

ACID

PROTON DONOR	H ⁺
Arrhenius Concept	increases H ⁺ in water (ex. H ₃ O ⁺)
Bronsted-Lowry Concept	can donate a proton (H ⁺)
Lewis Concept	electron pair acceptor (covalent bond created)
<i>strong acids</i>	dissociate fully (100% ionized)
<i>weak acids</i>	dissociate partially (<100% ionized)
	tart/sour taste

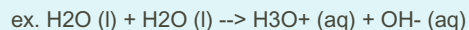
ACID/BASE REACTIONS

can be ions or substances	not limited to (aq) solutions
some react as acid or base depending on other reactant	
salt	ionic compound, product of acid base reaction, does NOT contain OH ⁻ , not metal oxide
ex. HCl (aq) + KOH (aq) ----> KCl (aq) + H ₂ O	

AUTOIONIZATION OF WATER

small % of water undergoes ionization to produce ions

$$K_w = 1 \times 10^{-14}$$



in pure water.... [H₃O⁺] × [OH⁻] = 10⁻¹⁴ and [H₃O⁺] = [OH⁻] = 10⁻⁷

the product between the molar concentrations of hydronium ion and hydroxide ion is a constant

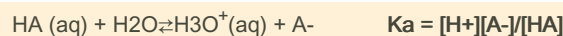
pH SCALE

ACID	BASE
pH = -log[H ₃ O ⁺] OR [H ₃ O ⁺] = 10 ^{-pH}	pOH = -log[OH ⁻] OR [OH ⁻] = 10 ^{-pOH}

pH = -log[H⁺]
 -pH = log[H₃O⁺]
 10⁻¹⁰
 [H⁺] = 10^{-pH}

ACID IONIZATION CONSTANT, K_a

WEAK ACID IONIZATION equilibria of weak acid



pK_a = -logK_a

pH = -log [H₃O⁺] [H₃O⁺] = 10^{-pH}

pOH = -log[OH⁻] [OH⁻] = 10^{-pOH}

p = -log

Degree of Ionization, α neutral molecule splits into charged ions when exposed in a solution

α of weak acid/base in water = fraction of total concentration that has formed ions ex. HA(aq) + H₂O ⇌ H₃O⁺ (aq) + A⁻ (aq)

% ionization (*weak acid*) = [A⁻] eq/[HA] originally × 100%

the larger the K_a, the stronger the acid

K_a Table

ACID-IONIZATION CONSTANTS AT 25°C

Substance	Formula	K _a
Acetic acid	HC ₂ H ₃ O ₂	1.7 × 10 ⁻⁵
Benzoic acid	HC ₇ H ₅ O ₂	6.3 × 10 ⁻⁵
Boric acid	H ₃ BO ₃	K _{a1} = 5.9 × 10 ⁻¹⁰
Carbonic acid	H ₂ CO ₃	K _{a1} = 4.3 × 10 ⁻⁷
	HCO ₃ ⁻	K _{a2} = 4.8 × 10 ⁻¹¹
Cyanic acid	HCN	3.5 × 10 ⁻⁴
Formic acid	HCHO ₂	1.7 × 10 ⁻⁴
Hydrocyanic acid	HCN	4.9 × 10 ⁻¹⁰
Hydrofluoric acid	HF	6.8 × 10 ⁻⁴
Hydrogen sulfate ion	HSO ₄ ⁻	1.1 × 10 ⁻²
Hydrogen sulfide	H ₂ S ⇌ HS ⁻ + H ₃ O ⁺	K _{a1} = 8.9 × 10 ⁻⁸
	HS ⁻ ⇌ S ²⁻ + H ₃ O ⁺	K _{a2} = 1.2 × 10 ⁻¹³
Hypochlorous acid	HOCl	3.5 × 10 ⁻⁸
Nitrous acid	HNO ₂	4.5 × 10 ⁻⁴
Oxalic acid	H ₂ C ₂ O ₄	K _{a1} = 5.6 × 10 ⁻²
	HC ₂ O ₄ ⁻	K _{a2} = 5.1 × 10 ⁻⁵
Phosphoric acid	H ₃ PO ₄	K _{a1} = 6.9 × 10 ⁻³
	H ₂ PO ₄ ⁻	K _{a2} = 6.2 × 10 ⁻⁸
	HPO ₄ ²⁻	K _{a3} = 4.8 × 10 ⁻¹³
Phosphorous acid	H ₃ PO ₃	K _{a1} = 1.6 × 10 ⁻²
	H ₂ PO ₃ ⁻	K _{a2} = 7 × 10 ⁻⁷
Propionic acid	HC ₃ H ₅ O ₂	1.3 × 10 ⁻⁵
Pyruvic acid	HC ₃ H ₃ O ₃	1.4 × 10 ⁻⁴
Sulfurous acid	H ₂ SO ₃	K _{a1} = 1.3 × 10 ⁻²
	HSO ₃ ⁻	K _{a2} = 6.3 × 10 ⁻⁸

