

**Spring 2009 CH302 Worksheet 5 Answer Key**—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<sup>+</sup>, OH<sup>-</sup>) using  $14 = \text{pH} + \text{pOH}$  and  $14 = \text{pK}_a + \text{pK}_b$

**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<sub>4</sub> 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<sup>+</sup>] of a 0.1 M malonic acid with a K<sub>a</sub> of 10<sup>-9</sup> 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<sub>b</sub>? 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<sup>-</sup>] of a 0.01 M methylamine solution of K<sub>b</sub> = 10<sup>-6</sup>?

What kind of acid base problem was this? **Weak base with a [OH<sup>-</sup>] of 10<sup>-4</sup> M**

6. What is the pOH of a 0.01 M CH<sub>3</sub>NH<sub>3</sub>Br solution? (Need a K<sub>a</sub>? 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<sub>4</sub> and 0.2M LiClO<sub>4</sub> 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  $\text{HClO}_4$  and 50 ml of 0.1 M  $\text{Ba}(\text{OH})_2$  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  $\text{HClO}_4$  and 1 liter of 0.5M  $\text{Ba}(\text{OH})_2$  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  $\text{CH}_3\text{NH}_3\text{Br}$  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  $\text{CH}_3\text{NH}_3\text{Br}$ ?

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  $\text{CH}_3\text{NH}_3\text{Br}$ ?

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<sub>3</sub>NH<sub>3</sub>Br?

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<sub>3</sub>NH<sub>3</sub>Br?

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<sub>3</sub> is added to 100 ml of 0.1 M methylamine and 100 ml of 0.1 M CH<sub>3</sub>NH<sub>3</sub>Br?

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<sub>a</sub> = 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<sub>3</sub> and 20 ml of 0.05M Ba(OH)<sub>2</sub> are added to 150 ml of 0.1 M methylamine and 75 ml of 0.2 M CH<sub>3</sub>NH<sub>3</sub>Br? 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<sub>a</sub>.**