Four Easy Steps To Solve: Neutralization (Titration) Problems and Always Get Them Correct!!

A neutralization, or titration, reaction involves reacting an acid with a base to produce a salt and water.

$$\underset{\text{Acid}}{CH_3COOH} + \underset{\text{Base}}{NaOH} \rightarrow \underset{\text{Water}}{HOH} + \underset{\text{Salt}}{NaCH_3COO}$$

These reactions are carried out in order to determine the concentration of a solution. A solution of known concentration, known as the standard solution, is slowly added to the solution of unknown concentration until neutralization occurs. Neutralization is said to occur when the acid and base have the same numbers of moles present in the combined solution. At this point both the acid and the base stop exhibiting their characteristic behaviours (they will, however, continue to be conductors of electricity).

Eg.1. 15.0 mL of 0.500 M NaOH is used to neutralize 25.0 mL of an acetic acid, CH_3COOH, solution of an unknown concentration. What is the concentration of the acetic acid?

Step 1 **- write a balanced equation**

$$CH_3COOH + NaOH \rightarrow HOH + NaCH_3COO$$

Step 2 **- calculate the number of moles of the standard solution present in the solution.**

$$15.0\text{mL} \times \frac{1\text{L}}{1000\text{ mL}} \times \frac{0.500\text{ moles NaOH}}{1\text{L}} = 0.0075\text{ moles NaOH}$$

Step 3 **- use the molar relationship from the equation to convert from moles of standard solution into moles of unknown solution**

$$0.0075\text{ moles NaOH} \times \frac{1\text{ mole } CH_3COOH}{1\text{ mole NaOH}} = 0.0075\text{ moles } CH_3COOH$$

Step 4 **-calculate the number of moles of the unknown present in the solution.**

$$\text{Concentration} = \frac{\text{number of moles}}{\text{volume}} = \frac{0.0075\text{ moles}}{0.025\text{ L}} = 0.300\text{ M } CH_3COOH$$

E.g. 2. How many mL of 0.200 M KOH will exactly neutralize 15.0 mL of 0.400 M H_2SO_4?

1 $H_2SO_4 + 2\,KOH \rightarrow 2HOH + K_2SO_4$

2 $15.0\ mL \times \frac{1L}{1000mL} \times \frac{0.400\ moles\ H_2SO_4}{1L} = 0.00600\ moles\ H_2SO_4$

3 $0.00600\ moles\ H_2SO_4 \times \frac{2\ mole\ KOH}{1\ mole\ H_2SO_4} = 0.0120\ moles\ KOH$

4. $concentration = \frac{number\ of\ moles}{volume}$

$0.200\ M = \frac{0.0120\ moles\ KOH}{volume}$

$volume = \frac{0.0120\ moles\ KOH}{0.200\ M}$

volume = 0.0600 L or 60 mL

Try these problems ...

1. How many mL of 0.0947 M NaOH are needed to neutralize 21.4 mL of 0.106 M HCl?

24.0 mL NaOH

2. If 75.0 mL of 0.823 M $HClO_4$ require 95.5 mL of $Ba(OH)_2$ for complete neutralization, what is the concentration of the $Ba(OH)_2$ solution?

0.323 M $Ba(OH)_2$

3. If 40.8 mL of 0.106 M H_2SO_4 neutralize 50.0 mL of KOH solution, find the concentration of the base?

0.173 M KOH

4. If 26.4 mL of LiOH solution are required to neutralize 21.7 mL of 0.500 M HBr, what is the concentration of the basic solution?

0.411 M LiOH