Acid- Base Titrations

An acid-base titration is a quantitative reaction (complete - not equilibrium) between an acid and a base. Either the acid is strong, or base is strong, and often both are.

A titration is performed to determine an unknown variable with respect to the acid or the base, usually concentration. All other variables will be known.

A titration is a special double replacement reaction where **the acid and base neutralize** each other. A classic example would be:

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

All strong acid - strong base neutralization reactions produce H_2O and a "salt"

Example:

$3HNO_3\ (aq) + Al(OH)_3\ (aq) \rightarrow Al(NO_3)\ (aq) + 3HOH(l)$

SA SB Salt Water

This is **not** an example of an acid-base neutralization:

$H_2SO_4(aq) + 2NaNO_3(aq) \rightarrow Na_2SO_4(aq) + 2HNO_3(aq)$

WHY? There is no water produced!

Stoichiometric calculations can be performed to determine one of :

1) molarity of the acid or base
2) volume of the acid or base
3) extensions to include pH or pOH

A typical question could be:

27.6 mL of 0.15 M of LiOH completely neutralized 34.8 mL of HCl. Calculate the concentration of HCl used.

$LiOH\ (aq) + HCl\ (aq) \rightarrow LiCl\ (aq) + HOH\ (l)$

27.6 mL 34.8mL

0.15 M C = ?

$n = Cv$

$= (0.15M)\ (0.0276L)$

$= 0.00414$

n (wanted) = n (given) x wanted/given

= 0.00414 mol x 1/1

= 0.00414 mol

$C = n/v$

$= \frac{0.00414\ mol}{0.0348\ L}$

$= 1.2 \times 10^{-1}$ M

(For a quickie multiple choice answer in a 1:1 mol ratio, use $C_a v_a = C_b v_b$)

Example #2 A solution of KOH has a pH of 8.5. It is neutralized when 68.3 mL of sulfuric acid is mixed with it. If the pH of the acid was 5.3, calculate the volume of the base.

$2KOH\ (aq) + H_2SO_4(aq) \rightarrow 2HOH\ (l) + K_2SO_4\ (aq)$
pH = 8.5 pH = 5.3
v=68.3mL
We need concentrations to find moles to find mole ratio to find volume.

$pH = -\log [\ H_2SO_4]\ (x\ 2)$
$[\ H_2SO_4] = 10^{-pH} \times ½$ (mole ratio because there are 2 H)
$[\ H_2SO_4] = 10^{-5.3} \times ½$
$= 5.01 \times 10^{-6} \times ½$
$= 2.51 \times 10^{-6}$ mol/L

$pOH = -\log [KOH]$
$[KOH] = 10^{-pOH}$
$= 10^{-5.5}$
$= 3.16 \times 10^{-6}$ M

Next we need to find the number of moles of H_2SO_4 for the mole ratio equation:

$n = Cv$
$= (2.51 \times 10^{-6}$ mol/L) (0.0683L)
$= 1.71 \times 10^{-7}$ mol

Now our mole ratio equation

n of KOH (wanted) = n of H_2SO_4 (given) x 2/1
$= 1.71 \times 10^{-7} \times 2/1$
$= 3.42 \times 10^{-7}$ mol

Now we can find the volume
$v = n/C$
$= \dfrac{3.42 \times 10^{-7}\ \text{mol}}{3.16 \times 10^{-6}\ \text{mol/L}}$

$= 0.108$ L
$= 0.1$ L

(Whew! That one was wicked, they're not all that bad!)