AP Chem Acid-Base Test Review!

H_2CO_3: Ka1 = 4.3 x 10^{-7}, Ka2 = 5.6 x 10^{-11}
H_2SO_3: Ka1 = 0.015, Ka2 = 6.4 x 10^{-8}
H_3PO_4: Ka1 = 0.0075, Ka2 = 6.2 x 10^{-8}, Ka3 = 4.2 x 10^{-13}
Ag_2CO_3: Ksp = 8.1 x 10^{-12}

Hypobromous acid, HBrO: Ka = 2.5 x 10^{-9}
Trimethyl amine, $(CH_3)_3N$: Kb = 6.4 x 10^{-5}
Aniline ($C_6H_5NH_2$): Kb = 4.3 x 10^{-10}

1. A buffer contains trimethyl amine $(CH_3)_3N$, dissolved at 0.20 M, and trimethyl ammonium chloride ($(CH_3)_3NHCl$), dissolved at 0.22 M.
a. Find the pH of the buffer.
b. Find pH if 0.004 moles of NaOH are added to 200. mL of the buffer. (assume no volume change)
c. Find pH if 0.004 moles of HCl are added to 200. mL of the buffer. (assume no volume change)

2. Determine the pH of
a. 0.040 M KOH
b. 0.040 M $Ba(OH)_2$
c. 0.040 M LiBr
d. 0.040 M HBr
e. 0.040 M NaH
f. A solution was made by dissolving 0.040 moles of K_2O into water, so that total solution volume is 300. mL
g. 0.10 M HBrO
h. 0.10 M KBrO
i. A solution where the concentration of HBrO and KBrO are equal.
j. A solution where [HBrO] = 0.20 M, and [NaBrO] = 0.10 M
k. 0.040 M $C_6H_5NH_2$
l. 0.40 M $C_6H_5NH_3Br$
m. A solution that is 0.040 M $C_6H_5NH_2$ and 0.050 M $C_6H_5NH_3Cl$

3. For parts a-d:
100. mL of 0.10 M HBrO are titrated with NaOH. 40.0 mL NaOH are required to reach the equivalence point.
a. Find the molarity of the NaOH.
b. Find the pH during the titration after 0, 20, 30, and 40 mL of NaOH have been added.
c. For which of the above volumes does a buffer solution exist in the flask?
d. Sketch the titration curve.
3. For parts e-g: 50. mL of 1.2 M $(CH_3)_3N$ are titrated with 0.75 M HNO_3.
e. What volume of HNO_3 will be needed to reach the equivalence point?
f. Calculate the pH during the titration after 0, 15, 40, 65, 80, and 85 mL have been added.
g. For which of the above volumes does a buffer solution exist in the flask?
h. Sketch the titration curve.

4a. Which of these "insoluble" compounds will be more soluble when acid is added?

$BaCO_3$ $PbCl_2$ $Cu(OH)_2$ MgO AgI MgF_2

4b. For compounds you chose in (a), write a net ionic rxn showing the solid compound dissolving into strong acid. (Balance and do phase subscripts).

4c. If you want to have a silver ion concentration of 0.10 M, and a carbonic acid concentration of 0.080 M, what pH range is needed to avoid precipitation of silver carbonate?

4d. CuF is more soluble at low pH than at high pH. Explain why.
Include a discussion of the ratio of [F-] to [HF] as part of your answer.

5. Find the pH, % ionization, [H^{+1}], [H_2CO_3], [HCO_3^{-1}], and [CO_3^{-2}] in a 0.10 M solution of carbonic acid.

6. Identify each compound as acidic, basic, or neutral, when it is dissolved in water.

KOH	$Ca(NO_3)_2$
HBr	C_5H_5NHI
NaH	$HClO_2$
Na_2HPO_4	$LiNO_2$
$HCOOH$	$CH_3CH_2CH_2NH_2$
CH_3OH	$CH_3CH_2CH_2OH$
$CH_3CH_2NH_2$	CH_3CH_2COOH
$CH_3CH_2NH_3Cl$	CO_2
SO_3	Na_2O
CaO	C_5H_5N
$KClO_2$	CH_3NH_3Br
NH_4I	$KHSO_3$

