

Acid and Bases



Properties of Acids

- Taste sour
- React with active metals to produce H_2
- React with carbonates to produce CO_2
- Neutralize bases



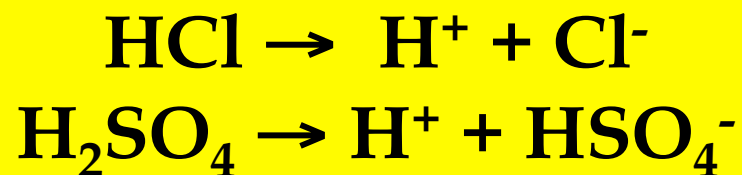
Properties of Bases

- Taste bitter
- Are slimy to the touch
- Neutralize acids



Arrhenius Acid/Base

- Acid - A substance that produces hydrogen ions, H^+ , in aqueous solutions.



- Base - Produces OH^- ions in solution



Brønsted -Lowry Acid/Base

- Acids are H⁺ donors
- Bases are H⁺ acceptors

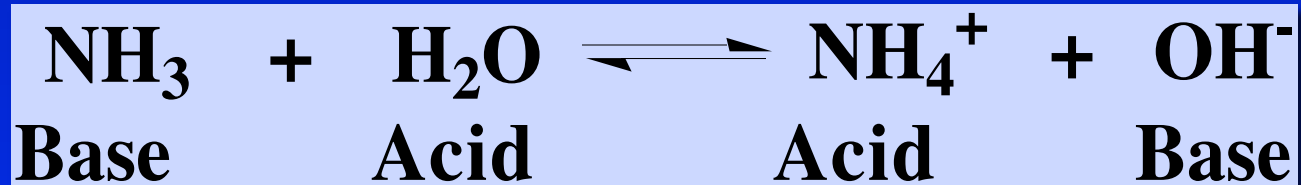


HCl is the acid - donates proton

H₂O is the base - accepts proton

Brønsted–Lowry Acids and Bases

- The Brønsted definition means NH_3 is a **BASE** in water — and water is itself an **ACID**.



Brønsted–Lowry Acids and Bases

- An acid–base reaction is the transfer of a proton from an acid to a base.



Brønsted–Lowry Acids and Bases



acid

base

acid

base

Conjugate Acid-Bases

- Conjugate acid-base pairs are a reactant and a product that differ by a proton, H^+ .



Conjugate acid-base pairs



Conjugate Acid-Bases

- Conjugate acid-base pairs are a reactant and a product that differ by a proton, H^+ .



Conjugate acid-base pairs

Conjugate Acid-Bases

- Every acid has a conjugate base, formed by the removal of a **proton** from the acid.
- Every base has a conjugate acid associated with it, formed by the addition of a **proton** to the base.
- Thus H_3O^+ is the conjugate acid of H_2O .

Conjugate Acid-Bases



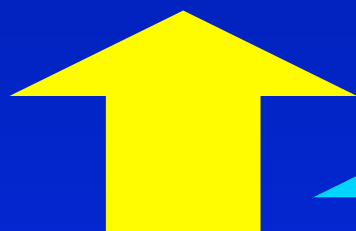
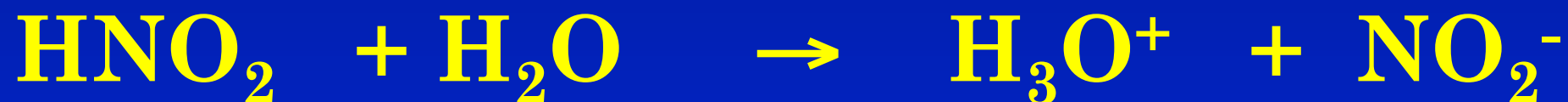
Acid

