Arrhenius Theory

Acid: H^+

Base: OH^-

Bronsted-Lowry Theory

Acid: H^+ donor

Base: H^+ acceptor

$$NH_{3(aq)} + HCl_{(aq)} \rightleftharpoons NH^+_{4(aq)} + Cl^-_{(aq)}$$

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$$HS^-_{(aq)} + H_2O_{(l)} \rightleftharpoons S^{2-}_{(aq)} + H_3O^+_{(aq)}$$

$$HS^-_{(aq)} + H_2O_{(l)} \rightleftharpoons H_2S_{(aq)} + OH^-_{(aq)}$$

Water Equilibrium

Conductivity is due to the presence of ions. For water:

$$H_2O_{(l)} \Longleftrightarrow H^+_{(aq)} + OH^-_{(aq)}$$

- therefore $K = \frac{[H^+][OH^-]}{[H_2O]}$ is very small
- slight conductivity shows that equilibrium greatly favors water molecules (less than 2 H^+ per billion water)

- therefore the concentration of water in pure water and in dilute aqueous solutions is essentially constant and can be combined with the equilibrium constant to produce a new constant called the *Ion Product Constant*

Ionization Constant for water (ion product constant)

$\mathbf{K_w = [H^+]\,[OH^-] = 1.0 \times 10^{-14}}$ at SATP

Since $[H^+]$ and $[OH^-]$ are found in 1:1 ratio
($H_2O_{(l)} \Longleftrightarrow H^+_{(aq)} + OH^-_{(aq)}$)

$[H^+_{(aq)}] = [OH^-_{(aq)}] = 1.0 \times 10^{-7}$ mol/L in **neutral** solutions.

Arrhenius's Theory - acid is a substance that ionizes water t produce H^+ ions.
- additional ions produced by the acid increases the H^+ concentration in the water. (more acid, more H^+)

Therefore acids always have a $[H^+] > 10^{-7}$ mol/L

Basic solutions produce a $[OH^-]$ greater than 10^{-7} mol/L

K_w can be used to calculate either $[H^+]$ or $[OH^-]$

since $\mathbf{K_w = [H^+]\,[OH^-]}$ then $[H^+] = K_w / [OH^-]$

and $[OH^-] = K_w / [H^+]$

pH and pOH

$pH + pOH = 14.00$

$pH = -\log[H^+_{(aq)}]$

$pOH = -\log[OH^-_{(aq)}]$

$[H^+_{(aq)}] = 10^{-pH}$

$[OH^-_{(aq)}] = 10^{-pOH}$

Ex. Calculate the pH of a solution where $[H^+_{(aq)}] = 3.24 \times 10^{-4}$M.

$pH = -\log[H^+_{(aq)}]$

$pH = -\log[3.24 \times 10^{-4}]$

$pH = 3.489$

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EXP

Ex. Calculate the concentration of hydroxide ions in a solution with a pOH of 10.14.

$[OH^-_{(aq)}] = 10^{-pOH}$

$[OH^-_{(aq)}] = 10^{-10.14}$

$[OH^-_{(aq)}] = 7.2 \times 10^{-11}$ M

^

10^x

Strong Acids

Calculate the concentration of the hydroxide ions, pH and pOH of a 0.15 mol/L solution of hydrochloric acid at 25°C.

Strong acids will always completely ionize

$HCl_{(aq)} \longrightarrow H^+_{(aq)} + Cl^-_{(aq)}$

0.15 mol/L $\quad$ 0.15 mol/L

$[OH^-_{(aq)}] = ?$ ✓

pH = ?

pOH = ?

$K_w = [H^+_{(aq)}][OH^-_{(aq)}]$

$[OH^-_{(aq)}] = \frac{K_w}{[H^+]}$

$[OH^-_{(aq)}] = \frac{1.0 \times 10^{-14}}{0.15 \text{ mol/L}}$

$[OH^-_{(aq)}] = 6.7 \times 10^{-14}$ M

$pH = -\log[H^+_{(aq)}]$

$pH = -\log[0.15]$

$pH = 0.82$

$pOH = -\log[OH^-_{(aq)}]$

$pOH = -\log[6.7 \times 10^{-14}]$

$pOH = 13.18$

Ionic Hydroxides

Calculate the hydrogen ion concentration in a 0.25 mol/L solution of barium hydroxide.

$$Ba(OH)_{2(s)} \longrightarrow Ba^{2+}_{(aq)} + 2OH^{-}_{(aq)}$$

0.25 mol/L 0.50 mol/L