

7. ACIDS AND BASES V – Buffers and Titrations

CHE 112 Q & A

These problems are intended to *supplement* the problems in the textbook, not *replace* them.

Data:

Acids				
Name	Formula	K_{a1}	K_{a2}	K_{a3}
acetic acid	$\text{HC}_2\text{H}_3\text{O}_2$	1.8×10^{-5}	x	x
ascorbic acid	$\text{H}_2\text{C}_6\text{H}_6\text{O}_6$	8.0×10^{-5}	1.6×10^{-12}	x
benzoic acid	$\text{HC}_7\text{H}_5\text{O}_2$	6.3×10^{-5}	x	x
carbonic acid	H_2CO_3	4.3×10^{-7}	5.6×10^{-11}	x
citric acid	$\text{H}_3\text{C}_6\text{H}_5\text{O}_7$	7.4×10^{-4}	1.7×10^{-5}	4.0×10^{-7}
cyanic acid	HCNO	3.5×10^{-4}	x	x
hydrocyanic acid	HCN	4.9×10^{-10}	x	x
hydrofluoric acid	HF	6.8×10^{-4}	x	x
hypochlorous acid	HClO	3.0×10^{-8}	x	x
hypobromous acid	HBrO	2.5×10^{-9}	x	x
hypoiodous acid	HIO	2.3×10^{-11}	x	x
lactic acid	$\text{HC}_3\text{H}_5\text{O}_3$	1.4×10^{-4}	x	x
oxalic acid	$\text{H}_2\text{C}_2\text{O}_4$	5.9×10^{-2}	6.4×10^{-5}	x
phosphoric acid	H_3PO_4	7.5×10^{-3}	6.2×10^{-8}	4.2×10^{-13}
sulfurous acid	H_2SO_3	1.7×10^{-2}	6.4×10^{-8}	x

Bases		
Name	Formula	K_b
ammonia	NH_3	1.8×10^{-5}
aniline	$\text{C}_6\text{H}_5\text{NH}_2$	4.3×10^{-10}
butylamine	$\text{C}_4\text{H}_9\text{NH}_2$	5.9×10^{-4}
dimethylamine	$(\text{CH}_3)_2\text{NH}$	5.4×10^{-4}
ethylamine	$\text{C}_2\text{H}_5\text{NH}_2$	6.4×10^{-4}
hydroxylamine	NH_2OH	1.1×10^{-8}
methylamine	CH_3NH_2	4.4×10^{-4}
pyridine	$\text{C}_5\text{H}_5\text{N}$	1.7×10^{-9}
trimethylamine	$(\text{CH}_3)_3\text{N}$	6.4×10^{-5}

Questions

Calculate the pH for the following:

- 765 mL of solution that contains 5.00 g hydrocyanic acid, HCN and 13.0 g KCN, potassium cyanide
- a solution that is prepared by dissolving 0.010 mol sodium lactate, $\text{NaC}_3\text{H}_5\text{O}_3$ in 100.0 mL of 0.035 M lactic acid, $\text{HC}_3\text{H}_5\text{O}_3$
- 0.500 L of solution that contains 1.51 g ammonia, NH_3 and 3.85 g ammonium chloride, NH_4Cl
- a solution that is prepared by dissolving 0.700 mol ethylammonium bromide, $\text{C}_2\text{H}_5\text{NH}_3\text{Br}$ in 3.00 L of 0.200 M ethylamine, $\text{C}_2\text{H}_5\text{NH}_2$

Answer the following questions.

- How many grams of potassium cyanide, KCN do you need in 250.0 mL of 0.50 M hydrocyanic acid, HCN to make a buffer with pH = 9.50?
- What mass of ammonium chloride, NH_4Cl must be added to 320.0 mL of 0.105 M ammonia, NH_3 to give a buffer with pH = 9.35?
- What is the concentration of trimethylamine, $(\text{CH}_3)_3\text{N}$ in a buffer solution which is 0.100 M in trimethylammonium ion, $(\text{CH}_3)_3\text{NH}^+$ if the pH is 10.41?
- A solution is prepared from 0.0208 moles of a weak acid, HX, and 0.00700 moles of NaX, diluted to 200.0 mL. It has a pH of 3.66. What is K_a for the acid?

9. A solution is prepared from 0.100 moles of a weak acid, HY, and 0.00800 moles of CaY_2 , diluted to 3.00 L. It has a pH of 5.20. What is K_a for the acid?

875 mL of buffer solution is 0.200 M in benzoic acid, $\text{HC}_7\text{H}_5\text{O}_2$ and 0.150 M in potassium benzoate, $\text{KC}_7\text{H}_5\text{O}_2$.

10. What is the pH of this buffer solution?
11. What is the pH of the solution after 10.0 mL of 2.00 M HCl has been added?
12. What is the pH of the solution after 15.0 mL of 1.00 M NaOH has been added?

4.00 L of buffer solution is 0.175 M in methylamine, CH_3NH_2 and 0.200 M in methylammonium chloride, $\text{CH}_3\text{NH}_3\text{Cl}$.

13. What is the pH of this buffer solution?
14. What is the pH of the solution after 10.0 mL of 2.00 M HCl has been added?
15. What is the pH of the solution after 15.0 mL of 1.00 M NaOH has been added?

200.0 mL of 0.450 M hypobromous acid, HBrO is being titrated with 0.250 M KOH.

16. What is the pH before any KOH has been added?
17. What is the pH after 100.0 mL of KOH has been added?
18. What is the pH after 360.0 mL of KOH has been added?
19. What is the pH after 400.0 mL of KOH has been added?

625 mL of 0.320 M pyridine is being titrated with 0.780 M HNO_3 .

20. What is the pH before any HNO_3 has been added?
21. What volume of HNO_3 is needed to reach the equivalence point?
22. What is the pH at the equivalence point?
23. What is the pH after 150.0 mL of HNO_3 has been added?
24. What is the pH after 300.0 mL of HNO_3 has been added?

Answers

If you cannot figure out how to get the correct answer, go to your instructor, Science Tutoring Center, etc.

Note: minor differences in the final answer may be due to different ways of solving the problems and are not a cause for concern.

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|---------------------------------|-------------------------------------|-----------|------------|
| 1. 9.34 | 7. 0.41 M $(\text{CH}_3)_3\text{N}$ | 13. 10.58 | 19. 12.23 |
| 2. 4.31 | 8. 7.4×10^{-5} | 14. 10.57 | 20. 9.36 |
| 3. 9.34 | 9. 1.0×10^{-6} | 15. 10.60 | 21. 256 mL |
| 4. 10.73 | 10. 4.08 | 16. 4.47 | 22. 2.92 |
| 5. 12 g KCN | 11. 3.95 | 17. 8.18 | 23. 5.09 |
| 6. 1.4 g NH_4Cl | 12. 4.16 | 18. 10.90 | 24. 1.43 |