CHM 1143   Exam 3
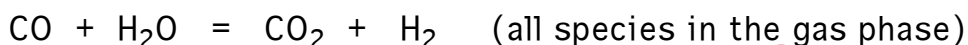
1) A vessel contains 0.50 M CO, 0.05 M H_2O, 0.30 M CO_2 and 0.10 M H_2. All are gasses. At the temperature of the vessel K= 88 for the reaction below. In what direction will the reaction proceed in order to reach equilibrium? (You must show your calculation of Q to justify your answer. Simply stating a direction will receive no credit).

$$CO + H_2O = CO_2 + H_2 \quad \text{(all species in the gas phase)}$$

$$Q = \frac{[CO_2][H_2]}{[CO][H_2O]} = \frac{(0.30M)(0.10M)}{(0.5M)(0.05M)} = 1.2$$

$$Q < K \quad \text{so forward}$$

2) Calculate the pH and pOH of the following aqueous solutions:

a) 0.0035 M HNO_3 $[H^+] = 0.0035 M$

$$pH = -\log(0.0035) = 2.46$$

b) 0.005 M $Ba(OH)_2$ $\dfrac{2OH^-}{1\,Ba(OH)_2}\left(0.005\,M\,Ba(OH)_2\right) = 0.01\,M\ OH^-$

$$pOH = -\log(0.01) = 2 \quad pH = 14 - pOH = 12$$

3)   Calculate the pH of 0.25 M HF (Ka= 6.8 x 10⁻⁴)

$$HF = H^+ + F^-$$

	0.25	0	0
	$-X$	$+X$	$+X$
equil.	$0.25-X$	X	X

$$K_a = \frac{[H^+][F^-]}{[HF]} = 6.8 \times 10^{-4}$$

$$\frac{(X)(X)}{0.25 - X} = 6.8 \times 10^{-4}$$

$$X = [H^+] = \sqrt{(0.25)(6.8 \times 10^{-4})}$$

$$= 0.013 \, \underline{M}$$
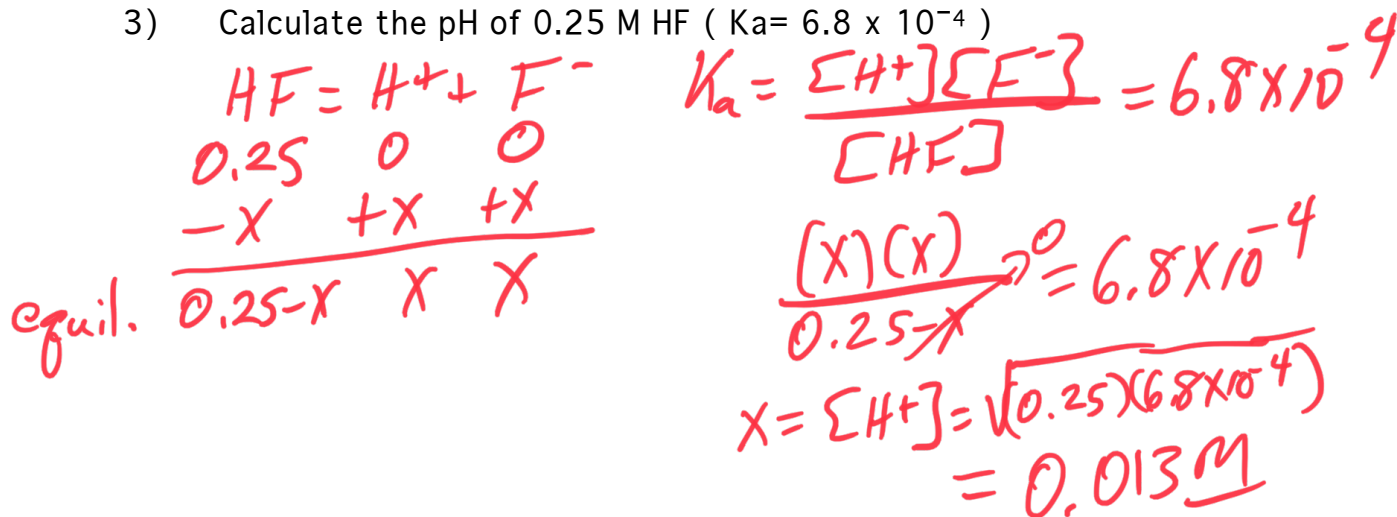
$$pH = -\log(0.013) = 1.89$$