Conjugate Base

Base

Conjugate Acid

Conjugate Acid-Bases



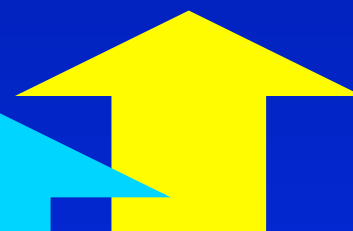
Acid



Base

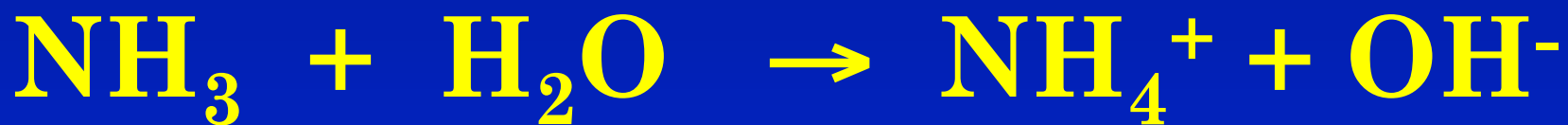


Conjugate
acid



Conjugate
base

Conjugate Acid-Bases



Base

Acid

Conjugate
acid

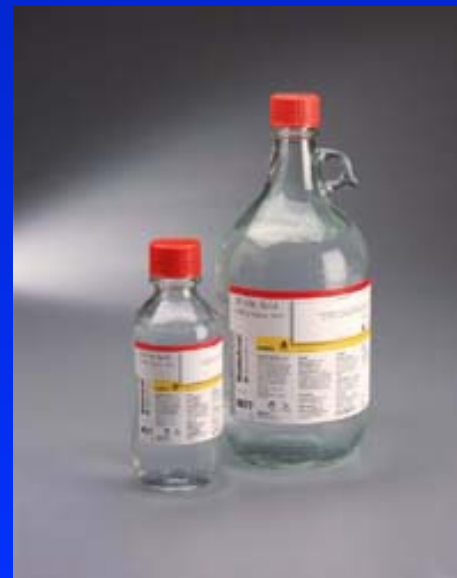
Conjugate
base

Acid Base Systems

| Type | Acid | Base |
|----------------|--------------------------------|-----------------------------------|
| Arrhenius | H ⁺ producer | OH ⁻ producer |
| Bronsted-Lowry | Proton (H ⁺) donor | Proton (H ⁺) acceptor |

Naming Acids

- Acids are ionic compounds (cation + anion)
- H^+ is the cation
- All acids start with H
- When acids dissolve into ion pairs, they produce an H^+



Naming Acids

- When the name of the anion ends in —ide, the acid name begins with the prefix **hydro-**, the stem of the anion has the suffix **—ic** and it is followed by the word acid.



- When the anion name ends in —ite, the acid name is the stem of the anion with the suffix **—ous**, followed by the word acid.



- When the anion name ends in —ate, the acid name is the stem of the anion with the suffix **—ic**, followed by the word acid.



Practice Naming Acids

| Anion | Anion Name | Formula | Name |
|-------------|------------|---------|------|
| S^{2-} | | | |
| SO_4^{2-} | | | |
| SO_3^{2-} | | | |

Name the anion

| Anion | Anion Name | Formula | Name |
|-------------|----------------|---------|------|
| S^{2-} | Sulfide | | |
| SO_4^{2-} | Sulfate | | |
| SO_3^{2-} | Sulfite | | |

