Some Review Problems for the Final Exam – Part 1

(Note: this selection of problems is NOT comprehensive!)

1. a. Using thermodynamic values, estimate the value of K_w at 37°C (normal body temperature).
   b. What is the pH of a neutral solution at 37°C?
2. The pH of 0.10 M HX is 3.72. What is the pH of 0.10 M NaX?
3. The equation for the dissolving of $Mg(OH)_{2\,(s)}$ in acid can be written in either of these two ways:
   $Mg(OH)_{2\,(s)} + 2\ H^+_{(aq)} \rightarrow Mg^{2+}_{(aq)} + 2\ H_2O_{(l)}$ $\quad \Delta G^\circ = -95.3$ kJ
   $1/2\ Mg(OH)_{2\,(s)} + H^+_{(aq)} \rightarrow 1/2\ Mg^{2+}_{(aq)} + H_2O_{(l)}$ $\quad \Delta G^\circ = -47.7$ kJ
   a. Explain why these two equations have different values for ΔG°.
   b. Will the values of K_{eq} determined for these two equations be the same or different? Explain.
   c. Will the solubilities of $Mg(OH)_{2\,(s)}$ in a buffer solution at pH 8.50 depend on which of the two equations is used as the basis of the calculation? Explain.
   d. If you mix together: solid $Mg(OH)_2$, 0.50 M H^+, and 0.10 M Mg^{2+} at 25°C, will some $Mg(OH)_2$ dissolve?
   e. If you mix together: solid $Mg(OH)_2$, 0.010 M H^+, and 2.0 M Mg^{2+} at 25°C, will some $Mg(OH)_2$ dissolve?
   f. If you mix together: solid $Mg(OH)_2$ and 2.0 M Mg^{2+} at 25°C, what would be the minimum pH that would make the reaction <u>nonspontaneous</u> as written?
4. For the reaction: $HPO_4^{2-} + CN^- \Leftrightarrow$
   a. Write the formulas of the products.
   b. Will the K_c for the above reaction be greater than 1 or less than 1? Explain.
   c. Calculate K_c.
5. What is the pH at the equivalence point when 50.0 mL of 0.100 M $HC_2H_3O_2$ is titrated with 0.200 M KOH?
6. Consider the equilibrium $N_2O_{4\,(g)} \Leftrightarrow 2\ NO_{2\,(g)}$ at 25°C.
   a. If the initial $P_{N2O4} = 1.50$ atm and if N_2O_4 is 12.8 % dissociated when it comes to equilibrium at this temperature, calculate the value of K_p.
   b. Calculate the value of K_c at 25°C.
7. Thymol blue is red below pH 1.2, yellow between pH 2.8 and 8.0, and blue above pH 9.6. What is the color of thymol blue in each of the following situations? (K_a of $HNO_2 = 4.5 \times 10^{-4}$)
   a. The indicator is placed in 350.0 mL of 0.205 M HNO_3.
   b. 250.0 mL of 0.500 M $NaNO_2$ is added to the solution in part a.
   c. 150.0 mL of 0.100 M NaOH is added to the solution in part b.
   d. 5.00 g $Ba(OH)_2$ is added to the solution in part c.
8. Calculate the pH and the concentration of all species in a solution of 0.25 M H_3PO_4.
9. Determine the pH of 0.10 M Na_3PO_4.
10. Calculate the solubility (g/L) of AgCl in 3.00 M NH_3, in 3.00 M NaCl, and in water.
11. Draw the condensed structural formulas of all isomers of C_3H_9N.
12. Draw the condensed structural formulas of all isomers of $C_4H_{11}N$.

13. a. Given the following data, determine the rate law and the value of the rate constant for the reaction.

Reaction: $2\,A + B \rightarrow D + 3\,E$

Initial [A], M	Initial [B], M	Initial [C], M	Initial rate of appearance of D, M/min
0.10	0.10	0.20	1.22
0.40	0.10	0.20	19.5
0.40	0.10	0.40	156
0.10	0.20	0.20	.61

b. How can C be part of the rate law?

c. If the rate of change of A is - 0.50 M/min, what are the rates of change of B, D, and E at this instant?

