Name: ICE Official Class: _____ Date: _____

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Titration Calculations

YOYO: Using Table K and L, write the complete neutralization reaction for the following reactants

1. Carbonic acid and potassium hydroxide. H_2CO_3 KOH K^{+1} CO_3^{-2} $H_2CO_3 + 2KOH \rightarrow K_2CO_3 + 2H_2O$

$1\ H_2CO_3 + 2\ KOH \rightarrow 1\ K_2CO_3 + 2\ HOH$

2. Phosphoric acid and sodium hydroxide

$H_3PO_4 + 3NaOH \rightarrow Na_3PO_4 + 3\ HOH$

Na^{+1} PO_4^{-3} $H_3PO_4 + 3NaOH \rightarrow Na_3PO_4 + 3\ H_2O$

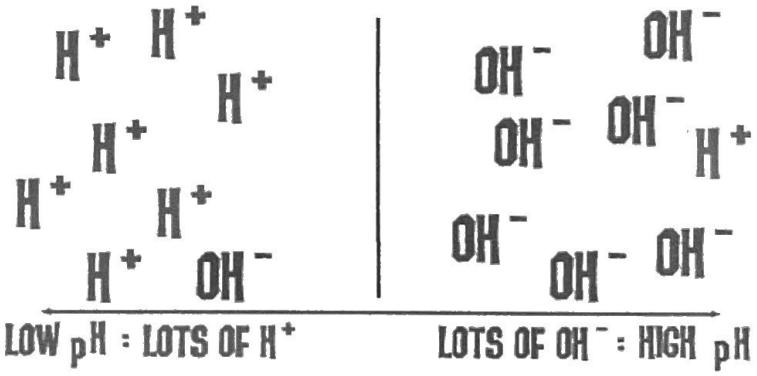
Types of Acids and Bases

protic - proton - H^+

- HCl produces 1 hydrogen and is called monoprotic acid
- H_2SO_4 produces 2 hydrogens and is called diprotic acid
- H_3PO_4 produces 3 hydrogens and is called triprotic acid
- NaOH has 1 hydroxide group and is called monohydroxy base

Concentration: Molarity (Table T)

- 1 M of HCl gives off 1 mole H+/ liter
- 2 M of HCl gives off 2 moles H+/ liter
- 1 M of H_2SO_4 gives off 2 moles of H+/liter
- 2 M of H_2SO_4 gives off 4 moles of H+/ liter



You try

- 1 M NaOH gives off 1 mole of OH-/ liter
- 2 M NaOH gives off 2 mole of OH-/ liter
- 2 M $Ca(OH)_2$ gives off 4 mole OH- liter

Titration

- Titration is used to find the molarity of an unknown acid or base.
- $M_aV_a = M_bV_b$
- This is done by adding measured volumes of an acid or base of known molarity to a base or acid of unknown molarity until neutralization occurs
- Neutralization is when the number of H^+ and OH^- are equal and the pH is 7, this is also known as equivalent point.
- An acid-base indicator is used to show when neutralization has occurred.
- The point of neutralization is the endpoint of the titration.

Sample Titration Problems

Sample #1: What is the concentration of a 30 ml sample of HCl if it can be neutralized by 50 ml of 1.2 M of NaOH?

$M_aV_a = M_bV_b$

Ma ?
Va 30mL
H: 1
Mb 1.2M
Vb 50mL
OH: 1

$1\ M_a(30mL) = (1.2M)(50mL)$

$\frac{M_a(30)}{30} = \frac{60}{30}$

$M_a = 2M$

Sample #2: How many milliliters of 3.0 M of H_2SO_4 are needed to neutralize 50 ml of 1.2 M $Al(OH)_3$?

Ma 3M
Va ?
H^+ 2
Mb 1.2M
Vb 50mL
OH 3

$(3)V_a(2) = (1.2)(50)(3)$

$\frac{6V_a}{6} = \frac{180}{6}$

$V_a = 30mL$

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Practice

1. Determine the concentration of H_3PO_4 if a 90. ml sample is neutralized by 30. ml of 0.9 M $Ca(OH)_2$.

Ma ? Mb 0.9 (Ma)(90)(3) = (0.9)(30)(2)

Va 90 Vb 30 $\frac{Ma\ 270}{270} = \frac{54}{270}$

H+ 3 OH- 2

Ma = 0.2 M

2. How much 6.0 M HNO_3 is needed to neutralize 39 ml of 2.0 M KOH?

Ma 6.0 M Mb 2 (6)(Va)(1) = (2)(39)(1)

Va ? Vb 39 mL $\frac{6Va}{6} = \frac{78}{6}$

H+ 1 OH- 1

Va = 13 mL

3. How much 3.0 M NaOH is needed to neutralize 30 ml of .75 M H_2SO_4?

Ma 0.75 M Mb 3.0 M (0.75)(30)(2) = (3)Vb (1)

Va 30 mL Vb ? $\frac{45}{3} = \frac{3Vb}{3}$

H+ 2 OH- 1

15 mL = Vb

4. What is the concentration of 20 ml of LiOH if it is neutralized by 60 ml of 4 M HCl?

Ma 4 Mb ? (4)(60)(1) = Mb(20)(1)

Va 60 Vb 20 mL $\frac{240}{20} = \frac{20Mb}{20}$

H+ 1 OH- 1

12 M = Mb

5. What is the concentration of 60 ml of H_3PO_4 if it is neutralized by 225 ml of 2 M $Ba(OH)_2$?

Ma ? Mb 2M (Ma)(60)(3) = (2)(225)(2)

Va 60 mL Vb 225 mL $\frac{Ma\ 180}{180} = \frac{900}{180}$

H+ 3 OH- 2

Ma = 5 M

6. How much 2 M HBr is needed to neutralize 380 ml of 0.1 M NH_4OH?

Ma 2M Mb 0.1M (2)(Va)(1) = (0.1)(380)(1)

Va ? Vb 380 mL $\frac{2Va}{2} = \frac{38}{2}$

H+ 1 OH- 1

Va = 19 mL

7. You have 50 mL of 1.0 M H_2SO_4(aq). What volume of 0.5 M NaOH would be required to neutralize the acid?

Ma 1M Mb 0.5M (1)(50)(2) = (.5)(Vb)(1)

Va 50mL Vb mL $\frac{100}{.5} = \frac{.5Vb}{.5}$

H+ 2 OH- 1

Vb = 200 mL

8. A acid has an H+ concentration of 0.1 M and a volume of 100 mL. What volume of a base with a 0.5 M [OH-] will be required to neutralize the reaction?

Ma 0.1M Mb 0.5M (0.1)(100) = (0.5)Vb

Va 100mL Vb ? $\frac{10}{0.5} = \frac{0.5Vb}{0.5}$

H+ 1 OH- 1

20 mL = Vb