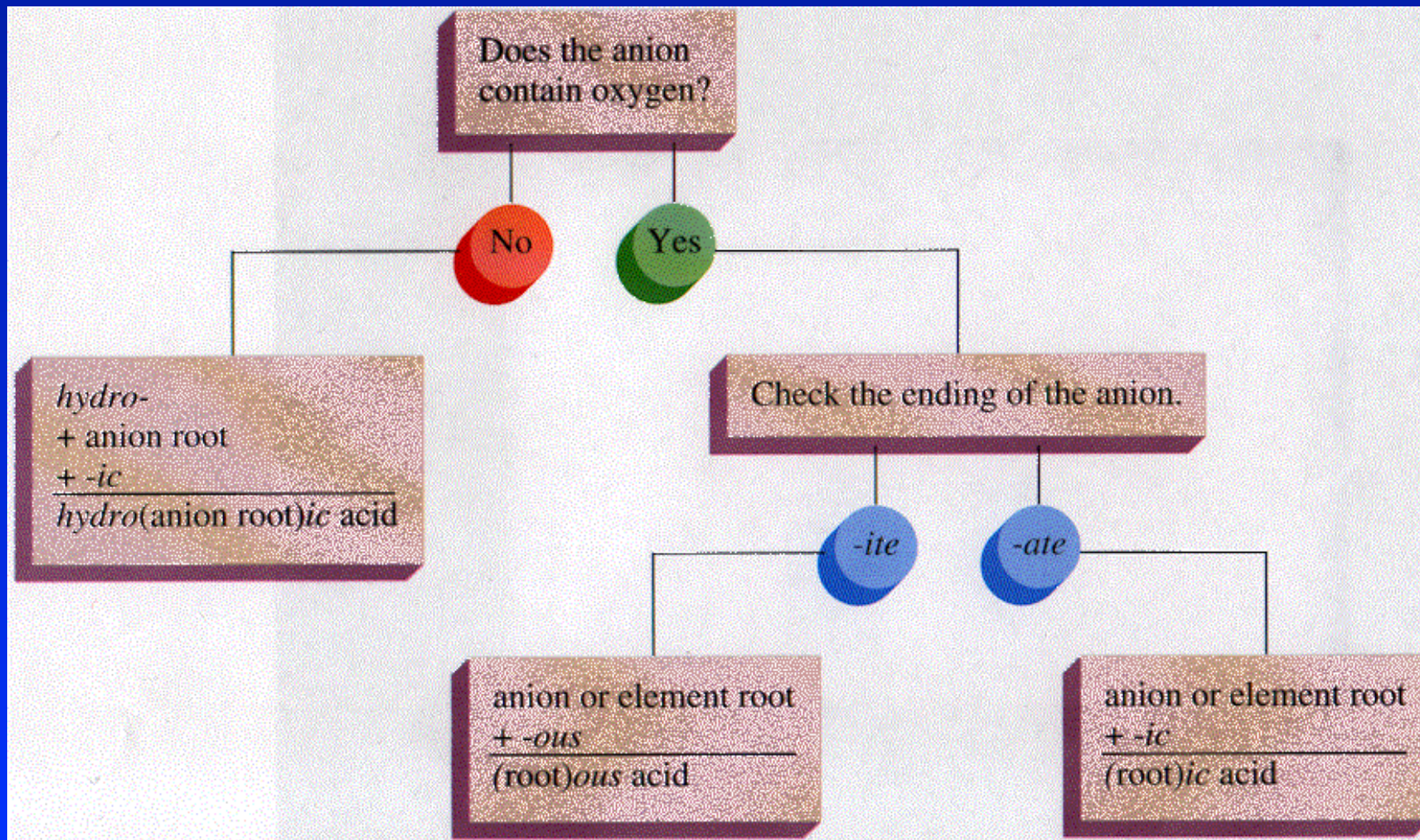
Write the Formula

| Anion | Anion Name | Formula | Name |
|-------------|------------|-----------|------|
| S^{2-} | Sulfide | H_2S | |
| SO_4^{2-} | Sulfate | H_2SO_4 | |
| SO_3^{2-} | Sulfite | H_2SO_3 | |

Name the acid

| Anion | Anion Name | Formula | Name |
|-------------|------------|-----------|---------------------------|
| S^{2-} | Sulfide | H_2S | Hydrosulfuric Acid |
| SO_4^{2-} | Sulfate | H_2SO_4 | Sulfuric Acid |
| SO_3^{2-} | Sulfite | H_2SO_3 | Sulfurous Acid |

Naming Acids



Naming Bases

- Most bases are named like any other ionic compound.
- The name of the cation followed by the name of the anion.



Potassium Hydroxide



Magnesium Hydroxide



Aluminum Hydroxide



Ammonia (**Memorize this one !**)

