Titration

Titration is a process that uses a neutralization reaction to determine the concentration of an acid or a base. Concentration, remember, is the mass of the solute per unit volume of solution. Chemists measure concentration in moles per liter or molarity (*M*).For acids and bases that produce the same number of hydrogen and hydroxide ions per mole [HCl and NaOH, H_2SO_4 and $Ca(OH)_2$, or H_3PO_4 and $Al(OH)_3$], the molarity of the acid used in a neutralization times its volume is equal to the molarity of the base used in the neutralization times its volume.

$$M_a \times V_a = M_b \times V_b$$

For acids and bases that do not produce hydrogen ions and hydroxide ions in a 1 to 1 ratio, it is necessary to calculate the effective concentration before applying the formula. See below:

Effective Concentration

$$M_{AE} = M_A \times n_H$$

M_{AE} = effective concentration of acid
M_A = concentration of acid
n_H = number of hydrogens

NOTE: $\mathbf{M_A = \frac{M_{AE}}{n_H}}$

$$M_{BE} = M_B \times n_{OH}$$

M_{BE} = effective concentration of base
M_B = concentration of base
n_{OH} = number of hydroxides

NOTE: $\mathbf{M_B = \frac{M_{BE}}{n_{OH}}}$

Sample Problems

Sample Problem 1

What is the concentration of a 30. mL sample of HCl if it can be neutralized by 50. mL of 1.2 M NaOH?

Step 1: Note the ratio of H^+ to OH^- is 1 to 1

Step 2: Substitute values into the equation

$\mathbf{M_A \times V_A = M_B \times V_B}$
$M_A(30.\ mL) = (1.2\ M)(50.\ mL)$

Step 3: Solve for the unknown

$$\mathbf{M_A = \frac{(1.2M)(50.mL)}{(30.mL)} = 2.0M}$$

Sample Problem 2

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

Step 1: Determine the effective concentration of the known substance

$0.9\ M \times 2 = 1.8\ M$

Step 2: Substitute values into the equation and solve for the unknown

$\mathbf{M_A \times V_A = M_B \times V_B}$
$M_A(90.\ mL) = (1.8\ M)(30.\ mL)$
$M_A = 0.6\ M$

Step 3: Determine the actual concentration of the unknown from the effective concentration

$$\mathbf{M_A = \frac{M_{AE}}{n_H}} = \frac{0.6M}{3} = 0.2M$$

Sample Problem 3

How much 3.0 M H_2SO_4 is needed to neutralize 50. mL of 1.2 M $Al(OH)_3$?

Step 1: Determine the effective concentrations of the substances

$M_A = 3.0\ M \times 2 = 6.0\ M$
$M_B = 1.2\ M \times 3 = 3.6\ M$

Step 2: Substitute values into the equation and solve for the unknown

$\mathbf{M_A \times V_A = M_B \times V_B}$
$(6.0\ M)\ V_A = (3.6\ M)(50.\ mL)$
$V_A = 30.\ mL$

Continue ☞

Answer the questions below by referring to the examples on the previous page. Write the answer in the answer space to the left of the question.

_____ **1.** How much 6.0 M HNO_3 is needed to neutralize 39 mL of 2.0 M KOH?

_____ **2.** How much 3.0 M NaOH is needed to neutralize 30. mL of 0.75 M H_2SO_4?

_____ **3.** What is the concentration of 20 mL of LiOH if it is neutralized by 60 mL of 4 M HCl?

_____ **4.** What is the concentration of 60 mL of H_3PO_4 if it is neutralized by 225 mL of 2 M $Ba(OH)_2$?

_____ **5.** How much 2 M HBr is needed to neutralize 380 mL of 0.1 M NH_4OH?

The answers to the questions above are all integers. Each answer stands for a letter of the alphabet. Write the correct letters in the spaces below to find the solution to the riddle.

ANSWERS:	1	2	3	4	5	6	7	8	9	10	11	12	13
LETTERS:	A	B	C	D	E	F	G	H	I	J	K	L	M
ANSWERS:	14	15	16	17	18	19	20	21	22	23	24	25	26
LETTERS:	N	O	P	Q	R	S	T	U	V	W	X	Y	Z

RIDDLE: How many varmints does it take to ruin a chemist's lawn?

SOLUTION: _____ _____ _____ _____ _____

Question 1 Question 2 Question 3 Question 4 Question 5