Acids, Bases and Neutralization

Arrhenius: Acid is a substance that produces H_3O^+ when dissolved in water

$$HCl(g) + H_2O \rightarrow H_3O^+(aq) + Cl^-(aq)$$

Base is a substance that produces OH^- in water

$$NaOH(s) \xrightarrow{H_2O} Na^+(aq) + OH^-(aq)$$

Bronsted: Acid is a substance that donates H^+

Base is a substance that accepts H^+

$$HCl(g) + NH_3(g) \rightarrow NH_4Cl(s)$$

Strong acids : Completely dissociate in water

$$HCl(g) + H_2O(\ell) \longrightarrow H_3O^+(aq) + Cl^-(aq)$$

Weak Acids : Dissociate incompletely

$$HF(g) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + F^-(aq)$$

Strong Base : completely dissociate (alkaline metal hydroxides)

$$NaOH \xrightarrow{H_2O} Na^+(aq) + OH^-(aq)$$
$$KOH \xrightarrow{H_2O} K^+(aq) + OH^-(aq)$$

Weak Base : dissociate incompletely

$$NH_3(g) + H_2O(\ell) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

often H_2O is left out of equation

$$HCl(aq) \longrightarrow H^+(aq) + Cl^-(aq)$$
$$HF(aq) \rightleftharpoons H^+(aq) + F^-(aq)$$

Amphiprotic: can accept or donate protons

$HCl(g) + H_2O(\ell) \rightarrow Cl^-(aq) + H_3O^+(aq)$

H_2O accepts a proton (base)

$NH_3(g) + H_2O(\ell) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$

H_2O donates a proton (acids)

strong acid

$HPO_4^{2-}(aq) + H^+(aq) \longrightarrow H_2PO_4^-(aq)$

(base)

$HPO_4^{2-}(aq) + OH^-(aq) \longrightarrow PO_4^{3-}(aq) + H_2O(\ell)$

(acid)

$HCO_3^-(aq) + H^+(aq) \rightarrow H_2CO_3(aq) \rightarrow H_2O(\ell) + CO_2(g)$

(base)

$HCO_3^-(aq) + OH^-(aq) \rightarrow CO_3^{2-}(aq) + H_2O(\ell)$

(acid)

Autoionization of water:

$H_2O(\ell) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$

(base) (acid)