Acid-Base Characteristics

Solution Type Relationship

Acid $[H^+] > [OH^-]$

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

Base $[H^+] < [OH^-]$



Self-ionization of Water

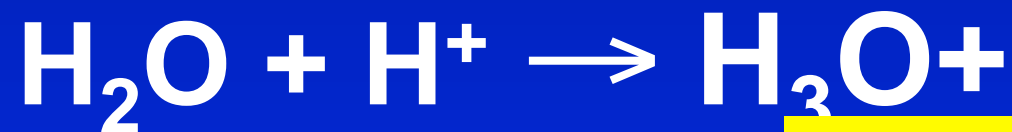
Water self-ionizes



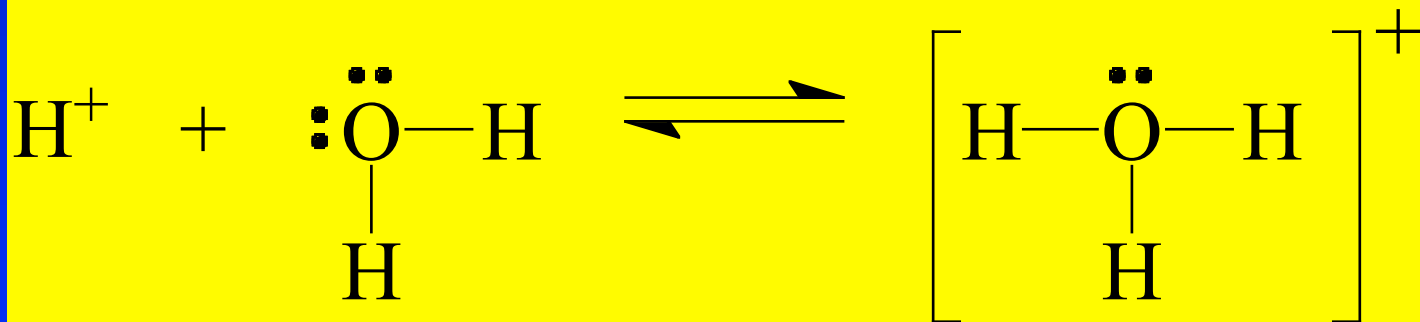
Drinking water is often slightly basic or acidic.
Acceptable pH is 6.5 to 8.5

Hydrated Hydrogen Ion

- A **Hydronium ion** is formed when water gains a proton



hydronium ion



Pure Water

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

Pure water has a pH = 7.

It is neutral.

$$K_w = 1 \times 10^{-7} \times 1 \times 10^{-7} = 1.0 \times 10^{-14}$$

@ 25°C

$[H^+]$ and $[OH^-]$

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

@ 25°C

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

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

Introduction to pH

pH is the negative logarithm of the hydrogen ion concentration.

$$\text{pH} = -\log [\text{H}^+]$$

Remember that sometimes H_3O^+ is written, so $\text{pH} = -\log [\text{H}_3\text{O}^+]$

pH and pOH

$$\text{pH} = -\log [\text{H}^+]$$

$$\text{pOH} = -\log [\text{OH}^-]$$

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

$\text{pH} < 7$ Acid

$\text{pH} > 7$ Base

$\text{pH} = 7$ Neutral

$$\text{pH} = -\log [\text{H}^+]$$

| $[\text{H}^+]$ | pH | Acid or Base |
|-----------------------|----|--------------|
| 6.5×10^{-11} | | |
| 3.3×10^{-3} | | |

$$\text{pH} = -\log [\text{H}^+]$$

| $[\text{H}^+]$ | pH | Acid or Base |
|-----------------------|-------|--------------|
| 6.5×10^{-11} | 10.18 | |
| 3.3×10^{-3} | 2.48 | |

$$\text{pH} = -\log [\text{H}^+]$$

| $[\text{H}^+]$ | pH | Acid or Base |
|-----------------------|-------|--------------|
| 6.5×10^{-11} | 10.18 | Base |
| 3.3×10^{-3} | 2.48 | Acid |

$$\text{pOH} = -\log [\text{OH}^-]$$

| $[\text{OH}^-]$ | pOH | pH | Acid or Base |
|----------------------|-----|----|--------------------|
| 3.4×10^{-6} | | | |
| 8.3×10^{-8} | | | |

$$\text{pOH} = -\log [\text{OH}^-]$$

| $[\text{OH}^-]$ | pOH | pH | Acid or Base |
|----------------------|------|----|--------------------|
| 3.4×10^{-6} | 5.47 | | |
| 8.3×10^{-8} | 7.08 | | |

$$\text{pOH} = -\log [\text{OH}^-]$$

| $[\text{OH}^-]$ | pOH | pH | Acid or Base |
|----------------------|------|------|--------------------|
| 3.4×10^{-6} | 5.47 | 8.53 | |
| 8.3×10^{-8} | 7.08 | 6.92 | |

$$\text{pOH} = -\log [\text{OH}^-]$$

| $[\text{OH}^-]$ | pOH | pH | Acid or Base |
|----------------------|------|------|--------------------|
| 3.4×10^{-6} | 5.47 | 8.53 | Base |
| 8.3×10^{-8} | 7.08 | 6.92 | Acid |

$[H^+]$ and $[OH^-]$

$$[H^+] = 10^{-pH}$$

$$[OH^-] = 10^{-pOH}$$

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

@ 25°C

Complete the Table

| pH | Acid or Base | pOH | [H ⁺] | [OH ⁻] |
|-------|--------------|-----|-------------------|--------------------|
| 3.80 | Acid | | | |
| 13.50 | Base | | | |
| 6.66 | Acid | | | |

