

1. What is the pH of a 1 L solution made with 3.26 g of trichloroacetic acid and 37.0 g of sodium trichloroacetate? The  $K_b$  of sodium trichloroacetate is  $10^{-12}$ . Molecular weights of trichloroacetic acid and sodium trichloroacetate are 163 g/mol and 185 g/mol respectively.

- a. 4
- b. 3.5
- c. 3
- d. 2

2. If 500 ml of each of the following solutions is combined, which will not produce a buffer?

- a. .1 M trichloroacetic acid + .1 M sodium trichloroacetate
- b. .3 M trichloroacetic acid + .15 M barium hydroxide
- c. .3 M trichloroacetic acid + .2 M sodium hydroxide
- d. .2 M sodium trichloroacetate + .18 M hydrochloric acid

3. Consider the following table of acids and their  $pK_a$  values. Rank these acids in order of increasing strength of their conjugate bases.

Acid	$pK_a$
CHOOH	3.77
CH <sub>3</sub> COOH	4.75
HF	3.20

- a. HF < CH<sub>3</sub>COOH < CHOOH
- b. CHOOH < CH<sub>3</sub>COOH < HF
- c. CH<sub>3</sub>COOH < CHOOH < HF
- d. HF < CHOOH < CH<sub>3</sub>COOH

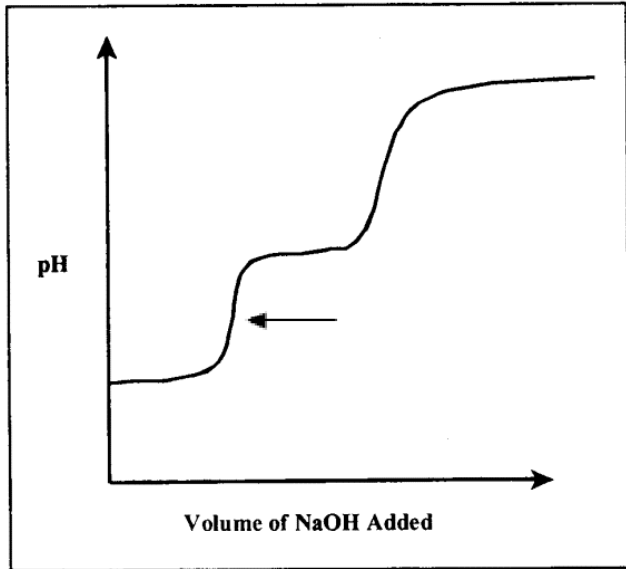
4. What volume of 1 M calcium hydroxide could be added to 500 mL of a buffer that is 0.4 M ammonia and 0.6 M ammonium chloride before exhausting the buffer?

- a. 600 mL
- b. 300 mL
- c. 150 mL
- d. 400 mL
- e. 200 mL

5. What is the pH of a 100 mL of a buffer solution containing .25 M formic acid and .30 M sodium formate if you add .01 mols of Ba(OH)<sub>2</sub>? The  $pK_a$  of formic acid is 4.

- a. 3.7
- b. 4
- c. 4.4
- d. 5

6. Consider the following titration curve of an acid, H<sub>2</sub>A:



At the point indicated by the arrow, which species is predominant?

- $\text{H}_2\text{A}$
- $\text{HA}^-$
- $\text{A}^{2-}$
- No species is predominant,  $[\text{H}_2\text{A}] = [\text{HA}^-]$

7. If 25 mL of a .17 M solution of barium hydroxide is titrated with 75 mL of a .1 M nitric acid solution, what is the final pH?

- 12
- 1.5
- 11
- 7

8. A 100 mL solution of .25 M  $(\text{CH}_3)_3\text{NHCl}$  is titrated with 80 mL of a .25 M solution of NaOH. What is the pH of the final solution? The  $\text{pK}_a$  of  $(\text{CH}_3)_3\text{NHCl}$  is  $4 \times 10^{-4}$ .

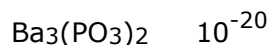
- 8
- 3.5
- 4
- 2

9. A .36 M solution of ethylamine ( $\text{C}_2\text{H}_5\text{NH}_2$ ) is titrated with a .12 M perchloric acid solution to the stoichiometric point. What is left in solution? What is the molarity? What is the pH range? The  $\text{pK}_b$  of ethylamine is 3.

