MULTIPLE CHOICE (2 pts each): Write the letter corresponding to the correct answer on the line next to each question. The LETTER ASSOCIATED WITH THE CORRECT ANSWER MUST BE WRITTEN ON THE LINE NEXT TO THE QUESTION in order to receive full credit.

1) In which of the following solutions would aspirin (acetyl salicylic acid) be most soluble? 1) _____

a) Pure water
b) A pH 7 buffer
c) 0.05M NaOH
d) 1.0M HCl

2) In which of the following solutions would $CuSO_4$ be most soluble? 2) _____

a) Pure water
b) 1.0M solution of NH_3 K_f $Cu(NH_3)_4^{2+} = 5.0 \times 10^{13}$
c) 1.0M HCl
d) 1.0M K_2SO_4

3) Which of the following salts would produce a basic solution in water? 3) _____

a) NH_4Cl b) $NaNO_3$ c) KCH_3COO d) $FeBr_2$

4) Which of the following is the strongest acid? 4) _____

a) HCl b) NaOH c) HF d) HBr

5) Which of the following choices would make the most effective high capacity buffer with a pH close to 4.5? K_a values are 1.8×10^{-5} (CH_3COOH) and 7.1×10^{-4} (HF). 5) _____

a) 1.4M CH_3COOH with 1.5M $NaCH_3COO$
b) 1.4M HF with 1.5M NaF
c) 0.05M CH_3COOH with 0.04M $NaCH_3COO$
d) 0.05M HF with 0.04M NaF

6) How many equivalence points would you expect for the titration of H_2CO_3? 6) _____

a) 2 b) 3 c) 1 d) 0

7) Which of the following combinations of solutions would form a precipitate? K_{sp} of $PbF_2 = 4.1 \times 10^{-8}$ 7) _____

a) 50 mL of 0.3M $Pb(NO_3)_2$ with 100 mL of 0.001M NaF
b) 30 mL of 0.5M $Pb(NO_3)_2$ with 70 mL of 0.0002M NaF
c) 200 mL of 0.04M $Pb(NO_3)_2$ with 10 mL of 0.01M NaF
d) 20 mL of 0.002M $Pb(NO_3)_2$ with 20 mL of 0.002M NaF

8) Which of the following cations would produce the most acidic solution? 8) _____

a) Fe^{3+} b) Cr^{3+} c) Ni^{3+} d) Mn^{3+}

SHORT ANSWER (14 pts each): Completely answer all of the following questions. Read all questions carefully!!! Show all work. Make sure to include units and report all mathematical answers to the correct number of significant figures. Write final answers in designated locations when indicated.

1) The K_{sp} value for lead chloride ($PbCl_2$) is 2.4×10^{-4}

a.) What is the molar solubility of $PbCl_2$ in water? Answer a:_____

b.) What is the molar solubility of $PbCl_2$ in a 0.500 M solution of NaCl?

Answer b:_____

c.) What is the molar solubility of $PbCl_2$ in a 0.500 M solution of $Pb(NO_3)_2$?

Answer c:_____

2) A 1.0L buffer solution is prepared containing 0.200M acetic acid ($K_a = 1.8x10^{-5}$) and 0.250M sodium acetate.

a.) What is pH of the buffer? Answer a: _____

b.) What is the pH after adding 0.070 mol KOH? Answer b:_____

c.) What is the pH after adding 0.040 mol HNO_3? Answer c: _____

3) 50.0 mL of 0.620M HCl was titrated with 0.150M NaOH.

a.) What was the pH of the acid solution before the titration began?

Answer a:_____

b.) What is the pH at the equivlance point? Answer b:_____

c.) Briefly explain how you arrived at your answer to part b.

Answer c: _____

d.) What is the pH after 20.0 mL of NaOH has been added?

Answer d:_____

4) 100.0 mL of 0.25M NH_3 ($K_b = 1.8x10^{-5}$) was titrated with 0.25M HCl.

a.) What was the pH of the solution before the titration began?

Answer a:_____

b.) What is pH after addition of 100.0mL HCl? Answer b:_____

c.) What controls the pH at the equivalence point? Answer c:_____

d.) Does your answer to part b support your answer to part c? Briefly explain.

Answer d: _____

5) You have a 0.67 M solution of NaC_6H_5COO. The K_a of C_6H_5COOH is $6.5x10^{-5}$.

a.) Write a balanced chemical equation showing the reaction with water that causes this solution to have a non-neutral pH.

Answer a: _____

b.) Calculate the $[OH^-]$ concentration Answer b: _____

c.) Calculate the pH of this solution Answer c: _____

6) The K_{sp} value for copper bromide (CuBr) is 4.2×10^{-8}. K_f for $Cu(CN)_4^{2-}$ is 5.0×10^{13}.

a.) What is the solubility of CuBr in water? Answer a: _____

b.) What is the solubility of CuBr in a 1.5M solution of NaCN? Answer b: _____

c.) What is the K_c value for the formation of $Cu(CN)_4^{2-}$ from solid CuBr and aqueous NaCN?