4)   Calculate the pH of 0.30 M potassium fluoride.

$$K_b = \frac{10^{-14}}{6.8 \times 10^{-4}} = 1.5 \times 10^{-11}$$

$$F^- + H_2O = HF + OH^-$$

0.30		0	0
$-X$		X	X
$0.30-X$		X	X

$$K_b = \frac{[HF][OH^-]}{[F^-]} = 1.5 \times 10^{-11}$$

$$K_b = \frac{X^2}{0.30 - X} = 1.5 \times 10^{-11}$$

$$X = [OH^-] = \sqrt{(0.30)(1.5 \times 10^{-11})}$$

$$= 2.1 \times 10^{-6} \, \underline{M}$$

$$pOH = -\log(2.1 \times 10^{-6}) = 5.67$$

$$pH = 14 - pOH = 8.33$$
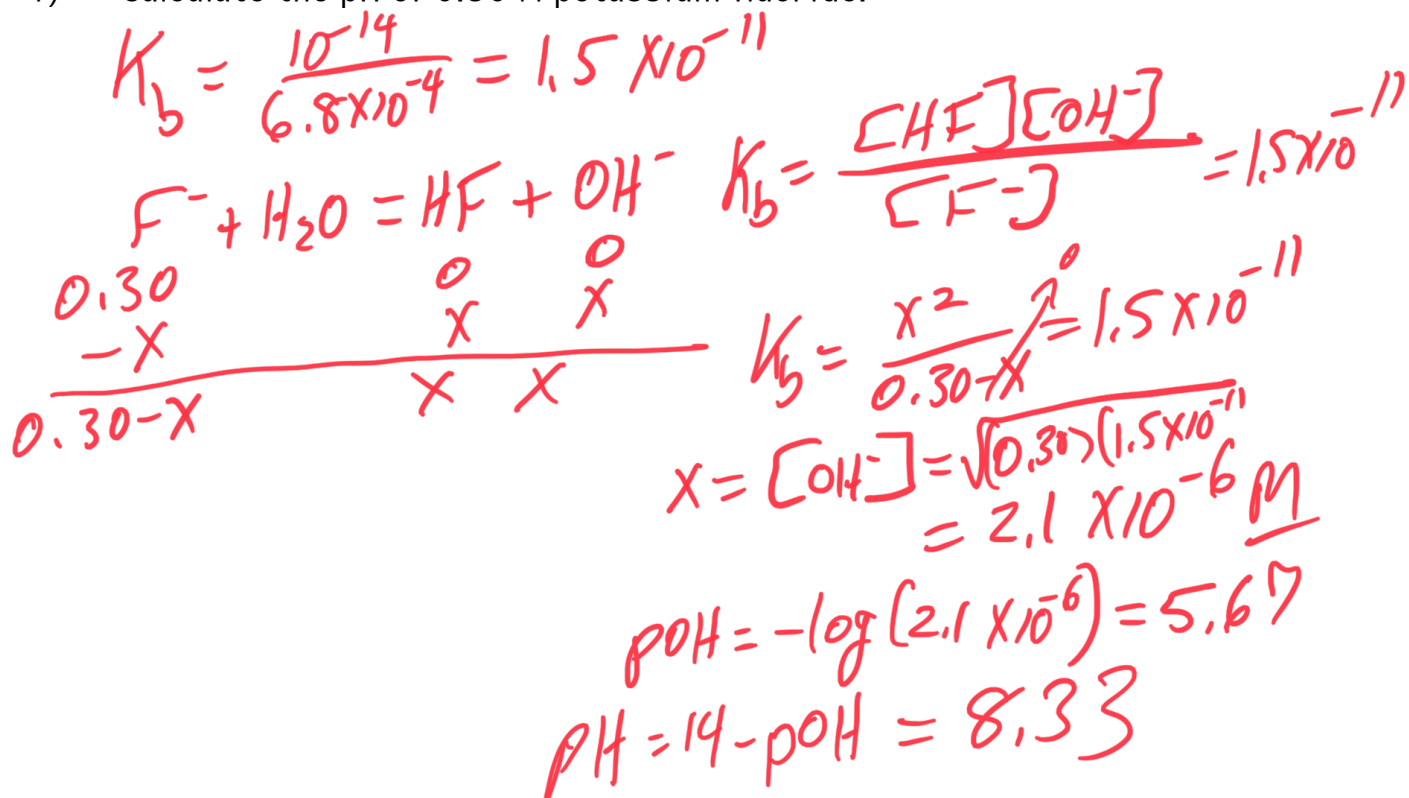
20 points each

5) Titration of a 0.301 g sample of our blue copper complex required 13.67 mL of 0.254 M HCl to react with the NH_3 in the sample. How many mmoles of NH_3 are present per gram of the complex?

