Spring 2009 CH302 Worksheet 5—How to Systematically Work Harder and Harder Acid Base Calculations Exactly the Same Way: Proof that the **Seven Steps to Solving Acid Base Problems** Work

1 Remove the spectator ions
2 Are there any strong acids or bases
3 Are there any weak acids or bases
4 Do I neutralize (are there both acids and bases and is at least one of them strong?)
5 Neutralize: convert everything to moles, write down neutralization reaction, perform limiting reagent calculation, convert back to molarity if necessary)
6 Select the appropriate acid base calculation and solve
7 Convert to appropriate final form (pH, pOH, H+, OH-) using 14 = pH + pOH and 14 = $pK_a + pK_b$

Important: These calculations are based upon the following important assumptions:

- Strong acids and bases completely dissociate
- Weak acids and bases do not dissociate significantly (typically they will have K values $<10^{-3}$)
- The dissociation of water does not contribute significantly to pH (concentrations of dissolved solutions are large, $> 10^{-4}$, and the K values are not near K_w, $>10^{-11}$)

In a nutshell, all of these problems are worked at high concentrations for a single equilibrium. When we get to complex equilibria you will learn how to tackle problems for which the assumptions do not hold.

1. What is the pOH of a 0.1 M $HClO_4$ solution?
   1
   2
   3
   4
   5
   6
   7
   8

What kind of acid base problem was this? _________________________________.

2. What is the pH of a 0.1 M RbOH solution?
   1
   2
   3
   4
   5
   6
   7
   8

What kind of acid base problem was this? _________________________________.

3. What is the $[H^+]$ of a 0.1 M malonic acid with a K_a of 10^{-9} solution?
   1
   2

3
4
5
6
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What kind of acid base problem was this? _________________________________.

4. What is the pH of a 0.1 M lithium malonate solution? (Need a K_b? Look at the problem above.)

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What kind of acid base problem was this? _________________________________.

5. What is the $[OH^-]$ of a 0.01 M methylamine solution of $K_b = 10^{-6}$?

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What kind of acid base problem was this? _________________________________.

6. What is the pOH of a 0.01 M CH_3NH_2Br solution? (Need a K_a? Look at the problem above.)

1
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7
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What kind of acid base problem was this? _________________________________.

7. What is the pH when equal volume mixtures of 0.2 M $HClO_4$ and 0.2M $LiClO_4$ are mixed?

1
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3

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5
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7
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What kind of acid base problem was this? ________________________________.

8. What is the pH when 100 ml of 0.1 M $HClO_4$ and50 ml of 0.25 M $Ba(OH)_2$ are mixed?

1
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What kind of acid base problem was this? ________________________________.

9. What is the pH when 1 liter of 0.1 M $HClO_4$ and 1 liter of 0.5M $Ba(OH)_2$ are mixed? (this is the first problem for which you need a calculator)

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What kind of acid base problem was this? ________________________________.

10. What is the pOH when 100 ml of 0.1 M malonic acid and 100 ml of 0.1 M sodium malonate are mixed? See the previous Ka value.

1
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What kind of acid base problem was this? ________________________________.

10. What is the pH when 100 ml of 0.1 M methylamine and 100 ml of 0.1 M CH_3NH_2Br are mixed? See the previous Kb.

1
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What kind of acid base problem was this? ________________________________.

The next four calculations represent the titration of a weak base with a strong acid. Note the pH gets smaller and smaller as more acid is added. See the previous Kb value.

11. What is the pH when no HBr is added to 100 ml of 0.1 M sodium malonate?

1
2
3
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What kind of acid base problem was this? ________________________________.

12. What is the pH when 50 ml of 0.1 M HBr is added to 100 ml of 0.1 M sodium malonate?

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What kind of acid base problem was this? ________________________________.

13. What is the pH when 100 ml of 0.1 M HBr is added to 100 ml of 0.1 M sodium malonate?

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What kind of acid base problem was this? ________________________________.

14. What is the pH when 110 ml of 0.1 M HBr is added to 100 ml of 0.1 M sodium malonate?

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What kind of acid base problem was this? ________________________________.

The next four calculations represent the titration of a weak acid with a strong base Note the pH gets larger and larger as more base is added.

15. What is the pH when no LiOH is added to 200 ml of 0.05 M CH_3NH_2Br?

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What kind of acid base problem was this? ________________________________.

16. What is the pH when 100 ml of 0.05 M LiOH is added to 200 ml of 0.05 M CH_3NH_2Br?

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What kind of acid base problem was this? ________________________________.

17. What is the pH when 200 ml of 0.05 M LiOH is added to 200 ml of 0.05 M CH_3NH_2Br?

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What kind of acid base problem was this? ________________________________.

18. What is the pH when 250 ml of 0.05 M LiOH is added to 200 ml of 0.05 M CH_3NH_2Br?

1

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What kind of acid base problem was this? ________________________________.

19. What is the pH when 10 ml of 0.1 M $HClO_3$ is added to 100 ml of 0.1 M methylamine and 100 ml of 0.1 M CH_3NH_2Br?

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What kind of acid base problem was this? ________________________________.

20. What is the pOH when 20 ml of 0.001 M KOH is added to 200 ml of 0.01 M malonic acid and 200 ml of 0.02 M sodium malonate are mixed?

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What kind of acid base problem was this? ________________________________.

Super-duper do it in your head pH problem. What is the pH when 10 ml of 0.1 M $HClO_3$ and 20 ml of 0.05M $Ba(OH)_2$ are added to 150 ml of 0.1 M methylamine and 75 ml of 0.2 M CH_3NH_2Br? Hint, put away your calculator and do it in your head.

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What kind of acid base problem was this? ________________________________.