Answer c: _____

IPLE CHOICE (2 pts each): Write the letter corresponding to the correct answer on the line next question. The LETTER ASSOCIATED WITH THE CORRECT ANSWER MUST BE WRITTEN ON THE LINE NEXT TO THE QUESTION in order to receive full credit.

1) In which of the following solutions would aspirin (acetyl salicylic acid) be most soluble? 1) C

a) Pure water
b) A pH 7 buffer
c) 0.05M NaOH
d) 1.0M HCl

2) In which of the following solutions would $CuSO_4$ be most soluble? 2) B

a) Pure water
b) 1.0M solution of NH_3 K_f $Cu(NH_3)_4^{2+} = 5.0x10^{13}$
c) 1.0M HCl
d) 1.0M K_2SO_4

3) Which of the following salts would produce a basic solution in water? 3) C

a) NH_4Cl b) $NaNO_3$ c) KCH_3COO d) $FeBr_2$

4) Which of the following is the strongest acid? 4) D

a) HCl b) NaOH c) HF d) HBr

5) Which of the following choices would make the most effective high capacity buffer with a pH close to 4.5? K_a values are $1.8x10^{-5}$ (CH_3COOH) and $7.1x10^{-4}$ (HF). 5) A

a) 1.4M CH_3COOH with 1.5M $NaCH_3COO$
b) 1.4M HF with 1.5M NaF
c) 0.05M CH_3COOH with 0.04M $NaCH_3COO$
d) 0.05M HF with 0.04M NaF

6) How many equivalence points would you expect for the titration of H_2CO_3? 6) A

a) 2 b) 3 c) 1 d) 0

7) Which of the following combinations of solutions would form a precipitate? K_{sp} of $PbF_2 = 4.1x10^{-8}$ 7) A

a) 50 mL of 0.3M $Pb(NO_3)_2$ with 100 mL of 0.001M NaF
b) 30 mL of 0.5M $Pb(NO_3)_2$ with 70 mL of 0.0002M NaF
c) 200 mL of 0.04M $Pb(NO_3)_2$ with 10 mL of 0.01M NaF
d) 20 mL of 0.002M $Pb(NO_3)_2$ with 20 mL of 0.002M NaF

8) Which of the following cations would produce the most acidic solution? 8) C

a) Fe^{3+} b) Cr^{3+} c) Ni^{3+} d) Mn^{3+}

SHORT ANSWER (14 pts each): Completely answer all of the following questions. Read all questions carefully!!! Show all work. Make sure to include units and report all mathematical answers to the correct number of significant figures. Write final answers in designated locations when indicated.

1) The K_{sp} value for lead chloride ($PbCl_2$) is 2.4×10^{-4}

$PbCl_2(s) \rightleftharpoons Pb^{2+} + 2Cl^-$

a.) What is the molar solubility of $PbCl_2$ in water? Answer a: 3.9×10^{-2} M

$2.4 \times 10^{-4} = (x)(2x)^2 \quad x^3 = 6.0 \times 10^{-5}$

$2.4 \times 10^{-4} = 4x^3 \quad x = 3.915 \times 10^{-2}$ M

b.) What is the molar solubility of $PbCl_2$ in a 0.500 M solution of NaCl? Answer b: 9.6×10^{-4} M

$2.4 \times 10^{-4} = (x)(0.500)^2$

$2.4 \times 10^{-4} = 0.25x$

$x = 9.6 \times 10^{-4}$ M

c.) What is the molar solubility of $PbCl_2$ in a 0.500 M solution of $Pb(NO_3)_2$? Answer c: 1.1×10^{-2} M

$2.4 \times 10^{-4} = (0.500)(2x)^2$

$2.4 \times 10^{-4} = 2x^2$

$x^2 = 1.2 \times 10^{-4}$

$x = 1.095 \times 10^{-2}$

2) A 1.0L buffer solution is prepared containing 0.200M acetic acid ($K_a = 1.8 \times 10^{-5}$) and 0.250M sodium acetate.

a.) What is pH of the buffer? Answer a: 4.842

$pH = 4.745 + \log\left(\frac{0.250}{0.200}\right)$

$pH = 4.745 + 0.09691 = 4.8419$

b.) What is the pH after adding 0.070 mol KOH? Answer b: 5.136

Acid $0.200 \text{ mol} - 0.070 \text{ mol} = 0.13 \text{ mol}/1L$

Conj Base $0.250 \text{ mol} + 0.070 \text{ mol} = 0.32 \text{ mol}/1L$

$pH = 4.745 + \log\left(\frac{0.32M}{0.13M}\right) = 4.745 + 0.3912 = 5.1362$

c.) What is the pH after adding 0.040 mol HNO_3? Answer c: 4.687

Acid $0.200 \text{ mol} + 0.040 \text{ mol} = 0.240 \text{ mol}/1L$

Conj Base $0.250 \text{ mol} - 0.040 \text{ mol} = 0.210 \text{ mol}/1L$

$pH = 4.745 + \log\left(\frac{0.21M}{0.24M}\right)$

$= 4.745 - 0.05799 = 4.687$

3) 50.0 mL of 0.620M HCl (strong) was titrated with 0.150M NaOH (strong).

a.) What was the pH of the acid solution before the titration began?