7. The compound $C_{14}H_{14}N_3COOH$ has a pKa of 5.10.
This compound is an acid-base indicator. $C_{14}H_{14}N_3COOH$ is red, and $C_{14}H_{14}N_3COO^{-1}$ is yellow.
a. Calculate the Ka of $C_{14}H_{14}N_3COOH$.
b. Calculate the ratio of $[C_{14}H_{14}N_3COO^{-1}]$ to $[C_{14}H_{14}N_3COOH]$ when the pH is 4.10.
c. Calculate the ratio of $[C_{14}H_{14}N_3COO^{-1}]$ to $[C_{14}H_{14}N_3COOH]$ when the pH is 5.10.
d. Calculate the ratio of $[C_{14}H_{14}N_3COO^{-1}]$ to $[C_{14}H_{14}N_3COOH]$ when the pH is 6.10.
e. In general, how does the ratio of $[C_{14}H_{14}N_3COO^{-1}]$ to $[C_{14}H_{14}N_3COOH]$ change as pH is raised? lowered?
f. At pH 4.1, 5.1, and 6.1, a solution containing this acid base indicator could be orange, yellow, or red.
Which pH corresponds to which color?
g. What type of titration could this indicator be used for? (we want it to change color at the equivalence point)
A weak acid being titrated with a strong base?
Or a weak base being titrated with a strong acid?

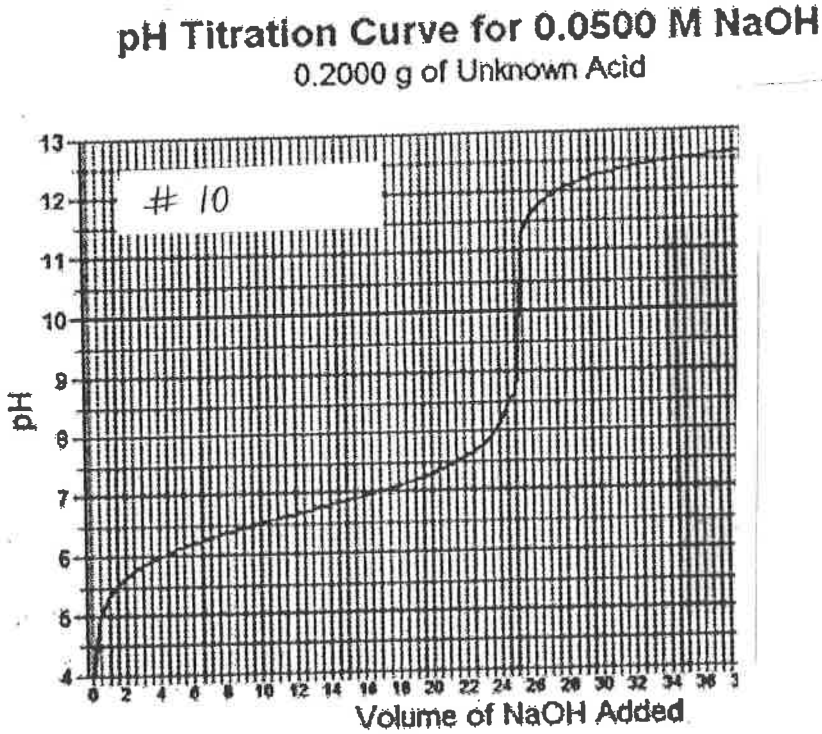
8. For each pair, circle the compound that would have the higher pH. Do this without a Ka/Kb chart. (Assume each compound was dissolved at 0.10 M)

HOCl	or	HOI
$NaClO_2$	or	$NaClO_3$
$AlCl_3$	or	NaCl
KCl	or	KF
$ZnCl_2$	or	$AlCl_3$
C_2H_5COOH	or	$C_2H_5CH_2OH$
$Ca(NO_2)_2$	or	$Sn(NO_3)_2$
$Sn(NO_3)_2$	or	$Sn(NO_3)_4$

