Warm Up

Predict the products for the following reaction, and identify each reactant as an acid or a base.

$$\underset{A}{C_6H_5COOH_{(aq)}} + \underset{B}{OH^-_{(aq)}} \xrightleftharpoons{H^+} \underset{B}{C_6H_5COO^-_{(aq)}} + \underset{A}{H_2O_{(\ell)}}$$

$$\underset{B}{HCO_3^-{}_{(aq)}} + \underset{A}{H_3O^+_{(aq)}} \xrightleftharpoons{H^+} \underset{A}{H_2CO_{3(aq)}} + \underset{B}{H_2O_{(\ell)}}$$

Revised

Arrhenius Theory

Acid - H^+

Base - OH^-

Bronsted-Lowry Theory

Acid - H^+ donors

Base - H^+ acceptors

Conjugate Acid-Base Pairs

$CH_3COOH_{(aq)} + H_2O_{(l)} \quad CH_3COO^-_{(aq)} + H_3O^+_{(aq)}$

Acid-Base reactions are at equilibrium !

(Look at forward reaction and reverse reaction)

- Every acid-base reaction at equilibrium has two acids and two bases.
- Acid on 'product' side is formed by addition of proton to base on 'reactant' side
- Base on 'product' side is formed by removal of a proton from acid on 'reactant' side

Conjugate acid-base pair
A pair of substances that differ by only a proton

$$\underset{A}{CH_3COOH_{(aq)}} + \underset{B}{H_2O_{(l)}} \rightleftharpoons \underset{B}{CH_3COO^-_{(aq)}} + \underset{A}{H_3O^+_{(aq)}}$$

$HCN_{(aq)} \quad CN^-_{(aq)}$

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

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

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

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

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

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

$\boxed{pH = 3.489}$

$\boxed{EE}$

$\boxed{3.24}$ $\boxed{EXP}$ $\boxed{-}$ $\boxed{4}$

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

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

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

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

$\boxed{10}$ $\boxed{y^x}$ $\boxed{(}$ $\boxed{-10.14}$

$\boxed{\wedge}$

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

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

0.15mol/L 0.15mol/L

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

$pH = -\log[0.15]$

$\boxed{pH = 0.82}$

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

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

$\boxed{pOH = 13.17}$

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

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

$[OH^-_{(aq)}] = \dfrac{1.0 \times 10^{-14}}{0.15}$

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

Strong Bases
(Ionic Hydroxides)

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

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

0.25mol/L

0.50mol/L