- equal amounts of  $\text{C}_2\text{H}_5\text{NH}_2$  and  $\text{C}_2\text{H}_5\text{NH}_3^+$ , .3 M, 3
- equal amounts of  $\text{C}_2\text{H}_5\text{NH}_2$  and  $\text{C}_2\text{H}_5\text{NH}_3^+$ , .18 M, 3
- only  $\text{C}_2\text{H}_5\text{NH}_3^+$ , .18 M, 11-12
- only  $\text{C}_2\text{H}_5\text{NH}_3^+$ , .09 M, 9-10

10. Consider the table of salts and their corresponding  $\text{K}_{\text{sp}}$  values.

Salt	$\text{K}_{\text{sp}}$
$\text{BaCO}_3$	$10^{-20}$
$\text{Cu}_3\text{PO}_4$	$10^{-20}$



Rank the salts in order of increasing solubility in water.

- $\text{BaCO}_3 < \text{Cu}_3\text{PO}_4 < \text{Ba}_3(\text{PO}_3)_2$
- $\text{Ba}_3(\text{PO}_3)_2 < \text{Cu}_3\text{PO}_4 < \text{BaCO}_3$
- $\text{Cu}_3\text{PO}_4 < \text{Ba}_3(\text{PO}_3)_2 < \text{BaCO}_3$
- $\text{BaCO}_3 < \text{Ba}_3(\text{PO}_3)_2 < \text{Cu}_3\text{PO}_4$

11. Which of the following compounds has the highest molar solubility in water?

- $\text{Cu}_3(\text{PO}_4)_2$  ( $K_{\text{sp}} = 1.9 \times 10^{-37}$ )
- $\text{Bi}_2\text{S}_3$  ( $K_{\text{sp}} = 1.8 \times 10^{-99}$ )
- $\text{Fe}_2\text{S}_3$  ( $K_{\text{sp}} = 1.4 \times 10^{-88}$ )
- $\text{PbI}_2$  ( $K_{\text{sp}} = 7.1 \times 10^{-9}$ )

12. Which equation will you use to calculate the molar solubility,  $x$ , of  $\text{HgCl}_2$  in water? ( $K_{\text{sp}} = 1.1 \times 10^{-18}$ )

- $1.1 \times 10^{-18} = 4x^3$
- $x^3 = 1.1 \times 10^{-18}$
- $(1.1 \times 10^{-18})^3 = x$
- $1.1 \times 10^{-18} / 3 = x^4$

13. How many grams of  $\text{CaCrO}_4$  ( $K_{\text{sp}} = 2.3 \times 10^{-2}$ ) could you dissolve in a 100 mL of 2.3 M  $\text{Ca}(\text{OH})_2$ ?

- $10^{-2}$
- $10^{-1}$
- 156
- 1.56
- $10^{-3}$
- 0.156

14. Each of the following answers are the solubility constants for a metal ions. Which one will be the most difficult to separate by precipitation?

- $10^{-9}, 10^{-15}$
- $10^{-5}, 10^{-33}$
- $10^{-2}, 10^{-3}$
- $10^{-3}, 10^{-5}$

15. When can you use the weak acid approximation?

- Always
- When  $K_a$  is near  $K_w$
- When the concentration of acid is smaller than  $[\text{H}^+]$  and  $K_w$  is negligible
- When  $K_a$  and  $K_w$  are far apart

16. In an attempt to prepare a large quantity of a solution with a pH of 9, a student dissolves 100.5 micrograms of perchloric acid in 1000 L of water. Roughly, what will be the actual pH of the solution and why?

- 7, because the leveling effect will prevent the dissociation of the acid.
- 9, because the final concentration of the strong acid will  $10^{-9}$  M.
- 9, because the conjugate base of the strong acid will predominate.
- 3, because the final concentration of the strong acid will  $10^{-3}$  M.
- 7, because the strong acid too dilute to contribute significantly to the  $[\text{H}^+]$ .

17. How many equations would be need to completely describe a solution of  $(\text{NH}_4)_3\text{AsO}_3$  and  $\text{NaCl}$ ?

