

Formulas:
(you may remove this page)

$$s^2 = K_{sp} \left(1 + \frac{[H^+]}{K_a} \right)$$

1 <u>H</u> 1.008																	2 <u>He</u> 4.003
3 <u>Li</u> 6.941	4 <u>Be</u> 9.012											5 <u>B</u> 10.81	6 <u>C</u> 12.01	7 <u>N</u> 14.01	8 <u>O</u> 16.00	9 <u>F</u> 19.00	10 <u>Ne</u> 20.18
11 <u>Na</u> 22.99	12 <u>Mg</u> 24.31											13 <u>Al</u> 26.98	14 <u>Si</u> 28.09	15 <u>P</u> 30.97	16 <u>S</u> 32.07	17 <u>Cl</u> 35.45	18 <u>Ar</u> 39.95
19 <u>K</u> 39.10	20 <u>Ca</u> 40.08	21 <u>Sc</u> 44.96	22 <u>Ti</u> 47.88	23 <u>V</u> 50.94	24 <u>Cr</u> 52.00	25 <u>Mn</u> 54.94	26 <u>Fe</u> 55.85	27 <u>Co</u> 58.47	28 <u>Ni</u> 58.69	29 <u>Cu</u> 63.55	30 <u>Zn</u> 65.39	31 <u>Ga</u> 69.72	32 <u>Ge</u> 72.59	33 <u>As</u> 74.92	34 <u>Se</u> 78.96	35 <u>Br</u> 79.90	36 <u>Kr</u> 83.80
37 <u>Rb</u> 85.47	38 <u>Sr</u> 87.62	39 <u>Y</u> 88.91	40 <u>Zr</u> 91.22	41 <u>Nb</u> 92.91	42 <u>Mo</u> 95.94	43 <u>Tc</u> (98)	44 <u>Ru</u> 101.1	45 <u>Rh</u> 102.9	46 <u>Pd</u> 106.4	47 <u>Ag</u> 107.9	48 <u>Cd</u> 112.4	49 <u>In</u> 114.8	50 <u>Sn</u> 118.7	51 <u>Sb</u> 121.8	52 <u>Te</u> 127.6	53 <u>I</u> 126.9	54 <u>Xe</u> 131.3
55 <u>Cs</u> 132.9	56 <u>Ba</u> 137.3	57 <u>La*</u> 138.9	72 <u>Hf</u> 178.5	73 <u>Ta</u> 180.9	74 <u>W</u> 183.9	75 <u>Re</u> 186.2	76 <u>Os</u> 190.2	77 <u>Ir</u> 190.2	78 <u>Pt</u> 195.1	79 <u>Au</u> 197.0	80 <u>Hg</u> 200.5	81 <u>Tl</u> 204.4	82 <u>Pb</u> 207.2	83 <u>Bi</u> 209.0	84 <u>Po</u> (210)	85 <u>At</u> (210)	86 <u>Rn</u> (222)