9. a. Draw Lewis Dot Structures for HNO_2, HIO_3, and HIO.
b. Which is a stronger acid: HIO_3 or HIO? Why? Explain on a molecular level.
c. Which is a stronger acid: HIO_3 or $HClO_3$? Why? Explain on a molecular level.
d. Consider the compounds KIO, HBrO, $HBrO_2$, $LiIO_3$, $NaClO_3$, HBr.
Classify each one as acidic basic or neutral. If more than one compound is acidic/basic, which is the most acidic/basic (rank them all)?

10. A Monoprotic acid is titrated with NaOH to yield the following graph. Use the graph to determine:

a. The molar mass of the acid.
b. The Ka of the acid.



11. Calculate Keq for each reaction:

a. $H^{+1} + OBr^{-1}$ <----> HOBr

b. $OBr^{-1} + H_2O$ <----> $HOBr + OH^{-1}$

c. $HOBr + OH^{-1}$ <----> $OBr^{-1} + H_2O$

d. $2\,Ag^{+1}{}_{(aq)} + CO_3^{-2}{}_{(aq)}$ <----> $Ag_2CO_{3(s)}$

e. $SO_3^{-2} + 2\,H^{+1}$ <----> H_2SO_3

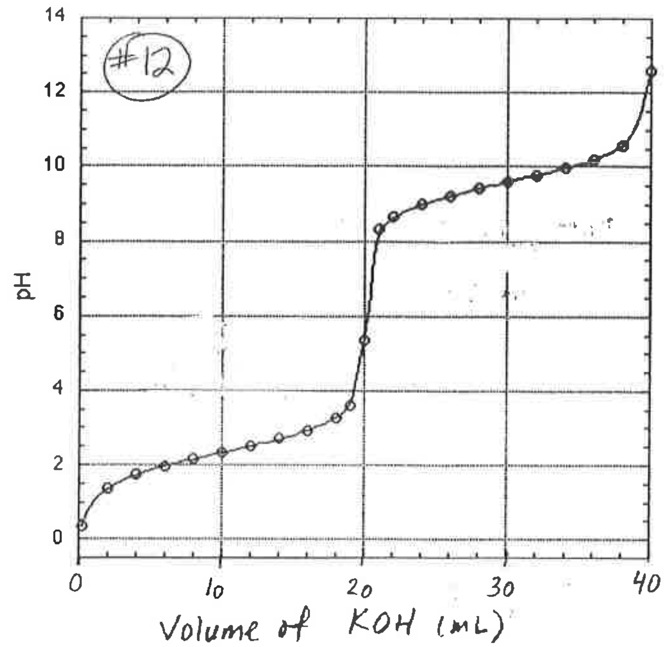
f. $(CH_3)_3N + H_2O$ <----> $(CH_3)_3NH^{+1} + OH^{-1}$

g. $H^{+1} + (CH_3)_3N$ <----> $(CH_3)_3NH^{+}$

12. A titration curve for a diprotic acid is shown below.

Label the graph:

Which ions/molecules (H_2X, HX^{-1}, or X^{-2}) are the main ones in the reaction flask at various places on the graph?
When is a buffer solution present, and what will be the approximate pH of the buffer solution?
Where are the equivalence points?



13. If you have these compounds available: H_2CO_3, $KHCO_3$, and Na_2CO_3

a. Which two compounds would you need to use to make a buffer with pH 10.00?
b. What should be the molarities of each compound in the buffer?
c. Which two compounds would you need to use to make a buffer with pH 6.10?
d. What should be the molarities of each compound in the buffer?

Most of the answers are here. The whole packet is written up on the website!

