

Acid/base practice problems (no calculator)

You can do all of these problems with or without a calculator. Answers given were generated without a calculator.

- 1) Calculate the pH (at 25°C, where $K_w = 1.0 \times 10^{-14}$) of the following mixtures:
- a) 30.0 mL of 0.020 M $\text{Ca}(\text{OH})_2$ and 20.00 mL of 0.040M HBr. Calculate the pOH of this solution as well. [**pH = 11.90, pOH = 2.10**]
 - b) 25.0 mL of 1.0 M HA ($K_a = 4 \times 10^{-4}$). [**1.70**]
 - c) 25.0 mL of 1.0 M HA and 10.0 mL of 1.0 M NaOH [**3.22**]
 - d) 25.0 mL of 1.0 M HA and 12.5 mL of 1.0 M NaOH [**3.40**]
 - e) 25.0 mL of 1.0 M HA and 15.0 mL of 1.0 M NaOH [**3.58**]
 - f) 25.0 mL of 1.0 M HA and 25.0 mL of 1.0 M NaOH [**8.55**]
 - g) 25.0 mL of 1.0 M HA and 26.0 mL of 1.0 M NaOH [**12.30**]
 - h) 25.0 mL of 10.0 M H_2SO_4 . K_{a2} for $\text{H}_2\text{SO}_4 = 1.1 \times 10^{-2}$ [**-1.00**]
 - i) 25.0 mL of 1.0 M "B" (a weak base), for which $K_b = 4.0 \times 10^{-4}$ [**12.30**]
 - j) 25.0 mL of 1.0 M "B" and 10.0 mL of 1.0 M HCl [**10.78**]
 - k) 25.0 mL of 1.0 M "B" and 12.5 mL of 1.0 M HCl [**10.60**]
 - l) 25.0 mL of 1.0 M "B" and 15.0 mL of 1.0 M HCl [**10.42**]
 - m) 25.0 mL of 1.0 M "B" and 25.0 mL of 1.0 M HCl [**5.45**]
 - n) 25.0 mL of 1.0 M "B" and 26.0 mL of 1.0 M HCl [**1.70**]
 - o) 25.0 mL of 1.0 M H_2A (for which $K_{a1} = 4.0 \times 10^{-4}$ and $K_{a2} = 4.0 \times 10^{-8}$) [**1.70**]
 - p) 25.0 mL of 1.0 M H_2A and 10.0 mL of 1.0 M NaOH [**3.22**]
 - q) 25.0 mL of 1.0 M H_2A and 12.5 mL of 1.0 M NaOH [**3.40**]
 - r) 25.0 mL of 1.0 M H_2A and 15.0 mL of 1.0 M NaOH [**3.58**]
 - s) 25.0 mL of 1.0 M H_2A and 25.0 mL of 1.0 M NaOH [**5.40**]
 - t) 25.0 mL of 1.0 M H_2A and 35.0 mL of 1.0 M NaOH [**7.22**]
 - u) 25.0 mL of 1.0 M H_2A and 37.5 mL of 1.0 M NaOH [**7.40**]
 - v) 25.0 mL of 1.0 M H_2A and 40.0 mL of 1.0 M NaOH [**7.58**]
 - w) 25.0 mL of 1.0 M H_2A and 50.0 mL of 1.0 M NaOH [**10.46**]
 - x) 25.0 mL of 1.0 M H_2A and 55.0 mL of 1.0 M NaOH [**12.80**]
- 2) H_3A is a weak acid with $\text{p}K_{a1} = 3.0$, $\text{p}K_{a2} = 7.0$, and $\text{p}K_{a3} = 11.0$. Calculate the ratio of $[\text{H}_3\text{A}]:[\text{H}_2\text{A}^{-1}]:[\text{HA}^{-2}]:[\text{A}^{-3}]$ in a solution with a pH of 6.0. If you were going to make a solution with a pH of 6.0 and only allowed to use two of H_3A , NaH_2A , Na_2HA , and Na_3A , which two would you pick? [**$10^3:10^6:10^5:1$, NaH_2A and Na_2HA**]
- 3) A certain indicator has a $\text{p}K_{\text{ind}} = 2.0$. You use it in the titration of 10.00 mL of 0.1200 M HCl with 0.1000 M NaOH. At what added volume of NaOH will the endpoint be reached? Does this make it a good or a bad indicator for this titration? [**10.00 mL, no**]

- 4) A 0.010 M solution of a weak acid (HA) has a pH of 3.50. What are the K_a and pK_a of the acid? (**1.0×10^{-5} and 5.00**)
- 5) A 0.250 mol sample of HY is dissolved in enough water to form 250 mL of solution. If the pH of the solution is 3.30, what are the K_a and pK_a of HY? (**2.5×10^{-7} and 6.60**)
- 6) For the diprotic acid H_2A ($pK_{a1} = 4.00$ and $pK_{a2} = 7.00$) calculate $[H_2A]$, $[HA^{1-}]$, $[A^{2-}]$, $[H^+]$, $[OH^-]$, pH, and pOH in a 0.200 M solution of H_2A . (**$[H_2A] = 0.195 M$, $[HA^{1-}] = [H^+] = 5 \times 10^{-3} M$, $[A^{2-}] = 1 \times 10^{-7} M$, $[OH^-] = 2 \times 10^{-12} M$, **pH = 2.30, and pOH = 11.70**)**
- 7) The K_a for phenol is 1.0×10^{-10} . What is the pH of 0.100 M sodium phenolate, C_6H_5ONa , the sodium salt of phenol? (**11.50**)
- 8) The pK_b for aniline ($C_6H_5NH_2$) is 9.40. What is the pH of 0.100 M aniline hydrochloride, $C_6H_5NH_3Cl$? (**2.80**)
- 9) Explain (using equations only) whether an aqueous solution of each of the following salts is acidic, basic, or neutral: (a) KBr; (b) NH_4I ; (c) KCN; (d) $CaCl_2$; (e) $Ba(CH_3COO)_2$; (f) $(CH_3)_2NH_2Br$. (**neutral, acidic, basic, neutral, basic, acidic**)
- 10) What are the $[H^+]$ and pH of a solution that consists of 0.50 M HX and 0.25 M NaX? The K_a of HX is 5.0×10^{-4} . (**1.0×10^{-3} and 3.00**)
- 11) What is the pH of a solution that consists of 0.20 M NH_3 and 0.10 M $(NH_4)_2SO_4$? The pK_b of NH_3 is 4.75. (**9.25**)
- 12) A solution consists of 0.25 M $KHCO_3$ and 0.75 M K_2CO_3 . Carbonic acid (H_2CO_3) is a diprotic acid with $pK_{a1} = 6.35$ and $pK_{a2} = 10.33$.
- a) Which pK_a is used in the calculation of the pH of the solution?
- b) What is the pH of this solution? (**10.81**)
- 13) What is the ratio of $[BrO^-]/[HBrO]$ in a buffer solution with a pH of 8.34? The pK_a of HBrO is 8.64. (**0.5**)
- 14) A buffer containing 0.200 M HA and 0.150 M NaA has a pH of 3.35. What is the pH after 12.5 mmol of NaOH is added to 500 mL of this solution? (**3.47**)
- 15) The indicator cresol red has a $K_a = 5.0 \times 10^{-9}$. Over what approximate pH range does the indicator change color? (**about 7.3 to 9.3**)