1. 6
2. 8
3. 4
4. 7
5. 5
6. 9

18. Which of the following equations is correct in describing a solution of  $(\text{NH}_4)_2\text{CO}_3$ ?

- a.  $[\text{NH}_4^+] + [\text{H}^+] = [\text{OH}^-] + [\text{CO}_3^{2-}] + [\text{HCO}_3^-]$
- b.  $2 C_{(\text{NH}_4)_2\text{CO}_3} = [\text{NH}_4^+] + [\text{NH}_3]$
- c.  $C_{(\text{NH}_4)_2\text{CO}_3} = 2[\text{NH}_4^+] + 2[\text{NH}_3]$
- d.  $[\text{NH}_4^+] = 2[\text{CO}_3^{2-}] + [\text{HCO}_3^-]$

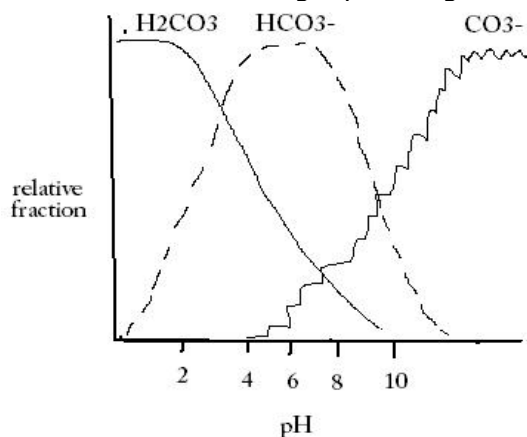
19. Which of the following is a likely pOH for a solution of  $10^{-9}$  M NaOH?

- a. 7.02
- b. 6.98
- c. 7.00
- d. 9.00
- e. 5.00

20. Consider the chemical EDTA, which has 6 acid/base groups on it. If all 6 are initially protonated and we titrate until all 6 are deprotonated, how many buffer regions and amphoteric species will occur?

- a. 5, 5
- b. 6, 5
- c. 6, 6
- d. 5, 6

21. Given the following alpha diagram. What is(are) the predominant specie(s) at pH 3?



- a.  $\text{H}_2\text{CO}_3$
- b.  $\text{H}_2\text{CO}_3, \text{HCO}_3^-$
- c.  $\text{HCO}_3^-$
- d.  $\text{HCO}_3^-, \text{CO}_3^{2-}$

22. The  $\text{pK}_a$  values for  $\text{H}_3\text{PO}_4$  are as following:  $\text{pK}_{a1}=2.1$ ,  $\text{pK}_{a2}=7.2$ ,  $\text{pK}_{a3}=12.8$ . What is the pOH of a 0.001M  $\text{HPO}_4^{2-}$ ?

- a. 10
- b. 9
- c. 5

d. 4

23. What is the pH of a 0.1 M solution of  $\text{Na}_2\text{CO}_3$ ?  $\text{pK}_{\text{a}1} = 4$ ,  $\text{pK}_{\text{a}2} = 11$ .

- a. 12
- b. 7.5
- c. 6.5
- d. 2

24. When calculating the pH of a 1 M solution of a diprotic acid ( $\text{H}_2\text{A}$ ), for which of the following  $K_{\text{a}}$  values would it be safe to ignore  $K_{\text{a}2}$  and simply treat the acid as a monoprotic species?

- a.  $K_{\text{a}1} = 1.14 \times 10^{-5}$ ,  $K_{\text{a}2} = 2.38 \times 10^{-6}$
- b.  $K_{\text{a}1} = 4.08 \times 10^{-3}$ ,  $K_{\text{a}2} = 5.60 \times 10^{-7}$
- c.  $K_{\text{a}1} = 3.26 \times 10^{-2}$ ,  $K_{\text{a}2} = 9.98 \times 10^{-7}$
- d.  $K_{\text{a}1} = 4.55 \times 10^{-1}$ ,  $K_{\text{a}2} = 8.19 \times 10^{-3}$

25. When calculating the pH of a 0.3M  $\text{H}_2\text{SO}_4$  solution, which equation do we use for calculations?

- a. strong acid
- b. weak acid
- c. amphiprotic
- d. buffer
- e. a full quadratic solution is necessary