

Chemistry 023

Weak Acid - Base Tutorial Problems

- 1) Should be self explanatory!
- 2) Propionic acid, $\text{CH}_3\text{CH}_2\text{COOH}$ is a weak organic acid with $\text{pK}_a = 4.87$. If you are to prepare 2.00 L of a solution with a pH of 2.50, what mass of propionic acid should be used?
- 3) The weak acid HA is dissolved in water, resulting in 0.200 M solution. The pH of this solution is found to be 1.40. Calculate the K_a for this weak acid.
- 4) a) Hypochlorous acid, HOCl is a very weak acid; the $K_a = 2.8 \times 10^{-8}$. Calculate the $[\text{H}^+]$, the pH and the % ionization of this acid, if the initial concentration of the acid is
i) 1.00 M ii) 0.0100 M

b) Based on your calculations from a), state what happens to a weak acid solution when it is diluted.
Does $[\text{H}^+]$ increase or decrease? Does the pH increase or decrease?
Does the degree (or %) of ionization increase or decrease?
- 5) Triethylamine, $(\text{CH}_3)_3\text{N}$, is a weak organic base with $K_b = 6.3 \times 10^{-5}$. A solution of triethylamine is 0.35 M. Calculate the pOH, the pH and the % ionization in this solution.
- 6) Consider the following three weak acids:
Formic Acid, HCOOH : $K_a = 1.8 \times 10^{-4}$
Hydrofluoric Acid, HF : $K_a = 6.9 \times 10^{-4}$
Hydrogen Oxalate ion, HC_2O_4^- : $K_a = 5.2 \times 10^{-5}$

a) Calculate the pK_a value for each acid.
b) Which acid is the strongest? Which acid is the weakest?
c) What is the formula of the conjugate base of each acid?
d) Calculate the K_b value of each conjugate base. Which conjugate base is strongest? Which conjugate base is weakest?

- 7) A weak acid, HA, is 25 % ionized when the initial concentration of the acid is 0.15 M. What is the K_a value of this acid ?
- 8) The K_a of acetic acid, CH_3COOH , is 1.8×10^{-5} . If a solution of acetic acid, is 2.0 % ionized, what is the initial concentration of this solution ?
- 9) Ammonia, NH_3 , is to be dissolved in water to produce 10 L of solution with a pOH of 2.82. What mass of ammonia is required to prepare this solution ? (K_b for NH_3 is 1.8×10^{-5})
- 10) Calculate the pH and % hydrolysis in the following solutions. (Use K_a and K_b data from Q. 1 as required.)
- 0.500 M potassium formate, HCOOK
 - At the equivalence point when 0.500 M nitrous acid, HNO_2 , is titrated with 0.100 M sodium hydroxide, NaOH .
 - 0.250 M ammonium bromide, NH_4Br
 - At the equivalence point when 0.800 M methylamine, CH_3NH_2 , is titrated with 0.400 M HCl .

*** Try parts b) and d) after you have completed #'s 15 and 16!! ***

HINT for parts b) and d): You must pick a volume of one of the substances; then find moles using that volume and continue solving the problem.

- 13) Formic acid, HCOOH , is dissolved in water to produce a solution with a pH of 4.5. What is the initial concentration of the formic acid ? What is the % dissociation (ionization) of this acid ? ($K_a = 1.9 \times 10^{-4}$)
- 14) Consider the following two weak bases:
- Ethylamine, $\text{CH}_3\text{CH}_2\text{NH}_2$: $K_b = 5.6 \times 10^{-4}$
- Ethanolamine, $\text{HOCH}_2\text{CH}_2\text{NH}_2$: $K_b = 2.8 \times 10^{-5}$
- Which is the stronger base ?
 - For the stronger base, calculate the pH and the % ionization for a solution with an initial concentration of 0.500 M.
- 15) In a titration, 35.0 mL of 0.200 M acetic acid, CH_3COOH , are titrated with 0.250 M sodium hydroxide, NaOH . What is the pH at the equivalence point of the titration ? (K_a for acetic acid is 1.8×10^{-5})
- 16) Suppose 50.0 mL of 0.100 M NH_3 (aq) are mixed with 20.0 mL of 0.250 M HCl . Calculate the pH of the resulting solution. (K_b for NH_3 is 1.8×10^{-5})

17) Carbonic acid, H_2CO_3 , is the result of dissolving carbon dioxide, CO_2 , in water:



This acid is a weak diprotic acid with $K_1 = 4.4 \times 10^{-7}$ and $K_2 = 4.7 \times 10^{-11}$

a) If the initial concentration of the H_2CO_3 formed in the above reaction is 0.100 M, calculate the following: pH, the concentration of all carbon containing species, and the % ionization (or dissociation).

Consider both the first and the second dissociation in your calculations.

20) 33.0 g of ammonium sulfate, $(\text{NH}_4)_2\text{SO}_4$, are dissolved in water to give a total volume of 1.00 L. What is the pH of this solution? (K_b for NH_3 is 1.8×10^{-5})
(Hint: First write the equation for the ionization of the $(\text{NH}_4)_2\text{SO}_4$.)

21) Vitamin C, or ascorbic acid, $\text{C}_6\text{H}_8\text{O}_6$, is a diprotic acid with $K_1 = 7.9 \times 10^{-5}$ and $K_2 = 1.6 \times 10^{-12}$.

a) A solution is prepared by dissolving 10.0 g of ascorbic acid in water to give a total volume of 1.00 L. What is the pH of this solution?

b) What is the concentration of the ascorbate (the 2- ion) ion in this solution?

22) Sulfurous acid, H_2SO_3 , is a diprotic acid which may be prepared by dissolving SO_2 gas in water: $\text{SO}_2(\text{g}) + \text{H}_2\text{O}(\ell) \rightarrow \text{H}_2\text{SO}_3(\text{aq})$

a) Write an equation for the first dissociation (ionization) of H_2SO_3 .

b) A solution of sulfurous acid is prepared by dissolving 0.100 mole of SO_2 in 1.00 L of water. If the pH of this solution is 1.47, what is the percent dissociation of the H_2SO_3 ?

c) Calculate K_1 for H_2SO_3 .

d) If K_2 for this acid is 6.2×10^{-8} , what is the concentration of sulfite ion, SO_3^{2-} ?

The answers are given in the tutorial manual.