	54 Xe 131.29
6	55 Cs 132.9054	56 Ba 137.33	57 La 138.9055	58-71 LANTH-ANIDES	72 Hf 178.49	73 Ta 180.9479	74 W 183.85	75 Re 186.207	76 Os 190.2	77 Ir 192.22	78 Pt 195.08	79 Au 196.9665	80 Hg 200.59	81 Tl 204.383	82 Pb 207.2	83 Bi 208.9804	84 Po (209)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra 226.0254	89 Ac 227.0278	90-103 ACTIN-IDES	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh	108 Hs	109 Mt	110	111	112						
			LANTHANIDE SERIES		58 Ce 140.12	59 Pr 140.9077	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 158.9254	65 Tb 158.9	66 Dy 162.50	67 Ho 164.9304	68 Er 167.26	69 Tm 168.9342	70 Yb 173.04	71 Lu 174.967	
			ACTANIDE SERIES		90 Th 232.0381	91 Pa 231.0359	92 U 238.0289	93 Np 237.0842	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)	