Strong acids derived from hydrogen halogens

HCl : hydrochloric acid

$HBr(aq) \longrightarrow H^+(aq) + Br^-(aq)$ hydrobromic acid

$HI(aq) \longrightarrow H^+(aq) + I^-(aq)$ hydroiodic acid

Nitric Acid

$3NO_2(g) + H_2O(g) \rightarrow NO(g) + 2HNO_3(e)$

$HNO_3(aq) \longrightarrow H^+(aq) + NO_3^-(aq)$

Sulfuric Acid

$SO_3(g) + H_2O(g) \rightarrow H_2SO_4(e)$

$H_2SO_4(aq) \rightarrow H^+(aq) + HSO_4^-(aq)$

HSO_4^- can further hydrolyze

$HSO_4^-(aq) \rightleftharpoons H^+(aq) + SO_4^{2-}(aq)$

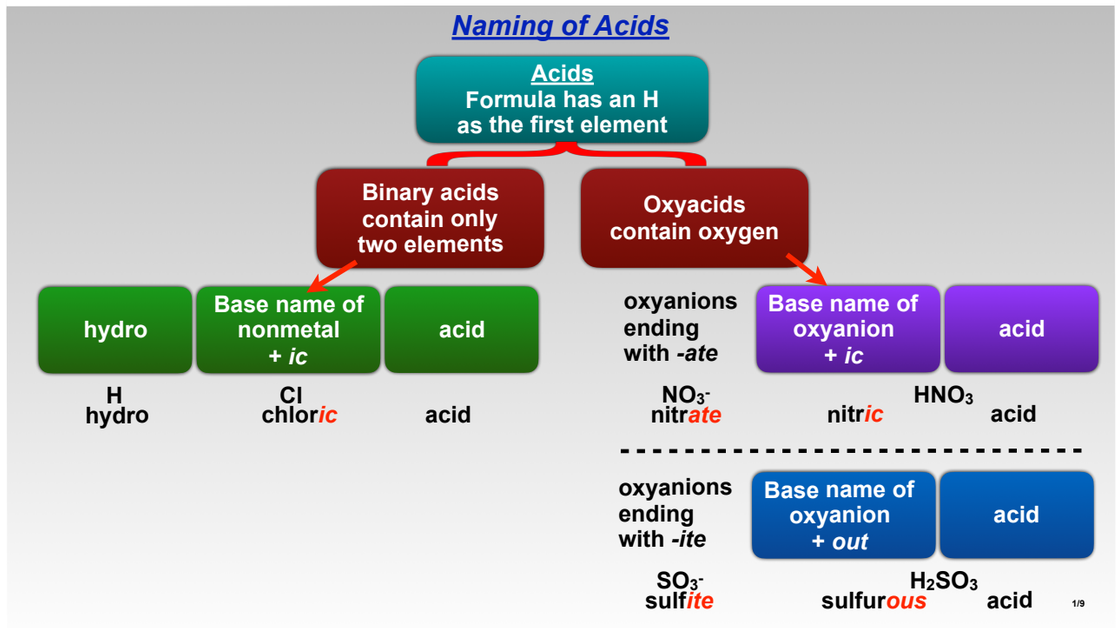
acid strength $H_2SO_4 >> HSO_4^-$

Phosphoric acid (not strong)

$H_3PO_4(aq) \rightleftharpoons H_2PO_4^-(aq) + H^+(aq)$

$H_2PO_4^-(aq) \rightleftharpoons HPO_4^{2-}(aq) + H^+(aq)$

$HPO_4^{2-}(aq) \rightleftharpoons PO_4^{3-}(aq) + H^+(aq)$



$HClO_4 \rightarrow ClO_4^-(aq) + H^+(aq)$ perchloric acid

$HClO_3 \rightarrow ClO_3^-(aq) + H^+(aq)$ chloric acid

$HBrO_3 \rightarrow BrO_3^-(aq) + H^+(aq)$ bromic acid

$HNO_2 \rightleftharpoons H^+(aq) + NO_2^-(aq)$ nitrous acid

$H_2CO_3 \rightleftharpoons H^+(aq) + HCO_3^-$ carbonic acid

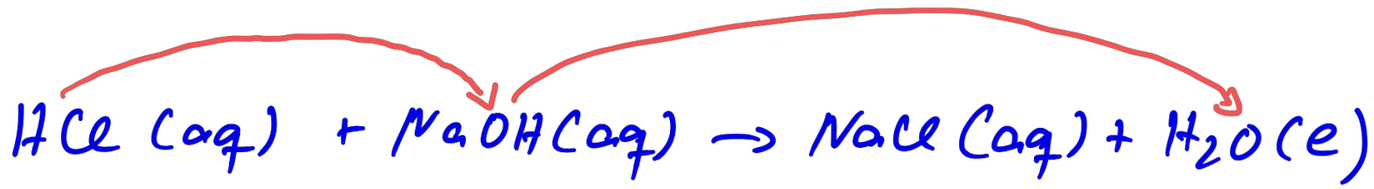
$H_3PO_3 \rightleftharpoons PO_3^{3-}(aq) + 3H^+(aq)$ phosphorous acid

(3 steps)

$H_2CrO_4 \rightleftharpoons CrO_4^{2-}(aq) + 2H^+(aq)$ chromic acid

(2 steps)

Neutralization: H^+ and OH^- combine to form H_2O:



$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(\ell)$$

Complete Ionic:

$$H^+(aq) + Cl^-(aq) + Na^+(aq) + OH^-(aq) \rightarrow$$

$$Na^+(aq) + Cl^-(aq) + H_2O(\ell)$$

Net Ionic:

