KEY

# Titrations Practice Worksheet

*Find the requested quantities in the following problems:*

1) If it takes 54 mL of 0.1 M NaOH to neutralize 125 mL of an HCl solution, what is the concentration of the HCl?

$M_1 = 0.1\ M$
$V_1 = 54\ mL$
$M_2 = ?$
$V_2 = 125\ mL$

$M_1V_1 = M_2V_2$

$(0.1\ M)(54\ mL) = (125\ mL)M_2$

$M_2 = \frac{(0.1\ M)(54\ mL)}{125\ mL} = 0.0432\ M = 4.32 \times 10^{-2}\ M$

The concentration of HCl is $4.32 \times 10^{-2}$ M.

2) If it takes 25 mL of 0.05 M HCl to neutralize 345 mL of NaOH solution, what is the concentration of the NaOH solution?

$M_1 = 0.05\ M$
$V_1 = 25\ mL$
$M_2 = ?$
$V_2 = 345\ mL$

$M_1V_1 = M_2V_2$

$(0.05\ M)(25\ mL) = (345\ mL)M_2$

$M_2 = \frac{(0.05\ M)(25\ mL)}{345\ mL} = 0.00362\ M = 3.62 \times 10^{-3}\ M$

The concentration of NaOH is $3.62 \times 10^{-3}$ M.

3) If it takes 50 mL of 0.5 M KOH solution to completely neutralize 125 mL of sulfuric acid solution ($H_2SO_4$), what is the concentration of the $H_2SO_4$ solution?

$H^+ : OH^-$ is 2:1

$n = MV$

$n = (0.5\ M)(50\ mL) = 25\ mol\ OH^-$

2 times $[OH^-]$ is needed to neutralize $[H^+]$. $\rightarrow [H^+] = \frac{1}{2}[OH^-]$

$[H^+] = \frac{25\ mol}{2} = 12.5\ mol\ H^+$ needed

$M = \frac{12.5\ mol}{125\ mL} = \boxed{0.10\ M}$

4) Can I titrate a solution of unknown concentration with another solution of unknown concentration and still get a meaningful answer? Explain your answer in a few sentences.

Titration cannot be done without molality of at least one of the substances. In order to solve $M_1V_1 = M_2V_2$, both molarities cannot be unknown.

5) Explain the difference between an endpoint and equivalence point in a titration.

Endpoint: titration can be stopped.
Equivalence point: when $[H^+]$ and $[OH^-]$ are neutralized.

The effectiveness of a titration is measured by the closeness of the end point to the equivalence point.

KEY

6) How many moles of LiOH are needed to exactly neutralize 2.0 moles of $H_2SO_4$?

1 mol $H_2SO_4$ dissociates into 2 mol $H^+$ ions
For 2 mol $H_2SO_4$, there are 4 mol $H^+$ ions

4 mol $H^+$ needs 4 mol $OH^-$

**4 mol LiOH are needed.**

7) How many moles of $H_2SO_4$ are needed to exactly neutralize 5.0 moles of NaOH?

1 mol NaOH dissociates into 1 mol $OH^-$ ions
For 5 mol NaOH, there are 5 mol $OH^-$ ions

$\frac{1}{2}(5\text{ mol}) = 2.5\text{ mol}$

1 mol $H_2SO_4$ dissociates into 2 mol $H^+$ ions.
Need ½ of the $[OH^-]$ to neutralize $H^+$

**2.5 mol $H_2SO_4$ needed**

8) How many moles of HCl are needed to neutralize 0.10 L of 2.0 M NaOH?

1 mol NaOH dissociates into 1 mol $OH^-$; 1 mol HCl dissociates into 1 mol
Find mol of $OH^-$:

$n = MV = (2.0\text{M})(0.10\text{L})$
$n = 0.20\text{ mol}$

**0.20 mol of HCl needed.**

9) How many moles of NaOH are needed to neutralize 0.010 L of 0.20 M $H_2SO_4$?

1 mol NaOH dissociates into 1 mol $OH^-$ | 1 mol $H_2SO_4$ dissociates into 2 mol $H^+$
Find mol of $H^+$ ions | For 0.0040 mol $H^+$ ions, need 0.0040 mol $OH^-$ ions

$n = MV = (0.20\text{M})(0.010\text{L})$
$n = 0.0020\text{ mol } H_2SO_4$
↳ gives $2(0.0020)$ $H^+$ ions

**0.0040 mol NaOH ions needed.**

10) If it takes 15.0 mL of 0.40 M NaOH to neutralize 5.0 mL of HCl, what is the molar concentration of the HCl solution?

$M_1 = 0.40\text{M}$
$V_1 = 15.0\text{mL}$
$M_2 = ?$
$V_2 = 5.0\text{mL}$

$M_1V_1 = M_2V_2$
$(0.40\text{M})(15.0\text{mL}) = (5.0\text{mL})(M_2)$
$M_2 = \frac{(0.40\text{M})(15.0\text{mL})}{5.0\text{mL}} = 1.2\text{ M}$

**The molar concentration of HCl is 1.2M.**

11) If it takes 10.0 mL of 2.0 M $H_2SO_4$ to neutralize 30.0 mL of KOH, what is the molar concentration of the KOH?

1 mol $H_2SO_4$ dissociates into 2 mol $H^+$

$n = MV = (2.0\text{M})(10.0\text{mL}) = 20\text{ mol}$
20 mol of $H_2SO_4$ → 40 mol $H^+$
need 40 mol $OH^-$

1 mol KOH dissociates into 1 mol $OH^-$

$n = MV$
$40\text{ mol} = M(30.0\text{mL})$
$M = \frac{40\text{ mol}}{30\text{ mL}} =$ **1.33 M KOH**

12) How many mL of 2.0 M $H_2SO_4$ are required to neutralize 30.0 mL of 1.0 M NaOH?

1 mol $H_2SO_4$ dissociates into 2 mol $H^+$

$n = MV = (1.0\text{M})(30.0\text{mL}) = 30.0\text{mol}$
30 mol NaOH → 30 mol $OH^-$
need 30 mol $H^+$ → $\frac{1}{2}(30\text{ mol})\ H_2SO_4$

1 mol NaOH dissociates into 1 mol $OH^-$

$n = MV$
$15.0\text{mol} = (2.0\text{ M})V$
$V = \frac{15.0\text{mol}}{2.0\text{M}} =$ **7.5mL $H_2SO_4$ needed**

13) How many mL of 0.10 M $Ca(OH)_2$ are required to neutralize 25.0 mL of 0.50 M $HNO_3$? 1 mol $Ca(OH)_2$ dissociates into 2 mol $OH^-$ | 1 mol $HNO_3$ → 1 mol $H^+$

$n = MV = (0.50\text{M})(25.0\text{mL})$
$n = 12.50\text{ mol } HNO_3$
↓
12.50 mol $H^+$ = 12.50 mol $OH^-$

12.50 mol $OH^-$ comes from
$\frac{1}{2}(12.50\text{ mol})\ Ca(OH)_2$

need 6.25 mol $Ca(OH)_2$

$n = MV$
$6.25\text{ mol} = (0.10\text{M})(V)$
$V = \frac{6.25\text{ mol}}{0.10\text{M}} =$ **62.5 mL $Ca(OH)_2$**