1 H Hydrogen

2 He Helium

3 Li Lithium

4 Be Beryllium

5 B Boron

6 C Carbon

7 N Nitrogen

8 O Oxygen

9 F Fluorine

10 Ne Neon

11 Na Sodium

12 Mg Magnesium

13 Al Aluminum

14 Si Silicon

15 P Phosphorus

16 S Sulfur

17 Cl Chlorine

18 Ar Argon

19 K Potassium

20 Ca Calcium

21 Sc Scandium

22 Ti Titanium

23 V Vanadium

24 Cr Chromium

25 Mn Manganese

26 Fe Iron

27 Co Cobalt

28 Ni Nickel

29 Cu Copper

30 Zn Zinc

31 Ga Gallium

32 Ge Germanium

33 As Arsenic

34 Se Selenium

35 Br Bromine

36 Kr Krypton

37 Rb Rubidium

38 Sr Strontium

39 Y Yttrium

40 Zr Zirconium

41 Nb Niobium

42 Mo Molybdenum

43 Tc Technetium

44 Ru Ruthenium

45 Rh Rhodium

46 Pd Palladium

47 Ag Silver

48 Cd Cadmium

49 In Indium

50 Sn Ti

51 Sb Antimony

52 Te Tellurium

53 I Iodine

54 Xe Xenon ...

77 Ir Iridium

78 Pt Platinum

79 Au Gold

80 Hg Mercury

81 Tl Thallium

82 Pb Lead

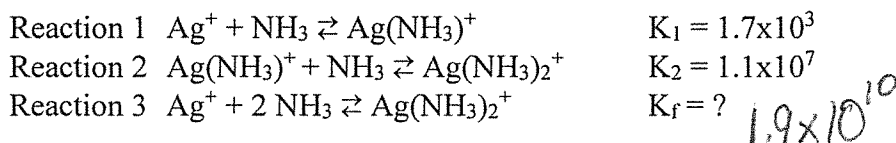
Honors General Chemistry
Prof. Shattuck, 2014

Test 3

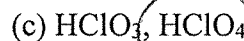
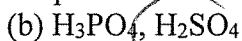
Name _____

Answer 8 of the following 10 questions. If you answer more than 8 cross out the ones you wish not to be graded, otherwise only the first 8 will be graded. (6 points each)

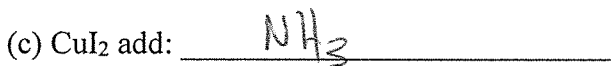
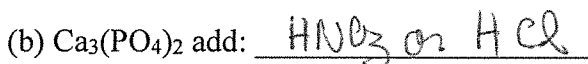
1. From the following information calculate the K_f for reaction 3.



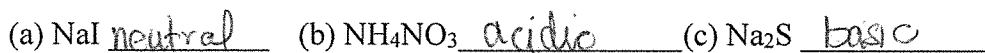
2. Circle the stronger acid in each pair:



3. How do you dissolve the following precipitates? Choose from 0.10 M solutions of HCl, HNO_3 , NH_3 , and NaOH. You can use a reagent only once.

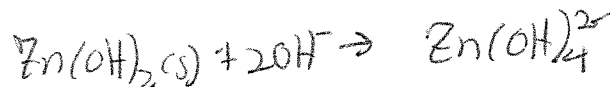
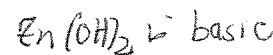


4. Are 0.100 M aqueous solutions of the following acidic, basic, or neutral?

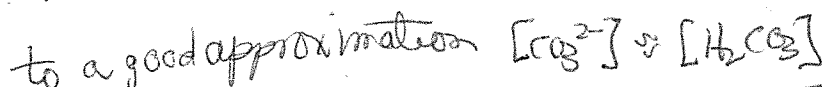
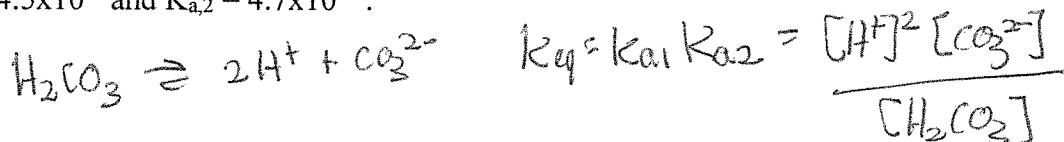


5. Is CaF_2 more soluble in: (a) pure water, (b) 0.10 M NaF, or (c) 0.10 M $\text{Ca}(\text{NO}_3)_2$?

6. Give the two reactions that show that solid $\text{Zn}(\text{OH})_2$ is amphoteric (reacts with both acid and base).



7. Calculate the pH of a 0.0100 M solution of NaHCO_3 . The acid dissociation constants are $K_{a,1} = 4.5 \times 10^{-7}$ and $K_{a,2} = 4.7 \times 10^{-11}$.