$-\log(0.620) = 0.2076$

Answer a: 0.208

b.) What is the pH at the equivlance point?

Answer b: 7.0

c.) Briefly explain how you arrived at your answer to part b.

Answer c: All acid neutralized, no excess base, strong so no equilibrium

d.) What is the pH after 20.0 mL of NaOH has been added?

$0.150 \frac{mol}{L} \times 0.02L = 0.0025 mol$ base

$0.620 \frac{mol}{L} \times 0.05L = 0.031$ mol acid

$0.031 mol - 0.0025 mol = 0.0285$ mol acid remaining

$\frac{0.0285 mol}{0.07L} = 0.407M\ HCl = 0.407M\ H_3O^+$

$-\log(0.407) = 0.3904$

Answer d: 0.390

4) 100.0 mL of 0.25M NH_3 ($K_b = 1.8 \times 10^{-5}$) was titrated with 0.25M HCl.

a.) What was the pH of the solution before the titration began?

$1.8 \times 10^{-5} = \frac{x^2}{0.25}$

$x^2 = 4.5 \times 10^{-6}$

$x = 0.00212M = [OH^-]$

$pOH = -\log(0.00212) = 2.67$

$pH = 14 - 2.67 = 11.33$

Answer a: 11.33

b.) What is pH after addition of 100.0mL HCl?

Answer b: 5.08

equivalence pt

$0.25 \frac{mol\ HCl}{L} \times 0.1L = 0.025 mol\ HCl \left(\frac{1 mol\ NH_4^+}{1 mol\ HCl}\right) = 0.025 mol\ NH_4^+$ produced

$\frac{0.025 mol\ NH_4^+}{0.2L} = 0.125M\ NH_4^+$

$K_a = \frac{1 \times 10^{-14}}{1.8 \times 10^{-5}} = 5.56 \times 10^{-10}$

$5.56 \times 10^{-10} = \frac{x^2}{0.125}$

$x^2 = 6.94 \times 10^{-11}$

$x = 8.33 \times 10^{-6} = [H_3O^+]$

$pH = -\log(8.33 \times 10^{-6}) = 5.07935$

c.) What controls the pH at the equivalence point?

Answer c: concentration of the conjugate (acid in this case)

d.) Does your answer to part b support your answer to part c? Briefly explain.

Answer d: Yes - the pH is acidic due to the presence of an acid

5) You have a 0.67 M solution of NaC_6H_5COO. The K_a of C_6H_5COOH is 6.5×10^{-5}.

$K_b = \frac{1 \times 10^{-14}}{6.5 \times 10^{-5}} = 1.54 \times 10^{-10}$

a.) Write a balanced chemical equation showing the reaction with water that causes this solution to have a non-neutral pH.

Answer a: $C_6H_5COO^-(aq) + H_2O(l) \rightleftharpoons C_6H_5COOH(aq) + OH^-(aq)$

b.) Calculate the $[OH^-]$ concentration

Answer b: 1.0×10^{-5} M

$1.54 \times 10^{-10} = \frac{x^2}{0.67}$

$x^2 = 1.03 \times 10^{-10}$

$x = 1.0153 \times 10^{-5}$

c.) Calculate the pH of this solution

Answer c: 9.01

$[OH^-] = 1.0153 \times 10^{-5}$

$pOH = -\log(1.0153 \times 10^{-5}) = 4.993$

$pH = 14 - 4.993 = 9.0066$

6) The K_{sp} value for copper bromide (CuBr) is 4.2×10^{-8}. K_f for $Cu(CN)_4^{2-}$ is 5.0×10^{13}.

a.) What is the solubility of CuBr in water?

Answer a: 2.05×10^{-4} M

$CuBr(s) \rightleftharpoons Cu^+(aq) + Br^-(aq)$

$4.2 \times 10^{-8} = (x)(x)$

$x = 2.05 \times 10^{-4}$

b.) What is the solubility of CuBr in a 1.5M solution of NaCN?

Answer b: 3300 M

$CuBr(s) + 4CN^- \rightleftharpoons Cu(CN)_4^{2-} + Br^-$

	$4CN^-$	$Cu(CN)_4^{2-}$	Br^-
	1.5M	0	0
	$-4x$	$+x$	$+x$
	$1.5 - 4x$ ignore	x	x

$K_{eq} = K_{sp} \times K_f = (4.2 \times 10^{-8})(5.0 \times 10^{13}) = 2.1 \times 10^6$

$2.1 \times 10^6 = \frac{(x)(x)}{(1.5)^4}$

$2.1 \times 10^6 = \frac{x^2}{5.0625}$ $\quad x = 3260.6$ M

$x^2 = 1.063 \times 10^7$

c.) What is the K_c value for the formation of $Cu(CN)_4^{2-}$ from solid CuBr and aqueous NaCN?

Answer c: 2.1×10^6

$K_c = K_{sp} \times K_f$

$= 4.2 \times 10^{-8} \times 5.0 \times 10^{13}$

$= 2.1 \times 10^6$