

In Class Exercise for Chapter 16

1. Calculate the pH of solutions prepared by:

(a) dissolving 0.20 g of sodium hydroxide in water to give 100.0 mL solution

$$\left(0.20 \text{ g} \times \frac{1 \text{ mol NaOH}}{39.998 \text{ g}} \times \frac{1 \text{ mol OH}^-}{1 \text{ mol NaOH}} \right) / 0.1000 \text{ L} = 0.050 \text{ M}$$

$$pH = 14 + \log [OH^-] = 12.70$$

(b) dissolving 1.26 g of pure nitric acid in water to give 0.500 L solution

$$\left(1.26 \text{ g} \times \frac{1 \text{ mol HNO}_3}{63.018 \text{ g}} \times \frac{1 \text{ mol H}^+}{1 \text{ mol HNO}_3} \right) / 0.5000 \text{ L} = 0.040 \text{ M}$$

$$pH = -\log [H^+] = 1.40$$

(c) diluting 40.0 mL of 0.075 M Ba(OH)₂ to a volume of 300.0 mL

$$\left(40.0 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.075 \text{ mol Ba(OH)}_2}{1 \text{ L}} \times \frac{2 \text{ mol OH}^-}{1 \text{ mol Ba(OH)}_2} \right) / 0.3000 \text{ L} = 0.020 \text{ M}$$

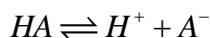
$$pH = 14 + \log [OH^-] = 12.30$$

(d) mixing equal volume of 0.20 M HCl and 0.50 M HNO₃

$$\left(1 \text{ L} \times \frac{0.20 \text{ mol HCl}}{1 \text{ L}} \times \frac{1 \text{ mol H}^+}{1 \text{ mol HCl}} + 1 \text{ L} \times \frac{0.50 \text{ mol HNO}_3}{1 \text{ L}} \times \frac{1 \text{ mol H}^+}{1 \text{ mol HNO}_3} \right) / 2 \text{ L} = 0.35 \text{ M}$$

$$pH = -\log [H^+] = 0.46$$

2. Lactic acid (C₃H₆O₃), which occurs in sour milk and foods such as sauerkraut, is a weak monoprotic acid. The pH of 0.10 M solution of lactic acid is 2.43. What is the value of K_a for this acid?

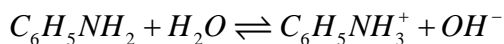


	HA	H ⁺	A ⁻
Initial	0.10	0	0
Change	-x	+x	+x
Eq	0.10 - x	+x	+x

$$pH = 2.43 \rightarrow [H^+] = 10^{-2.43} = 0.00372 \text{ M } H^+ = x$$

$$K_a = \frac{x^2}{0.10 - x} = \frac{(0.00372)^2}{0.10 - 0.00372} = 1.44 \times 10^{-4}$$

3. Aniline (C₆H₅NH₂) is an organic base used in the manufacture of dyes. Calculate the pH and concentrations of all species present in a 0.15 M solution of aniline (K_b = 4.3 × 10⁻¹⁰).



	C ₆ H ₅ NH ₂	C ₆ H ₅ NH ₃ ⁺	OH ⁻
Initial	0.15	0	0
Change	-x	+x	+x

$$K_b = \frac{x^2}{0.15 - x} = 4.3 \times 10^{-10} \quad \text{Eq} \quad \begin{array}{ccc} 0.15 - x & +x & +x \end{array} \rightarrow 4.3 \times 10^{-10} \sim \frac{x^2}{0.15}$$

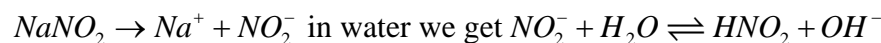
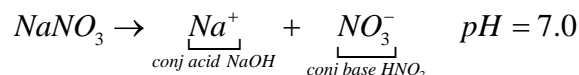
$$x = 8.03 \times 10^{-6} M \quad \text{ck assumption: } \frac{8.03 \times 10^{-6}}{0.15} \times 100\% = 0.005\% < 5\%$$

assumption is therefore valid

$$[C_6H_5NH_2] \sim 0.15 M; [C_6H_5NH_3^+] = [OH^-] = 8.03 \times 10^{-6} M$$

$$pH = 14 + \log[OH^-] = 8.90$$

4. Calculate the pH of 0.020 M solution of $NaNO_3$ (K_a is super huge). What about the pH of a 0.020 M $NaNO_2$ solution (4.5×10^{-4})?



	NO_2^-	HNO_2	OH^-
Initial	0.020	0	0
Change	-x	+x	+x
Eq	0.020 - x	+x	+x

$$K_b = \frac{K_w}{K_a} = \frac{1.0 \times 10^{-14}}{4.5 \times 10^{-4}} = 2.22 \times 10^{-11} = \frac{x^2}{0.020 - x} \sim \frac{x^2}{0.020}$$

$$x = 6.66 \times 10^{-7} M \quad \text{ck assumption: } \frac{6.66 \times 10^{-7}}{0.2} \times 100\% = 0.003\% < 5\%$$

$$pH = 14 + \log[OH^-] = 7.82$$

5. Follow the directions given below and for each case explain your reasoning.

(a) arrange each group of compounds in order of decreasing acid strength

(i) H_2O , H_2S , H_2Se

As we go down a column we increase polarizability and reduce EN
 $H_2Se > H_2S > H_2O$

(ii) $HClO_3$, $HClO$, $HClO_2$

Acidity increases with # of O-atoms: $HClO_3 > HClO_2 > HClO$

(iii) PH_3 , H_2S , HCl

Across a row from left to right we increase EN – make sure we have an acid: $HCl > H_2S > PH_3$

(b) identify the weakest acid for each set below.

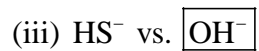
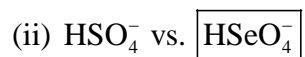
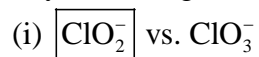
(i) H_2SO_3 , $HClO_3$, $HClO_4$ the strongest acid is $HClO_4$ since it has both the most EN central atom as well as the largest number of O-atoms; since Cl is more EN than S, $HClO_3$ is a stronger acid than H_2SO_3

(ii) NH_3 , H_2O , H_2S EN decreases going across a row from right to left

(iii) $B(OH)_3$, $Al(OH)_3$, $Ga(OH)_3$ for an oxoacid, acid strength decreases with decreasing EN of the central atom – since Ga is the least EN

Ga(OH)₃ is the weakest acid

(c) Identify the stronger base in each of the following pairs.



6. If the percent dissociation of a 0.1 M solution of HNO₃ is actually 99.6%, what is the K_a for this acid?

$$\% \text{ dissociation} = \frac{[\text{H}^+]}{[\text{HNO}_3]} \times 100\% \rightarrow 0.996 = \frac{x^2}{0.1} \rightarrow x = 0.0996M$$

$$K_a = \frac{x^2}{0.1 - x} = \frac{0.0996^2}{0.1 - 0.0996} = 24.8$$