

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⁺, OH⁻) 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 HClO₄ 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 CH₃NH₂Br 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 HClO₄ and 0.2M LiClO₄ are mixed?

What kind of acid base problem was this? **Strong acid with a pH of 1 (remember the volume change)**

8. What is the pH when 100 ml of 0.1 M HClO_4 and 50 ml of 0.25 M $\text{Ba}(\text{OH})_2$ are mixed?

What kind of acid base problem was this? **Neutralization. Final solution .015 moles OH^- / .15 L = .1 M pH = 13**

9. What is the pH when 1 liter of 0.1 M HClO_4 and 1 liter of 0.5 M $\text{Ba}(\text{OH})_2$ are mixed? (this is the first problem for which you 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 $\text{CH}_3\text{NH}_2\text{Br}$ 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 $\text{CH}_3\text{NH}_2\text{Br}$?

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 $\text{CH}_3\text{NH}_2\text{Br}$?

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 CH₃NH₂Br?

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 CH₃NH₂Br?

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 HClO₃ is added to 100 ml of 0.1 M methylamine and 100 ml of 0.1 M CH₃NH₂Br?

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 HClO₃ 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 CH₃NH₂Br? 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.**