Acids and Bases

Brønsted-Lowry Definition

Acid is a proton (H^+) donor

Base is a proton (H^+) acceptor

Strong Acids and Bases

"Strong" means one thing

The substance dissociates 100% in water

Strong Acid

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

$$K_a = \frac{[H^+][Cl^-]}{[HCl]} \approx \infty$$

Strong Electrolyte

$$NaCl(s) \longrightarrow Na^+(aq) + Cl^-(aq)$$

$$K_{sp} = [Na^+][Cl^-] \approx \infty$$

Strong Acids

HCl	Hydrochloric
HBr	Hydrobromic
HI	Hydroiodic
$HClO_4$	Perchloric
$HClO_3$	Chloric
H_2SO_4	Sulfuric
HNO_3	Nitric

All Dissociate 100%

Strong Bases

Lithium Hydroxide	$LiOH$
Sodium Hydroxide	$NaOH$
Potassium Hydroxide	KOH
Rubidium Hydroxide	$RbOH$
Cesium Hydroxide	$CsOH$
Calcium Hydroxide	$Ca(OH)_2$
Barium Hydroxide	$Ba(OH)_2$
Strontium Hydroxide	$Sr(OH)_2$

All Dissociate 100%

What is the pH of a 0.1 M solution of Nitric Acid

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

$[H^+] = C_a$ C_a is the concentration of the acid

0.1 M acid makes a solution with $[H^+] = 0.1M$

$$pH = -\log(0.1) = 1$$

What is the pH of a 0.5M solution of HBr?

A. 0.5

B. 1

C. 0.3

D. 0

E. 12

$[H^+] = 0.5 \quad 0 < pH < 1$

We can ignore the "conjugate base" of a strong acid

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

$$K_a = \frac{[H^+][Cl^-]}{[HCl]} \approx \infty$$

equilibrium constant is so large,
even if we add Cl^- the shift back to
HCl will be negligible

"spectator ions"

If you know $[H^+]$ you know $[OH^-]$

$$K_w = [H^+][OH^-]$$
$$\log(K_w) = \log([H^+][OH^-])$$
$$\log(K_w) = \log[H^+] + \log[OH^-]$$

$$\log(10^{-14}) = \log[H^+] + \log[OH^-]$$
$$-14 = -pH - pOH$$
$$14 = pH + pOH$$

Weak Acid

$$HA(aq) \longrightarrow H^+(aq) + A^-(aq)$$

	HA	H^+	A^-
I	C	O (really 10^{-7})	O
C	-x	+x	+x
E	C-x	+x	+x

$$K_a = \frac{[H^+][A^-]}{[HA]} = \frac{(x)(x)}{C-x}$$

assuming x << C

$$x \sim \sqrt{K_a C}$$

This is a great simple result

$$[H^+] \approx \sqrt{K_a C_a}$$

C_a is the concentration of the acid
K_a is the equilibrium constant for the acid

This assumes the concentration is large
and that K_a is small

What is the pH of a 1M solution of weak acid with a $K_a = 10^{-6}$?

A. 1

B. 3

C. 7

D. 8

E. 9

$[H^+] = \text{sqrt}(1 \times 10^{-6}) = 10^{-3}$

Weak Base

$$B(aq) + H_2O(l) \longrightarrow BH^+(aq) + OH^-(aq)$$

$$K_b = \frac{[BH^+][OH^-]}{[B]}$$

identical result as before (same assumptions)

$$[OH^-] = \sqrt{K_b C_b}$$

Weak Acids

$$HA(aq) \longleftrightarrow H^+(aq) + A^-(aq)$$

with the proton
acid

without the proton
base

HA	weak acid
A^-	weak base

Weak Base

$$A^-(aq) + H_2O(l) \longrightarrow HA(aq) + OH^-(aq)$$

$$K_b = \frac{[HA][OH^-]}{[A^-]}$$

identical result as before (same assumptions)

$$[OH^-] = \sqrt{K_b C}$$

Same with the base

$$B(aq) + H_2O(l) \longrightarrow BH^+(aq) + OH^-(aq)$$

without the proton
base

with the proton
acid

$$BH^+(aq) \longrightarrow H^+(aq) + B(aq)$$

Weak acids

HA and BH^+

Name is acid HA "acetic acid"

BH^+ has a positive charge and an "extra" proton NH_4^+

Weak bases

B and A^-

A^- is negative
usually name ends in "ate"
CH_3COO^- acetate

B is hardest to identify
it is not one of the other three
often it is an "amine"

What is the pH of a 1M solution of sodium benzoate?

A. 4.9

B. 5.1

C. 6.2

D. 7

E. 9.09

benzoate is a weak base (A^-)
only pH of 9.09 is basic

$$\Delta_R G^\circ(T) = -RT \ln K$$

$$\Delta T = iK_b m_{solute}$$

$$\ln \frac{K_2}{K_1} = \frac{\Delta_R H^\circ}{R}\left[\frac{1}{T_2} - \frac{1}{T_1}\right]$$

$$\Delta T = -iK_f m_{solute}$$

$$\Delta P = X_{solute} P^\circ$$

$$\Pi = iMRT$$