BASE

PROTON RECEPTOR	OH ⁻
Arrhenius Concept	increase [OH ⁻] in water
Bronsted-Lowry Concept	can accept a proton (H ⁺)
Lewis Concept	electron pair donor (covalent bond created)
<i>strong bases</i>	dissociate fully (100% ionized)
<i>weak bases</i>	dissociate partially (>100%)

bitter taste, slippery feeling

BRONSTED ACID/BASE STRENGTH

ACID	BASE
Strong acids	Negligible basicity
HCl	Cl ⁻
H ₂ SO ₄	HSO ₄ ⁻
HNO ₃	NO ₃ ⁻
H ₂ O ⁺ (aq)	H ₂ O
Weak acids	Weak bases
HSO ₄ ⁻	SO ₄ ²⁻
H ₂ PO ₄ ⁻	H ₂ PO ₄ ⁻
HF	F ⁻
CH ₃ COOH	CH ₃ COO ⁻
H ₂ CO ₃	HCO ₃ ⁻
H ₂ S	HS ⁻
H ₂ PO ₄ ⁻	HPO ₄ ²⁻
NH ₄ ⁺	NH ₃
HCO ₃ ⁻	CO ₃ ²⁻
HPO ₄ ²⁻	PO ₄ ³⁻
H ₂ O	OH ⁻
Negligible acidity	Strong bases
OH ⁻	O ²⁻
H ₂	H ⁻
CH ₄	CH ₃ ⁻

acid 1 + base 2 $\rightleftharpoons$ (conjugate) base 1 + (conjugate) acid 2
rxn direction favors weaker acid and base

AUTOIONIZATION OF WATER PROBLEMS

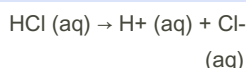
1. hydrogen (hydronium) ion concentration when [OH⁻] = 2×10^{-3} M

$$K_w = [H^+][OH^-] = 1 \times 10^{-14}$$

$$[H^+][2 \times 10^{-3}] = 1 \times 10^{-14}$$

$$[H^+] = 5.0 \times 10^{-12} \text{ M}$$

2. hydroxide ion concentration in 0.002M HCl solution



HCl is a strong acid, will dissociate 100%

$$K_w = [H^+][OH^-] = 1 \times 10^{-14}$$

$$[0.002\text{M}][OH^-] = 1 \times 10^{-14}$$

$$[OH^-] = 5.0 \times 10^{-12}$$

CALCULATING pH OF STRONG ACID & BASE

1. pH of 0.10M Ba(OH)₂ solution Ba(OH)₂ + H₂O $\rightarrow$ Ba²⁺ + 2OH⁻

$$I \quad 0.10\text{M} \quad \parallel \quad 0 \quad 0$$

$$C \quad -0.10 \quad \parallel \quad +0.10 \quad +2(0.10)$$

$$E \quad 0\text{M} \quad \parallel \quad 0.10 \quad 0.20$$

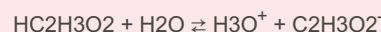
$$pOH = -\log[OH^-] = -\log[0.20\text{M}] = \quad pH = 14.00 - 0.6990 = 13.30$$

answer: *basic solution*

ACID EQUILLIBRIUM CALCULATIONS (pH from Ka)

calculate pH of 1.0M Acetic acid soln, using approximations.

$$K_a = 1.8 \times 10^{-5}$$



$$I \quad 1.0 \text{ M} \quad \parallel \quad 0 \text{ M} \quad 0 \text{ M}$$

$$C \quad -x \quad \parallel \quad +x \quad +x$$

$$E \quad 1-x \quad \parallel \quad x \quad x$$

$$K_a = \frac{[H_3O^+][C_2H_3O_2^-]}{[HC_2H_3O_2]}$$

$$K_a = \frac{x^2}{1.0 - x} = 1.8 \times 10^{-5}$$

$$\sqrt{x^2} = \sqrt{1.8 \times 10^{-5}}$$

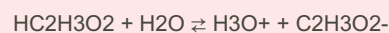
$$x = 4.24 \times 10^{-3} \text{ M}$$

$$\% \text{ionization} = \frac{[H_3O^+]}{[HC_2H_3O_2]} \times 100\%$$

$$= \frac{4.24 \times 10^{-3} \text{ M}}{1.0 \text{ M}} \times 100\% = 0.424\% < 5\% \text{ can neglect!}$$

$$pH = -\log[4.24 \times 10^{-3}] = 2.30$$

calculate pH of 1.0×10^{-5} M Acetic acid soln (*diluted concentration*)



$$I \quad 1.0 \times 10^{-5} \text{ M} \quad \parallel \quad 0 \text{ M} \quad 0 \text{ M}$$

$$C \quad 1.0 \times 10^{-5} \text{ M} - x \quad \parallel \quad +x \quad +x$$

$$E \quad 1.0 \times 10^{-5} \text{ M} - x \quad \parallel \quad x \quad x$$

$$K_a = \frac{x^2}{1.0 \times 10^{-5} \text{ M} - x} = 1.8 \times 10^{-5} \text{ M}$$

$$\sqrt{x^2} = \sqrt{1.8 \times 10^{-10}}$$

$$x = 1.34 \times 10^{-5}$$

$$\% \text{ionization} = \frac{[H_3O^+]}{[HC_2H_3O_2]} \times 100\%$$

$$= 13\% > 5\% \text{ can't neglect!}$$

$$x^2 / 1.0 \times 10^{-5} \text{ M} = 1.8 \times 10^{-5} \text{ M}$$

$$x^2 + 1.8 \times 10^{-5} x - 1.8 \times 10^{-10} = 0$$

$$1.8 \times 10^{-5} \pm \sqrt{(1.8 \times 10^{-5})^2 - 4(1)(-1.8 \times 10^{-10})} / 2(1)$$

$$= 7.15 \times 10^{-6} \text{ M} = [H_3O^+]$$

$$pH = -\log[7.15 \times 10^{-6} \text{ M}] = 5.14$$