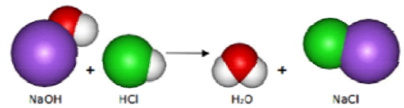
Neutralization and pH



Complete Neutralization

When acids and bases are added together, they neutralize each other properties. This involves reacting an acid with a base (e.g. $HCl + NaOH \rightarrow NaCl + H_2O$ or $H_2SO_4 + Mg(OH)_2 \rightarrow MgSO_4 + 2\ H_2O$). In every case, a neutralization is essentially: **acid + base → salt + water** which makes sense because if you work out the net ionic equation you get $\mathbf{H^+ + OH^- \rightarrow H_2O}$ and a salt is produced when all the Hs of an acid are completely replaced by metal(s). With complete neutralization, the moles of H^+ from the acid equals moles of OH^- from the base ($n_{H^+} = n_{OH^-}$).

e.g. 35 mL of 0.25 M NaOH solution is neutralized by 20 mL of a HCl solution. Calculate the concentration of the acid.

i) determine moles of H^+ and OH^- present:

- $NaOH_{(aq)} \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$ thus 1 mole of NaOH delivers 1 mole of OH^-
- thus $n_{OH^-} = (\#_{OH^-\ from\, base})M_BV_B$ = (1)(0.035 L)(0.25 mol/L) = 8.75×10^{-3} moles
- which equals the moles of H^+ used to completely neutralize the OH^-

ii) calculate concentration of acid:

- $HCl \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$ 1 mole of HCl delivers 1 mole of H^+
- thus $n_{H^+} = (\#_{H^+\ from\, acid})M_AV_A$
- $8.75 \times 10^{-3} = (1)M_A(0.02\ L)$ and thus $M_A = 8.75 \times 10^{-3}/0.02 = 0.4375$ M

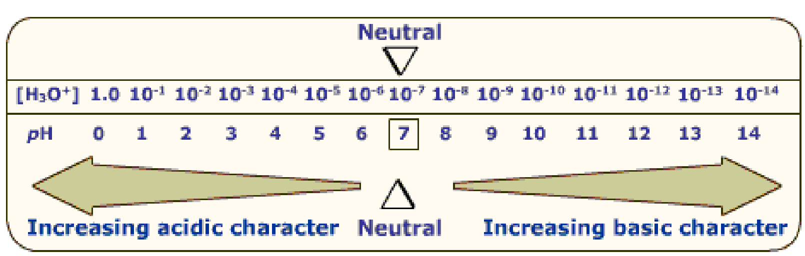
So you can solve these types of questions stoichiometrically (use the balanced chemical equation) or you can break them down as I did above **or** you could just put it all together and solve the following complete neutralization equation (try it using the question above).

$$\boxed{\#_{H^+} M_AV_A = \#_{OH^-} M_BV_B}$$

pH

It is often difficult to quantify the degree of acidity/basicity of a solution since it depends on strength, concentration and solubility of the chemicals. The pH scale was invented in 1909 by the Danish chemist Soren Sorensen for a brewery to measure the real, final acidity of beer. He introduced the pH scale to accommodates strength, concentration and solubility by measuring the actual concentration of hydrogen ions $[H^+]$ in a solution. This scale works for both acids and bases, because in any solution there is always H^+ and OH^- present because water breaks down to form small amounts of these ions. In neutral water, at SATP, the concentration of H^+equals the concentration of OH^- which equals 1×10^{-7} mol/L which means there is 1 of these ions present for every 10 million water molecules (hence, 1 out of 10×10^6 or $1/(10 \times 10^6)$). To convert this to pH, take the -log of the H^+ concentration (so pH = -log$[H^+]$). So for neutral water, pH = -log(1×10^{-7}) = 7. The (-) converts these small concentrations into positive numbers to make them easier to deal with, but means that the pH scale is inverse to ion concentration; that is, the lower the concentration of H^+, the higher the pH value (recall that the negative exists in the first place because the concentration of these ions (in neutral water for example is 1 out of 10×10^6 water molecules = 1×10^{-7} mol/L).

In an acid, there is additional H^+ in the solution from the acid, so the $[H^+]$ increases and is > 1×10^{-7} mol/L. Thus, the pH < 7. In reality, since there is always H^+ and OH^- present , in acid the $[H^+] > [OH^-]$. In base, $[H^+]$ decreases and is < 1×10^{-7} mol/L which means the pH > 7 and the $[H^+] < [OH^-]$. Note that sometimes, alkalinity is used to mean base, but an alkaline base is one in which the metal is specifically an alkaline metal or alkaline earth metal and all other metals only form bases. Also, note that the proticity of an acid affects its final pH because each molecule of acid produces multiple H^+ in water so the $[H^+]$ will be a multiple of the acid concentration.



The pH scale is logarithmic and as a result, each whole pH value below 7 is ten times more acidic than the next value. For example, pH 4 is ten times more acidic than pH 5 and 100 times (10 times 10) more acidic than pH 6. The same holds true for pH values above 7, each of which is ten times more basic than the next lower whole value. For example, pH 10 is ten times more alkaline than pH 9 and 100 times (10 times 10) more alkaline than pH 8.