Chem 121 **Name________________________________**
Exam 3 **April 3, 2009**
100 Points

Please follow the instructions for each section of the exam. Show your work on all mathematical problems. Provide answers with the correct units and significant figures. Be concise in your answers to discussion questions.

Complete all of problems 1-4.

1. Of the following, the amphiprotic ion is: (4 points)

   a. HCO_3^- c. CO_3^{2-}
   b. NH_4^+ d. ClO_4^- Answer ______

2. The effect of adding 0.001 mol KOH to 1.00 L of a solution that is 0.10M NH_3 and 0.10M NH_4^+ is to: (4 points)

   a. Raise the pH by several units c. Lower the pH very slightly
   b. Raise the pH very slightly d. Lower the pH by several units Answer ______

3. The reaction $2CO_2$ (g) $\rightleftarrows$ 2CO (g) + O_2 (g) has $K_c = 2.0 \times 10^{-6}$. Based on this, the reaction must be (4 points)

   a. Product-favored and fast c. Reactant-favored and slow
   b. Reactant-favored and fast d. None of the above. Answer ______

4. A buffer solution is prepared by dissolving 0.200 moles of picolinic acid (a monoprotic acid with $K_a = 4.10 \times 10^{-6}$) and 0.200 moles of sodium picolinate (its conjugate base) in 1.00 L of solution. (15 points).
   a. What is the pH of this buffer?
   b. What will be the new pH after 5 mL of 2.087 M NaOH is added to 100.0 mL of this buffer solution?

Answer three (3) of problems 5-8. Clearly mark the problem you do not want graded. 15 points each.

5. A solution contains 25.00 mL of 0.0500M NaOH, 15.00 mL of 0.100M HCl, 10.00 mL of 0.100M KOH, 5.00 mL of 0.200M HNO_3, and 10.0 mL of 0.100M NaCl. What is the pH of the solution?

6. Explain whether the following statement is true or false: “The exothermic reaction below will be spontaneous at all temperatures.”

$$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$$

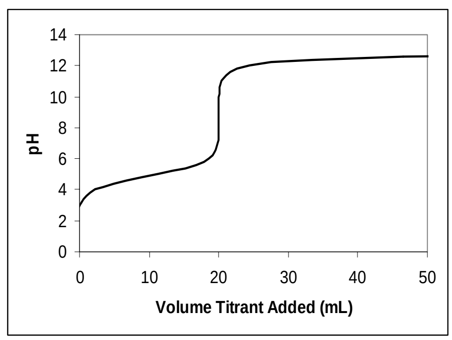
7. Will the precipitation of MgF_2 occur if a 22.5 mg sample of $MgCl_2 \cdot 6H_2O$ (molar mass = 203.29 g/mol) is added to 325 mL of 0.0035M KF? K_{sp} for $MgF_2 = 3.7 \times 10^{-8}$

8. The curve below corresponds to one of the three titrations listed. Which titration is represented by the titration curve? Explain how you chose the correct answer and ruled out the other two.

   a. The titration of 20 mL of 0.100 M ammonia ($pK_b = 4.75$) with 0.100 M HCl.

   b. The titration of 20 mL of 0.100 M propionic acid ($pK_a = 4.89$) with 0.100 M NaOH

   c. The titration of 20 mL of 0.100 M oxalic acid ($pK_{a1} = 1.27$, $pK_{a2} = 4.28$) with 0.100 M NaOH.



In the space below, answer either problem 9 or problem 10. 15 points.

9. An aqueous solution that is 2.00M in $AgNO_3$ is slowly added from a buret to an aqueous solution of 0.0100M Cl^- and 0.250M I^-. Which ion, I^- or Cl^- will precipitate first? Justify your answer with a calculation. K_{sp} for AgCl = 1.8×10^{-10}, K_{sp} for AgI = 8.5×10^{-17}.

10. Consider a solution is prepared by dissolving 0.10 mol of malonic acid and 0.20 mol of propionic acid in 1.00 L of solution. Malonic acid is a weak diprotic acid with $K_{a1} = 1.5 \times 10^{-3}$ and $K_{a2} = 2.0 \times 10^{-6}$, while propionic acid is a weak monoprotic acid with $K_a = 1.3 \times 10^{-5}$. Write enough valid equations to solve for the pH of this solution. You do not need to arrive at a numerical answer; you just need enough equations to solve for all of the unknowns.

In the space below, answer either problem 11 or problem 12. 15 points.

11. I've given you the task of preparing a pH 4.75 buffer. You've sought the help of a few of your classmates and have narrowed your choices down to the following list. Each of these combinations should produce a buffer with pH=4.75. Which student's suggestion would provide the best choice to make the highest capacity buffer? Justify your reasoning

Student	**Buffer Composition**	**K_a of weak acid**
Annie Yun	0.200M salicylic acid and 0.0032 M sodium salicylate	1.1×10^{-3}
Ty Trate	0.010 M acetic acid and 0.010 M sodium acetate	1.8×10^{-5}
Chris Talls	0.200 M acetic acid and 0.200 M sodium acetate	1.8×10^{-5}

12. Your lab has synthesized a new weak, diprotic acid, that you have named *acidic* acid (creative!). The pK_{a1} for this acid is 4.26, while pK_{a2} is 11.08. What is the pH of a 0.100 M solution of acidic acid?

Possibly Useful Information

$R = 8.31441 \text{ J mol}^{-1} \text{ K}^{-1}$

$^{o}C = K - 273.15$

$\Delta G = \Delta H - T\Delta S$

$\Delta G = \Delta G^{o} - RT\ln Q$

$pH + pOH = 14$

$K_aK_b = K_w$

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

$$pH = pK_a + \log\left(\frac{[\text{conjugate base}]}{[\text{weak acid}]}\right)$$

1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8	9 8B	10	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 H 1.00794																	2 He 4.00260
3 Li 6.941	4 Be 9.01218											5 B 10.811	6 C 12.011	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.1797
11 Na 22.9898	12 Mg 24.3050											13 Al 26.9815	14 Si 28.0855	15 P 30.9738	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.9559	22 Ti 47.88	23 V 50.9415	24 Cr 51.9961	25 Mn 54.9381	26 Fe 55.847	27 Co 58.9332	28 Ni 58.693	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.9059	40 Zr 91.224	41 Nb 92.9064	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.906	46 Pd 106.42	47 Ag 107.868	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.757	52 Te 127.60	53 I 126.904	54 Xe 131.29
55 Cs 132.905	56 Ba 137.327	57 *La 138.906	72 Hf 178.49	73 Ta 180.948	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.967	80 Hg 200.59	81 Tl 204.383	82 Pb 207.2	83 Bi 208.980	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.025	89 †Ac 227.028	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (271)	111 Rg (272)							

*Lanthanide series	58 Ce 140.115	59 Pr 140.908	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.965	64 Gd 157.25	65 Tb 158.925	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.967
†Actinide series	90 Th 232.038	91 Pa 231.036	92 U 238.029	93 Np 237.048	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 (262)