14. A reaction has the rate law: rate = $k[B]^2$

a. If the concentration of B decreases from 2.0 M to 0.50 M in 5.0 minutes, what is the value of the rate constant for this reaction?

b. How long will it take for the concentration of B to decrease from 0.50 M to 0.125 M?

15. A reaction has the rate law: rate = $k[A]$

a. If the concentration of A decreases from 2.0 M to 0.50 M in 5.0 minutes, what is the value of the rate constant for this reaction?

b. How long will it take for the concentration of A to decrease from 0.50 M to 0.125 M? Compare your results from #14 and #15. Comment.

16. a. Draw the structure of the molecule named "trifluoroacetic acid". (Affectionately referred to by organic chemists as "TFA".)

b. Which should be the stronger acid, acetic acid or trifluoroacetic acid? Explain the underlying reason.

c. Which is the stronger base, acetate or trifluoroacetate? Explain.

17. Given the following skeleton structure, fill in any multiple bonds and lone pairs. (Do not add any atoms.) Then, state the shape, hybridization, and bond angle around each of the indicated atoms.

18. You would like to make a "phosphate buffer" that has a pH of 7.05. Describe three different ways of making 1.5 liters of this buffer in which the least concentrated component has a concentration of 0.10 M. Available compounds: 2.00 M HCl, 2.00 M NaOH, solid NaH_2PO_4, solid Na_2HPO_4.

19. You have a solution containing 0.020 moles of HPO_4^{2-} and 0.030 moles of PO_4^{3-} in 200. mL. What volume of 3.00 M HCl or 3.00 M NaOH is needed to change the pH of this solution to 13.00?

Thermodynamic Values:

Substance	$\Delta H_f°$, kJ/mol	$\Delta G_f°$, kJ/mol	S°, J/K
$H_2O_{(l)}$	- 285.83	- 237.19	69.91
$H^+_{(aq)}$	0	0	0
$OH^-_{(aq)}$	- 229.94	-157.30	- 10.54

K_a of $HC_2H_3O_2 = 1.8 \times 10^{-5}$
K_a of $HCN = 4.0 \times 10^{-10}$
K_a of $H_3PO_4 = 7.5 \times 10^{-3}$
K_a of $H_2PO_4^- = 6.2 \times 10^{-8}$
K_a of $HPO_4^{2-} = 3.6 \times 10^{-13}$
K_{sp} of $AgCl = 1.8 \times 10^{-10}$
K_f of $Ag(NH_3)_2 = 1.6 \times 10^{7}$

Some Answers:

1. $K_w = 2.4 \times 10^{-14}$, pH = 6.81
2. pH = 9.72
3. a. different coefficients b. yes c. no d. yes e. no f. 8.20
4. b. left c. 9.0×10^{-4}
5. 8.78
6. $K_p = 0.113$
7. a. pH = 0.69, red. b. pH = 3.22, yellow. c. pH = 3.42, yellow. d. pH = 11.34, blue.
8. pH = 1.40, $[H_3O^+] = 0.040$ M, $[H_3PO_4] = 0.21$ M, $[H_2PO_4^-] = 0.040$ M, $[HPO_4^{2-}] = 6.2 \times 10^{-8}$ M, $[PO_4^{3-}] = 5.6 \times 10^{-19}$ M
9. pH = 12.61
10. In ammonia, 21 g/L. In chloride ion, 8.6×10^{-9} g/L. In water, 1.9×10^{-3} g/L.
13. a. $k = 1.5 \times 10^3$ $M^{-3}min^{-1}$ c. B: -0.25 M/min, D: 0.25 M/min, E: 0.75 M/min
14. a. 0.30 $M^{-1}min^{-1}$ b. 20. min
15. a. 0.277 min^{-1} b. 5.0 min
18. 1. 21 g Na_2HPO_4 + 26 g NaH_2PO_4 + water so that V_{total} = 1.50 L
    2. 108 mL HCl+ 52 g Na_2HPO_4 + water so that V_{total} = 1.50 L
    3. 75 mL NaOH + 44 g NaH_2PO_4 + water so that V_{total} = 1.50 L
19. 3.0 mL