

Acids and Bases

Brønsted-Lowry Definition

Acid is a proton (H^+) donor

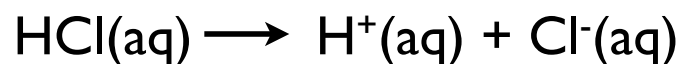
Base is a proton (H^+) acceptor

Strong Acids and Bases

"Strong" means one thing

The substance dissociates 100% in water

Strong Acid



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

Strong Electrolyte



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

Strong Acids

HCl	Hydrochloric
HBr	Hydrobromic
HI	Hydroiodic
HClO ₄	Perchloric
HClO ₃	Chloric
H ₂ SO 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



$[\text{H}^+] = C_a$ C_a is the concentration of the acid

0.1 M acid makes a solution with $[\text{H}^+] = 0.1\text{M}$

$$\text{pH} = -\log(0.1) = 1$$

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

A. 0.5

B. 1

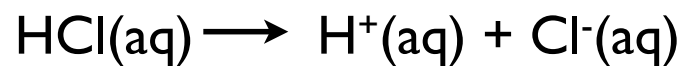
C. 0.3

D. 0

E. 12

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

We can ignore the “conjugate base” of a strong acid



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

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 $[OH^-]$

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

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

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

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

$$-14 = -\text{pH} - \text{pOH}$$

$$14 = \text{pH} + \text{pOH}$$

Weak Acid



	HA	H ⁺	A ⁻
I	C	0	0
C	-x	+x	+x
E	C-x	+x	+x

really 10⁻⁷



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

assuming $x \ll C$

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

This is a great simple result

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

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

A. 1

B. 3

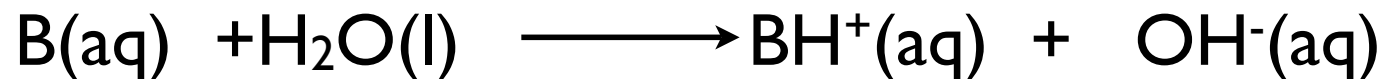
C. 7

D. 8

E. 9

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

Weak Base

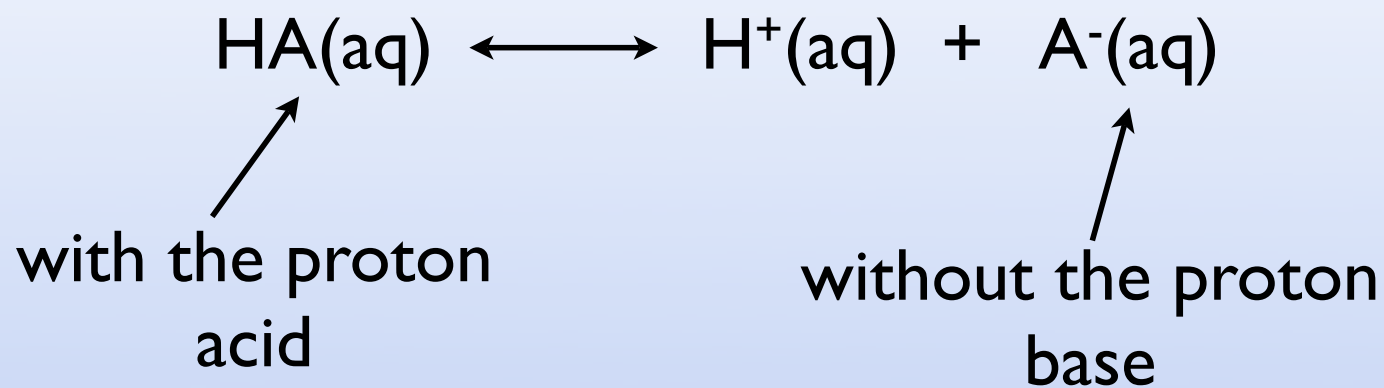


$$K_b = \frac{[\text{BH}^+][\text{OH}^-]}{[\text{B}]}$$

identical result as before (same assumptions)

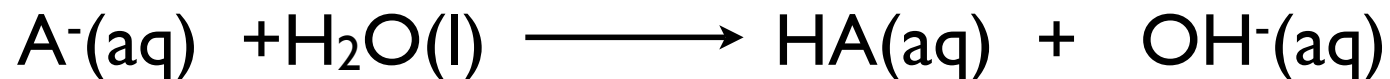
$$[\text{OH}^-] = \sqrt{K_b C_b}$$

Weak Acids



HA weak acid
A⁻ weak base

Weak Base

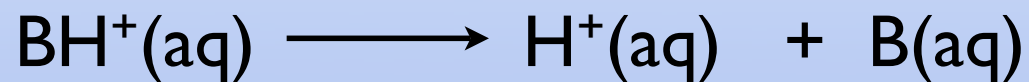
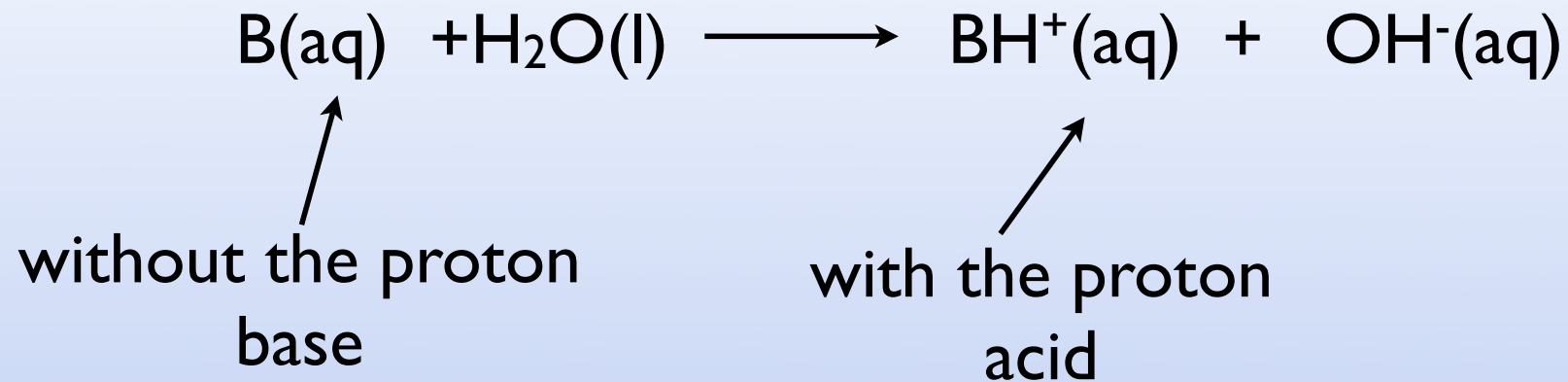


$$K_b = \frac{[\text{HA}][\text{OH}^{-}]}{[\text{A}^{-}]}$$

identical result as before (same assumptions)

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

Same with the base



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 1 M 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

$$\Delta_{\text{R}}G^{\circ}(T) = -RT \ln K$$

$$\Delta T = iK_{\text{b}}m_{\text{solute}}$$

$$\Delta T = -iK_{\text{f}}m_{\text{solute}}$$

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

$$\Pi = iMRT$$

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