6.6 Indicators, Neutralizations and Titrations Assignment

1. What is the approximate pH of a solution that is:

   a. yellow in methyl red, yellow in phenol red, and yellow in alizarin yellow?

   6.0-6.8

   b. yellow in methyl red, red in phenol red, and red in alizarin yellow?

   ① > 6.0 ③ > 12 ∴ pH ≥ 12.0
   ② > 8.0

2. Write **balanced** neutralization reactions for the following:

   a. the reaction between acetic acid, $HC_2H_3O_2$ and potassium hydroxide, KOH

   $HC_2H_3O_{2(aq)} + KOH_{(aq)} \rightarrow H_2O_{(l)} + KC_2H_3O_2$

   b. the reaction between nitric acid, HNO_3 and calcium hydroxide, $Ca(OH)_2$

   $2HNO_{3(aq)} + Ca(OH)_{2(aq)} \rightarrow 2H_2O + Ca(NO_3)_2$

3. If 25.00 mL of a 0.100 M NaOH solution is required to neutralize 15.00 mL of a solution of HCl, what is the molarity of the acid?

   $NaOH + HCl \rightarrow H_2O + NaCl$

   $M_A V_A = M_B V_B$

   $M_A (0.015L) = (0.1M)(0.025L)$

   $M_A = 0.167M$

4. What is the concentration of a calcium hydroxide solution, $Ca(OH)_2$, if 30.00 mL of the base is completely neutralized by 10.0 mL of 0.0200 M HCl?

   $2HCl + Ca(OH)_2 \rightarrow 2H_2O + CaCl_2$

   10mL 0.02M 30mL

   $1M_A V_A = 2M_B V_B$

   $(0.02)(0.01) = 2M_B(0.03)$

   $M_B = 0.00333M$

5. What is the molarity of a 25 mL solution of HCl that is titrated to an end point by 10 mL of a 0.200 M solution of NaOH?

$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

25mL 10mL 0.2M

$M_A V_A = M_B V_B$

$M_A(0.025L) = (0.2M)(0.01L)$

$M_A = 0.080M$

6. What is the molar concentration of a 50-mL solution of $Ba(OH)_2$ that is titrated to an end point by 15 mL of a 0.00300 M solution of HCl?

$2\,HCl(aq) + Ba(OH)_2(aq) \rightarrow BaCl_2(aq) + 2\,H_2O\,(l)$

15mL 50mL 0.003

$M_A V_A = 2M_B V_B$

$(0.003M)(0.015L) = 2M_B(0.05L)$

$M_B = 4.5 \times 10^{-4}$

7. What is the molarity of a 21 mL nitric acid solution that completely neutralizes 25.0 mL of a 0.300 M solution of NaOH?

$HNO_3(aq) + NaOH(aq) \rightarrow NaNO_3(aq) + H_2O(l)$

21mL 25mL 0.30M

$M_A V_A = M_B V_B$

$M_A(0.021L) = (0.30M)(0.025L)$

$M_A = 0.36M$

8. What is the molar concentration of a 45.0 mL solution of KOH that is completely neutralized by 15.0 mL of a 0.500 M H_2SO_4 solution?

$H_2SO_4 + 2\,KOH \rightarrow K_2SO_4 + 2\,H_2O$

15mL 45mL 0.5M

$2M_A V_A = M_B V_B$

$2(0.5M)(0.015L) = M_B(0.045L)$

$M_B = 0.333M$

9. A neutral solution is produced when 42.00 mL of a 0.150 M NaOH solution is used to titrate 50.00 mL of a sulfuric acid (H_2SO_4) solution. What is the concentration of the sulfuric acid solution before titration?

$H_2SO_4 + 2\,NaOH \rightarrow Na_2SO_4 + 2\,H_2O$

0.05L 0.15M
0.042L

$Y M_A V_A = X M_B V_B$

$2 M_A (0.05L) = (0.15)(0.042)$

$M_A = 6.30 \times 10^{-2} M$

1 : 1

$NaOH + HCl \rightarrow H_2O + NaCl$

10. 0.080 moles of solid NaOH are added to 0.1L of a 1M HCl solution. Which reactant is in excess? Determine the $[H^+]$ and $[OH^-]$ at equilibrium.

moles acid: $n = MV = (0.1L)(1M) = 0.1$ moles

∴ acid is in excess $(0.1 > 0.08)$

acid in excess: $0.1 - 0.08$ moles $= 0.02$ moles

$HCl \rightarrow H^+ + Cl^-$

$[HCl] = \frac{n}{V} = \frac{0.02 mol}{0.1L} = 0.2M = [H^+]$

$K_w = [H^+][OH^-]$:

$1.0 \times 10^{-14} = (0.2M)[OH^-] \rightarrow [OH^-] = 5 \times 10^{-14}$

11. Calculate the pOH resulting from mixing 75.0mL of 0.200M HBr with 225.0 mL of 0.150M KOH.

moles acid: $n = MV = (0.075L)(0.2M) = 0.015 mol\ HBr$

base: $n = MV = (0.225L)(0.15M) = 0.03375\ KOH$

$HBr + KOH \rightarrow H_2O + KBr$

∴ base is in excess

$0.3375 - 0.015 = 0.01875 mol$

$[KOH] = M = \frac{n}{V} = \frac{0.01875 mol}{0.3L} = 0.0625M = [OH^-]$

$pOH = -\log[OH^-] = -\log(0.0625M)$

$pOH = 1.20$