Warm Up

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

$$\overset{A}{C_6H_5COOH_{(aq)}} + \overset{B}{OH^-_{(aq)}} \rightleftharpoons \overset{B}{C_6H_5COO^-_{(aq)}} + \overset{A}{H_2O_{(l)}}$$

H^+ H^+

$$\overset{B}{HCO_3^-{}_{(aq)}} + \overset{A}{H_3O^+_{(aq)}} \rightleftharpoons \overset{A}{H_2CO_{3(aq)}} + \overset{B}{H_2O_{(l)}}$$

H^+ H^+

Revised Arrhenius Theory

Acids H^+

Bases OH^-

(acid/base ≠ water
bases → Na_2CO_3, NH_3)

Bronsted-Lowry Theory

Acids → H^+ donors

Bases → H^+ acceptors

Water Equilibrium

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

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

- therefore $K = \dfrac{[H^+][OH^-]}{[H_2O]}$ 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 *

$x \quad x$

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

$$K = \frac{[H^+][OH^-]}{[H_2O]}$$

$$\underbrace{K[H_2O]} = [H^+][OH^-]$$

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

pH and pOH

acidic

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

basic

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

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

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

$K_w = [H^+_{(aq)}][OH^-_{(aq)}] = 1.0 \times 10^{-14}$

$pH + pOH = 14.00$

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

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

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

$\boxed{pH = 3.489}$

3.24 $\boxed{Exp}$ $\boxed{EE}$ $\boxed{-}$ $\boxed{4}$

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

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

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

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

$\boxed{10^x}$

10^(-10.14)

H^+