Complete the Table

| pH | Acid or Base | pOH | [H ⁺] | [OH ⁻] |
|-------|--------------|-------|-------------------|--------------------|
| 3.80 | Acid | 10.20 | | |
| 13.50 | Base | .50 | | |
| 6.66 | Acid | 7.34 | | |

Complete the Table

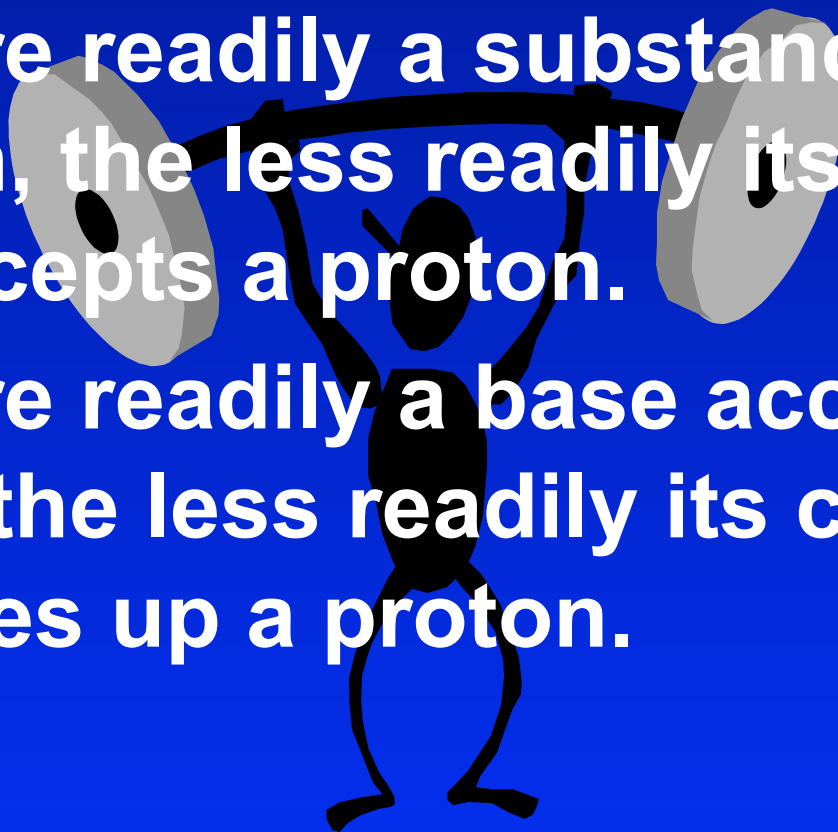
| pH | Acid or Base | pOH | [H ⁺] | [OH ⁻] |
|-------|--------------|-------|-------------------------|--------------------|
| 3.80 | Acid | 10.20 | 1.6 x 10 ⁻⁴ | |
| 13.50 | Base | .50 | 3.2 x 10 ⁻¹⁴ | |
| 6.66 | Acid | 7.34 | 2.2.x 10 ⁻⁷ | |

Complete the Table

| pH | Acid or Base | pOH | [H ⁺] | [OH ⁻] |
|-------|--------------|-------|-----------------------|-----------------------|
| 3.80 | Acid | 10.20 | 1.6×10^{-4} | 6.3×10^{-11} |
| 13.50 | Base | .50 | 3.2×10^{-14} | 3.2×10^{-1} |
| 6.66 | Acid | 7.34 | 2.2×10^{-7} | 4.6×10^{-8} |

Conjugate Acid–Base Strengths

- The more readily a substance gives up a proton, the less readily its conjugate base accepts a proton.
- The more readily a base accepts a proton, the less readily its conjugate acid gives up a proton.



Conjugate Acid–Base Strengths

- The stronger an acid, the weaker its conjugate base.
- The weaker an acid, the stronger its conjugate base.



Conjugate Acid–Base Strengths

Acid strength ↑

| Acid | Base |
|-------------------------------|----------------------------------|
| HCl | Cl ⁻ |
| H ₃ O ⁺ | H ₂ O |
| HF | F ⁻ |
| CH ₃ COOH | CH ₃ COO ⁻ |
| HCN | CN ⁻ |
| NH ₄ ⁺ | NH ₃ |

Base strength ↓