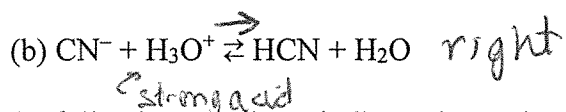
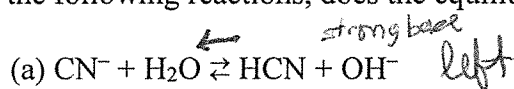


$$[\text{H}^+]^2 = K_{a,1} K_{a,2}$$

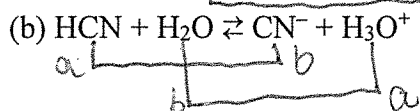
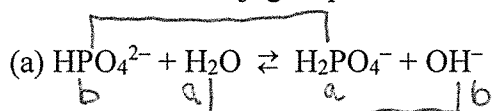
$$[\text{H}^+] = \sqrt{K_{a,1} K_{a,2}} \quad \text{or}$$

$$\text{pH} = \frac{\text{p}K_{a,1} + \text{p}K_{a,2}}{2} = \frac{6.347 + 10.328}{2} = 8.34$$

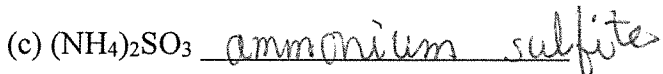
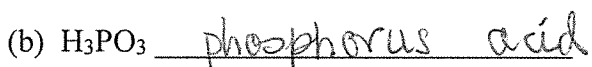
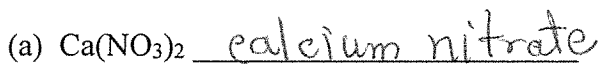
8. For the following reactions, does the equilibrium position lie to the left or right?



9. For the following reactions, indicate the conjugate acid–base pairs. Make sure to label the acid and base in each conjugate pair as the acid or base.



10. Name the following compounds:



Part II.

Answer 2 of the following 3 questions. If you answer more than 2 cross out the one you wish not to be graded, otherwise only the first 2 will be graded. (12 points each)

11. You need to prepare 100.0 mL of a pH = 4.00 buffer solution using 0.100 M benzoic acid ($\text{pK}_a = 4.20$, $K_a = 6.31 \times 10^{-5}$) and 0.220 M sodium benzoate. How much of each solution should be mixed to prepare this buffer? $\text{pH} = 4.00$ $[\text{HF}] = 1.0 \times 10^{-4} \text{ M}$

$$\text{buffer } [\text{HF}] = K_a \frac{C_A}{C_B} \quad \frac{C_A}{C_B} = \frac{[\text{HF}]}{K_a} = \frac{1.0 \times 10^{-4} \text{ M}}{6.31 \times 10^{-5} \text{ M}} = 1.585$$

$$\frac{C_A}{C_B} = \frac{n_A/V}{n_B/V} = \frac{n_A}{n_B} = \frac{V_A(0.100 \text{ M})}{V_B(0.220 \text{ M})} = 1.585$$

giving $\frac{V_A}{V_B} = 3.487$ with $V_A + V_B = 100.0 \text{ mL}$ and

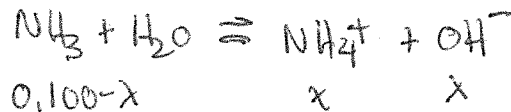
$$V_A = 3.487 V_B \quad \text{so} \quad 3.487 V_B + V_B = 100.0 \text{ mL}$$

solving for $V_B = 22.3 \text{ mL}$

and $V_A = 100.0 \text{ mL} - V_B = 77.7 \text{ mL}$

check: $[\text{HF}] = 6.31 \times 10^{-5} \text{ M} \frac{(77.7 \text{ mL } 0.100 \text{ M})}{(22.3 \text{ mL } 0.220 \text{ M})} = 1.00 \times 10^{-4} \text{ M}$

12. Calculate the pH of a 0.100 M NH_3 solution if $K_b = 1.8 \times 10^{-5}$ M. Show the reaction that determines the pH.



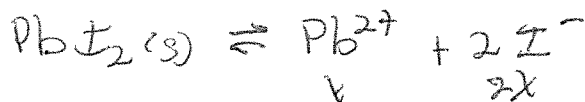
$$K_b = 1.8 \times 10^{-5} = \frac{x^2}{0.100 - x}$$

$$x = [\text{OH}^-] = \sqrt{K_b K_b} = \sqrt{0.100 \text{ M } 1.8 \times 10^{-5}}$$

