

## Arrhenius Theory

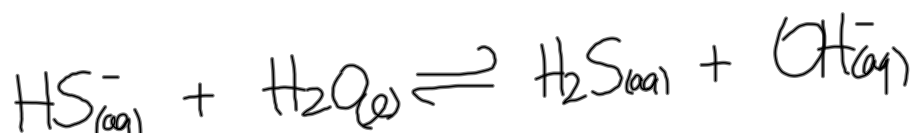
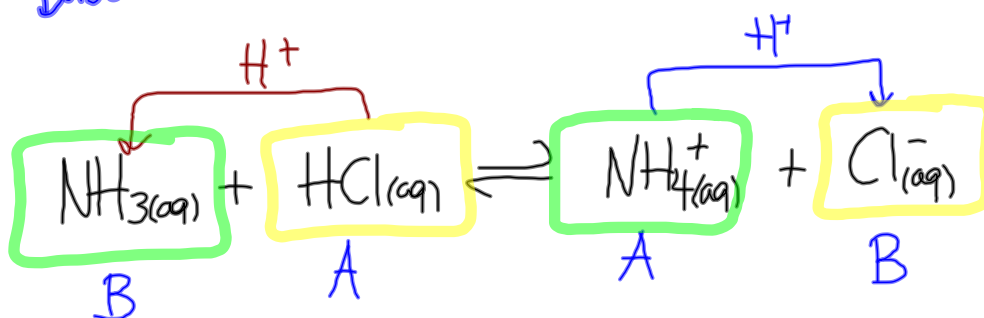
Acid:  $H^+$

Base:  $OH^-$

## Bronsted-Lowry Theory

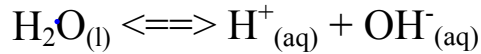
Acid:  $H^+$  donor

Base:  $H^+$  acceptor



# Water Equilibrium

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



- therefore  $K = \frac{[\text{H}^+][\text{OH}^-]}{[\text{H}_2\text{O}]}$  is very small

- slight conductivity shows that equilibrium greatly favors water molecules (less than 2 H<sup>+</sup> 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)

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

Since [H<sup>+</sup>] and [OH<sup>-</sup>] are found in 1:1 ratio  
( $\text{H}_2\text{O}_{(l)} \rightleftharpoons \text{H}^+_{(aq)} + \text{OH}^-_{(aq)}$ )

[H<sup>+</sup><sub>(aq)</sub>] = [OH<sup>-</sup><sub>(aq)</sub>] = 1.0 x 10<sup>-7</sup> mol/L in **neutral** solutions.

Arrhenius's Theory - acid is a substance that ionizes water to produce H<sup>+</sup> ions.

- additional ions produced by the acid increases the H<sup>+</sup> concentration in the water. (more acid, more H<sup>+</sup>)

**Therefore acids always have a [H<sup>+</sup>] > 10<sup>-7</sup> mol/L**

**Basic solutions produce a [OH<sup>-</sup>] greater than 10<sup>-7</sup> mol/L**

K<sub>w</sub> can be used to calculate either [H<sup>+</sup>] or [OH<sup>-</sup>]

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

$$\text{and } [\text{OH}^-] = K_w / [\text{H}^+]$$

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

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

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

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



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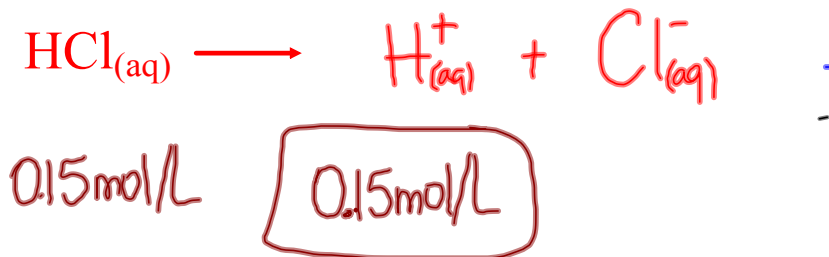


10<sup>x</sup>

# 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\***



$$[\text{OH}^-] = ?$$

$$K_w = [\text{H}^+][\text{OH}^-]$$

$$\text{pH} = ?$$

$$\text{pOH} = ?$$

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

$$\frac{K_w}{[\text{H}^+]}$$

$$[\text{OH}^-] = 6.7 \times 10^{-14} \text{ M}$$

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

$$\text{pH} = -\log[0.15]$$

$$\text{pH} = 0.82$$

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

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

$$\text{pOH} = 13.18$$

## Ionic Hydroxides

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