$$NH_3 + H^+ = NH_4$$

$$13.67 mL \left(0.254 \underline{M}\right) = 3.47\ mmol\ H^+ = mmol\ NH_3$$

$$\frac{3.47\ mmol\ NH_3}{0.301g\ complex} = 11.5\ \frac{mmol\ NH_3}{g\ complex}$$

6) Data for the aqueous reaction below are given in the table:

$$S_2O_8{}^{2-} + 3\ I^{1-} = 2\ SO_4{}^{2-} + I_3{}^{1-}$$
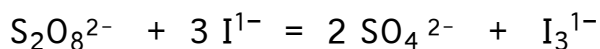
Determine the order of the reaction with respect to $S_2O_8{}^{2-}$ and to I^{1-} and write the rate expression. Determine the numeric value (with correct units) of k, the specific rate constant.
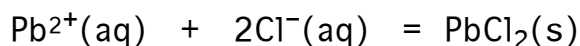
Exp #	$[S_2O_8{}^{2-}]$	$[I^{1-}]$	Rate M/sec
1	0.012	0.050	7.0 x 10⁻⁶
2	0.024	0.050	1.4 x 10⁻⁵
3	0.024	0.10	2.8 x 10⁻⁵

)double   double   double   double

$$rate = k\left[S_2O_8{}^{2-}\right]^1\left[I^-\right]^1$$

$$k = \frac{7.0 \times 10^{-6}\ \underline{M}/s}{(0.012\underline{M})(0.050\underline{M})} = 0.020\underline{M}^{-1}s^{-1}$$

7)   a) Write the equilibrium constant expression for the following reactions:

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

$$K = \frac{1}{[Pb^{2+}][Cl^-]^2}$$

$$2H_2O_2(g) \ = \ O_2(g) \ + \ 2H_2O(l)$$

$$K = \frac{[O_2]}{[H_2O_2]^2}$$

$$Ca_3(PO_4)_2(s) \ = \ 3Ca^{2+}(aq) \ + \ 2PO_4^{3-}(aq)$$

$$K = [Ca^{2+}]^3[PO_4^{3-}]^2$$

$$Fe_2O_3(s) \ + \ 3CO(g) \ = \ 2Fe(s) \ + \ 3CO_2(g)$$
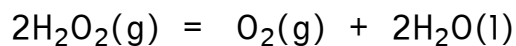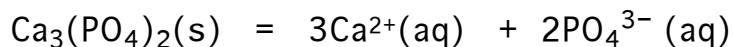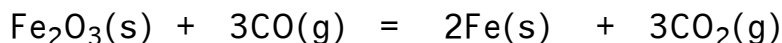
$$K = \frac{[CO_2]^3}{[CO]^3}$$

8) The half-life of phenobarbital in the blood is 60 hours. If your epileptic black and white cocker spaniel receives a dose of 75 mg at 8 am, how much is still in his body 7 hours later?

$$k = \frac{0.693}{60\,hrs} = 0.012\,hr^{-1} \quad \ln \frac{A}{75} = -0.012\,hr^{-1}\,(7\,hr)$$

$$A = 75\,e^{-0.012(7)} = 70.\,mg$$

9) Fill in the table:

[H$^+$]	[OH$^-$]	pH	pOH
0.005 M	2×10^{-12}	2.30	11.70
1.0×10^{-11}	0.0010	11.00	3.00
1.0×10^{-11}	0.0010	11.00	3.00

10) a) Circle the compounds which would result in basic solutions when dissolved in water:

HCl   NaNO$_3$ (NH$_3$)   KBr   MgCl$_2$ (KF)   FeI$_3$ (Mg(ClO)$_2$)   Mg(ClO$_4$)$_2$

b) Calculate the pH of a solution of 4.0 g HF plus 8.4 g of NaF in enough water to make 250 mL of solution.

$$pH = pK_a + \log \frac{n_{CB}}{n_{CA}} = 3.17 + \log \frac{\frac{8.4\,g}{42\,g/mol}}{\frac{4.0\,g}{20.\,g/mol}} = 3.17$$