$$= 1.34 \times 10^{-3} \text{ M}$$

$$\text{pOH} = 2.872 \quad \text{and} \quad \text{pH} = 11.13$$

13. Calculate the solubility of PbI_2 in pure water if $K_{sp} = 8.7 \times 10^{-9} \text{ M}^3$.



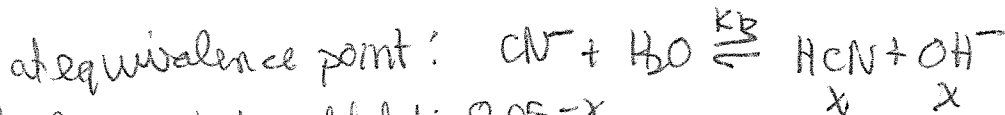
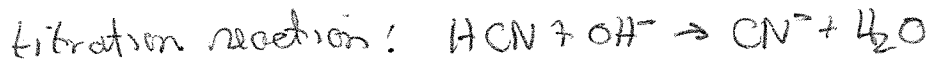
$$K_{sp} = 8.7 \times 10^{-9} \text{ M}^3 = [\text{Pb}^{2+}][\text{I}^-]^2 = 4x^3$$

$$x = s = [\text{Pb}^{2+}] = 1.296 \times 10^{-3} \text{ M} \approx 1.3 \times 10^{-3} \text{ M}$$

Part III.

Answer 2 of the following 3 questions. If you answer more than 2 cross out the one you wish not to be graded, otherwise only the first 2 will be graded. (14 points each)

14. Calculate the pH at the equivalence point of a titration of 30.0 mL of 0.100 M HCN with 0.100 M NaOH. For HCN, $K_a = 4.0 \times 10^{-8}$ M. Show the reaction that determines the pH.



initial concentration diluted: 0.05 - x

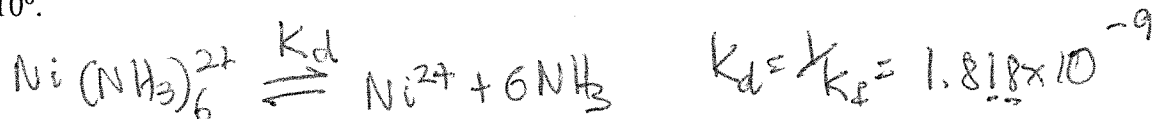
$$K_b = \frac{[\text{HCN}][\text{OH}^-]}{[\text{CN}^-]} = \frac{K_w}{K_a} = 2.5 \times 10^{-7} = \frac{x^2}{0.05 - x}$$

$$x = [\text{OH}^-] = \sqrt{K_b K_b} = \sqrt{0.050 \text{ } 2.5 \times 10^{-7}} = 1.118 \times 10^{-4} \text{ M}$$

$$\text{pOH} = 3.952$$

$$\text{pH} = 10.05$$

15. A 0.170-mole quantity of NiCl_2 is added to a liter of 1.20 M NH_3 solution. What is the concentration of Ni^{2+} ions at equilibrium. Assume the formation constant of $\text{Ni}(\text{NH}_3)_6^{2+}$ is 5.5×10^8 .



initial 0.170 M 1.20 - 6(0.170) = 0.180

equil. 0.170 - x +x 0.18 + x

$$K_d = \frac{[\text{Ni}^{2+}][\text{NH}_3]^6}{[\text{Ni}(\text{NH}_3)_6^{2+}]} = \frac{x(0.18+x)^6}{0.170-x} \approx \frac{x(0.180)^6}{0.170}$$

$$x = [\text{Ni}^{2+}] = 9.1 \times 10^{-6} \text{ M}$$

16. Calculate the solubility of CaCO_3 in a lake buffered at $\text{pH} = 5.60$. The equilibrium constants are $K_{a2} = 5.6 \times 10^{-11}$ and $K_{sp} = 4.5 \times 10^{-9}$.

$$S^2 = K_{sp} \left(1 + \frac{[\text{H}^+]}{K_{a2}} \right) \quad \text{pH} = 5.60$$

$$[\text{H}^+] = 2.512 \times 10^{-6} \text{ M}$$

$$S^2 = 4.5 \times 10^{-9} \left(1 + \frac{2.512 \times 10^{-6} \text{ M}}{5.6 \times 10^{-11} \text{ M}} \right)$$

$$S^2 = 2.0186 \times 10^{-4} \text{ M}^2$$

$$S = 0.0142 \text{ M}$$

$$S = 0.014 \text{ M}$$