1. a) 9.76, b) 9.85, c) 9.68 **2.** a) 12.60 b) 12.90 c) 7.00 d) 1.40 e) 12.60 f) 13.43
2. g) 4.80 h) 10.80 i) 8.60 j) 8.30 k) 8.62 l) 2.52 m) 4.54

3. a) 0.25 M, b) at 0, 20, 30, 40 mL, the pH is 4.80, 8.60, 9.08, 10.72 (respectively) c/d) see website key
3. e) 80. mL HNO3 needed to reach equivalence point
f) At 0, 15, 40, 65, 80, and 85 mL, the pH is 11.94, 10.44, 9.81, 9.17, 5.07, and 1.06 (respectively) g/h) website.

4.a. When H+ is added, all of them will be more soluble except $PbCl_2$ and AgI
4b. $BaCO_{3\,(s)} + H^{+1}_{(aq)}$ --------> $Ba^{+2}_{(aq)} + HCO_3{}^{-1}_{(aq)}$
OR $BaCO_{3\,(s)} + 2\,H^{+1}_{(aq)}$ --------> $Ba^{+2}_{(aq)} + H_2CO_{3(aq)}$ (and $H_2CO_{3(aq)}$ <------> $CO_2 + H_2O$)
$Cu(OH)_{2(s)} + 2\,H^{+1}_{(aq)}$ --------> $Cu^{+2}_{(aq)} + 2\,H_2O_{(l)}$
$MgO_{(s)} + 2\,H^{+1}_{(aq)}$ --------> $Mg^{+2}_{(aq)} + H_2O_{(l)}$
$MgF_{2(s)} + 2\,H^{+1}_{(aq)}$ --------> $Mg^{+2}_{(aq)} + 2\,HF_{(aq)}$
($AgI_{(s)} + H^{+1}_{(aq)}$ --------> ~~$Ag^{+1}_{(aq)} + HI_{(aq)}$~~ N.R. since HI will remain ionized since it is a strong acid.)
($PbCl_{2\,(s)} + H^{+1}_{(aq)}$ --------> ~~$Ba^{+2}_{(aq)} + 2\,HCl_{(aq)}$~~ N.R. since HCl will remain ionized since it is a strong acid.)

4c. pH must be 4.31 or below **4d.** see website.

5. pH 3.68, $[H^+] = [HCO_3{}^{-1}] = 0.00021$ M, $[CO_3{}^{-2}] = 5.6 \times 10^{-11}$, $[H_2CO_3] = 0.10$ M, 0.21% ionization

6. Going down the first column: B, A, B, B, A, N, B, A, A, B, B, A
Going down the second column: N, A, A, B, B, N, A, A, B, B, A, A

7. a. Ka = 7.9 x 10-6. b. 0.10 c. 1.0 d. 10.
7e. The higher the pH, the higher the ratio of [base] to [acid]; the base form dominates at high pH.
The lower the pH, the lower the ratio. The acid form dominates at low pH.
7f. Red at pH 4.1, orange at pH 5.1, yellow at pH 6.1.
7g. weak base titrated with strong acid, since the equivalence point will be acidic; this indicator changes at acidic. (this indicator is "methyl red").

8. HOI, $NaClO_2$, NaCl, KF, $ZnCl_2$, $C_2H_5CH_2OH$, $Ca(NO_3)_2$, $Sn(NO_3)_2$. (see website for explanations)

9. a. See website. Remember to attach H to oxygen if the acid contains oxygen!
9b. HIO_3 c. $HClO_3$ d. From most acidic to most basic:
HBr (most acidic) > $HBrO_2$ (acidic) > HBrO (acidic) > $NaClO_3$ (neutral) > $LiIO_3$ (basic) > KIO (most basic)

10. Molar mass is around 155-160 amu, Ka is around 2×10^{-7} (using a pKa of 6.7)
11. a. 4.0×10^8 b. 4.0×10^{-6} c. 2.5×10^5 d. 1.2×10^{11} e. 1.0×10^9 f. 6.4×10^{-5} g. 6.4×10^9

12. See website.

13. a and b) Use $[KHCO_3] = 1.0$ M, $[Na_2CO_3] = 0.56$ M (or different molarities with the same ratio)
13. c and d) Use $[H_2CO_3] = 1.0$ M, $[KHCO_3] = 0.54$ M (or different molarities with the same ratio)