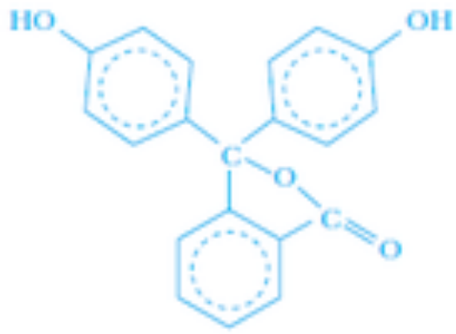
$$H^+(aq) + OH^-(aq) \rightarrow H_2O(\ell)$$

$$2HI(aq) + Ba(OH)_2(aq) \rightarrow 2H_2O(\ell) + BaI_2(aq)$$

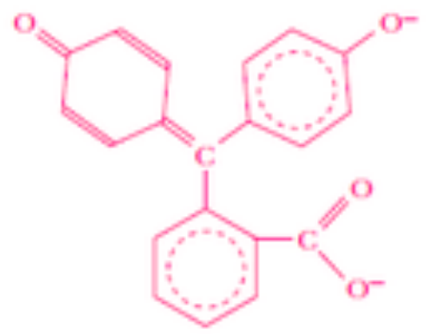
$$2H^+(aq) + 2OH^-(aq) \rightarrow 2H_2O(\ell)$$

$$H_2SO_4(aq) + 2LiOH(aq) \rightarrow 2H_2O(\ell) + Li_2SO_4(aq)$$

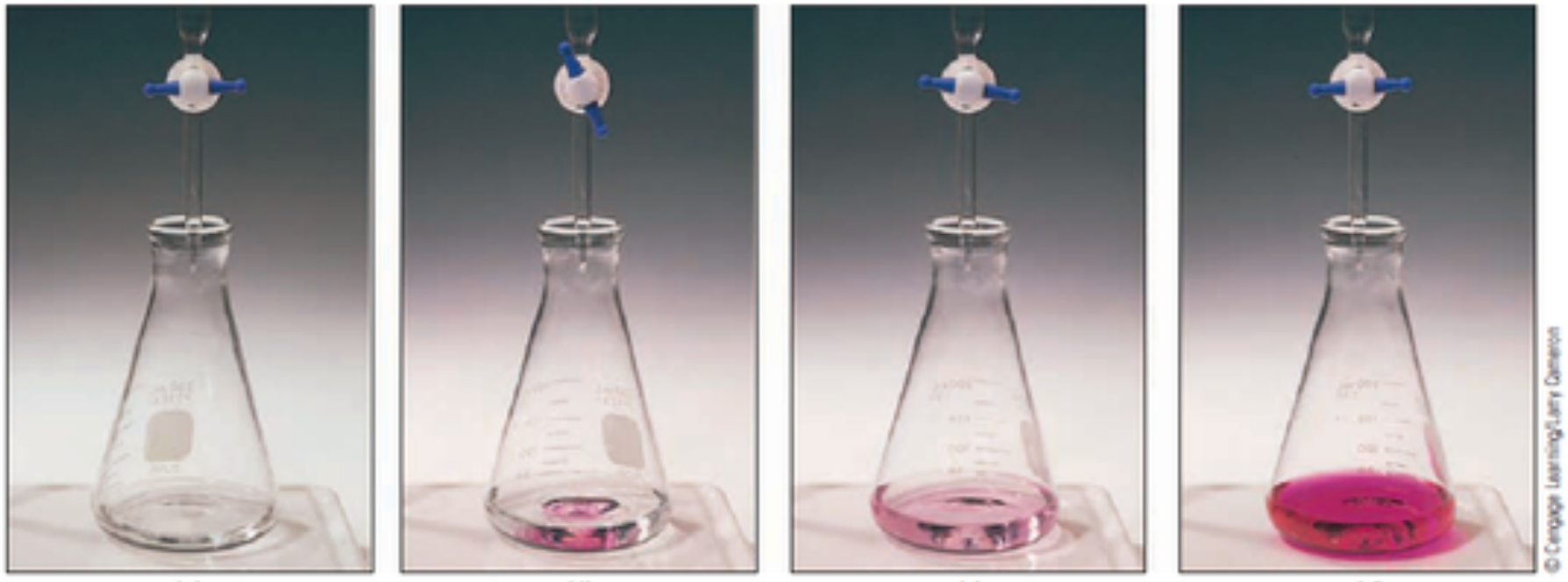
Acid/Base Titration



Acid form, colorless



Basic form, pink



https://www.quora.com/Why-do-we-use-phenolphthalein-as-an-indicator-in-acid-base-titration