CH302 Worksheet 8 —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 on 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 contribut4e 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?

What kind of acid base problem was this? Strong acid with a pOH of 13.

2. What is the pH of a 0.1 M RbOH solution?

What kind of acid base problem was this? Strong base with a pH of 13

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

What kind of acid base problem was this? Weak acid with a pH of 5

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

What kind of acid base problem was this? Weak base with a pH of 11

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

What kind of acid base problem was this? Weak base with a $[OH^-]$ of 10^{-4} M

6. What is the pOH of a 0.01 M CH_3NH_3Br solution? (Need a K_a? Look at the problem above.)

What kind of acid base problem was this? Weak acid with a pOH of 9

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

What kind of acid base problem was this? Strong acid with a pH of 1

8. What is the pH when 100 ml of 0.1 M $HClO_4$ and 50 ml of 0.1 M $Ba(OH)_2$ are mixed?

What kind of acid base problem was this? Neutral water solution with pH of 7 at room temperature

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 to need a calculator)

What kind of acid base problem was this? Strong base with a pH of 13.65

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?

What kind of acid base problem was this? Buffer with a pOH of 5

10. What is the pH when 100 ml of 0.1 M methylamine and 100 ml of 0.1 M CH_3NH_3Br are mixed?

What kind of acid base problem was this? Buffer with a pH of 8

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.

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

What kind of acid base problem was this? Weak base with a pH of 11

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

What kind of acid base problem was this? Buffer with a pH of 9

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

What kind of acid base problem was this? It is a weak acids with pH of 5.15

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

What kind of acid base problem was this? Excess strong acid with pH of 2.3

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_3Br?

What kind of acid base problem was this? Weak acid with pH of 4.65

16. What is the pH when 100 ml of 0.05 M LiOH is added to 200 ml of 0.05 M CH_3NH_3Br?

What kind of acid base problem was this? Buffer with a pH of 8

17. What is the pH when 200 ml of 0.05 M LiOH is added to 200 ml of 0.05 M CH_3NH_3Br?

What kind of acid base problem was this? Weak base with pH of 10.2

18. What is the pH when 250 ml of 0.05 M LiOH is added to 200 ml of 0.05 M CH_3NH_3Br?

What kind of acid base problem was this? Excess strong base with pH of 11.7

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_3Br?

What kind of acid base problem was this? Buffer with pH of 7.95 (note it is a little less than pH 8 because we added a little bit of strong acid to a 1:1 buffer with $pK_a = 8$.

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?

What kind of acid base problem was this? Buffer with a pOH of 4.69

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_3Br? Hint, put away your calculator and do it in your head.

What kind of acid base problem was this? This is a buffer with pH 8. Note that the strong acid and strong base are present in equal amounts and neutralize each other. Also note this is a 1:1 buffer with $pH = pK_a$.