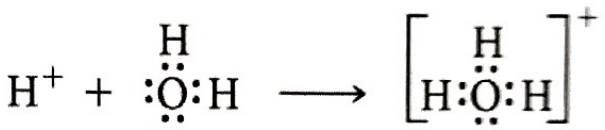
Acids and Bases: Equilibrium that Bites Back!

Types of Acids and Bases

	Arrhenius	Brønsted—Lowry	Notes
Acids	H^+ donor	H^+ donor	Same!!
Bases	OH^- donor	H^+ acceptor	different :(

***Note*:** H^+ ions are so reactive they cannot exist in water alone. Instead, they react with water molecules to produce complex ions, mainly **hydronium ion,** H_3O^+. Be careful: **H^+** and **H_3O^+** are often used interchangeably!



Chemists prefer the **Brønsted–Lowry** definition, because it Illustrates the reversibility of acid/base reactions as a proton exchange (mmm, equilibrium). To examine why, let's look at how the Bronsted-Lowry base, NH_3 (ammonia) reacts with water:

$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

Note: when a Bronsted-Lowry base reacts with water, OH^- is still produced! But it comes from what's left of the water molecule *after* NH_3 removes a proton (H^+).

You MUST know (i.e. memorize): NH_3 is a weak Brønsted-Lowry base!

Terms to Know

monoprotic acids: donate 1 H^+ (ex. $HC_2H_3O_2$)

diprotic acids: donate 2 H^+'s (ex. $H_2C_2O_4$)

polyprotic acids: donate many H^+'s (ex. H_3PO_4)

But be careful!

Acids only donate **ONE PROTON AT A TIME!**

*Don't forget the bases!

→ polyprotic bases: accept more than one H^+; anions with -2 or -3 charge (ex. PO_4^{3-}; HPO_4^{2-})

Amphoteric or amphiprotic: substances can act as either acids or bases (ex. H_2O, HCO_3^-, and $H_2PO_4^{2-}$)

- **Example 1:** Water as a base, accepting H^+ from HCl.

$$HCl(aq) + H_2O(l) \rightarrow Cl^-_{(aq)} + H_3O^+_{(aq)}$$

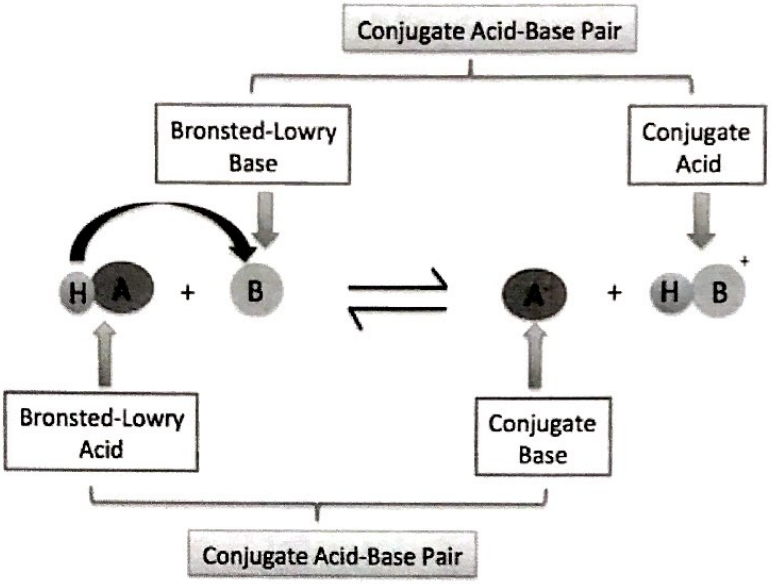
- **Example 2:** Water as an acid, donating H^+ to NH_3.

$$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+_{(aq)} + OH^-_{(aq)}$$

Conjugate Acid-Base Pairs

In a Brønsted–Lowry acid–base reaction, the original base becomes an acid in the reverse reaction, and the original acid becomes a base in the reverse process.

- Each reactant and the product it becomes is called a Conjugate **pair.**
- Conjugate pairs differ by the presence of 1 H^+ ion!



$$\underset{\text{acid}}{HA} + \underset{\text{base}}{H_2O} \rightleftharpoons \underset{\text{conjugate base (CB)}}{A^-} + \underset{\text{conjugate acid (CA)}}{H_3O^+}$$

➔ Conjugate acid-base pair? HA and A^-
or H_2O and H_3O^+

Note: By definition, the acid and base are the reactants, and the conjugates of each are the products.

Let's Try!

$$\underset{B}{NH_3} + \underset{A}{H_2O} \rightleftharpoons \underset{CA}{NH_4^+} + \underset{CB}{OH^-}$$

➔ Conjugate acid-base pair? NH_3 and NH_4^+
or H_2O and OH^-

Acid	Conjugate Base	Base	Conjugate Acid
HCl	Cl^-	NH_3	NH_4^+
HPO_4^{2-}	PO_4^{3-}	HPO_4^{2-}	$H_2PO_4^-$
H_2SO_4	HSO_4^-	OH^-	H_2O

Acid Nomenclature Review

Binary acids contain two different elements: hydrogen and one of the more electronegative elements. Aqueous solutions of these compounds are known by the acid names.

RULES:

1. Name begins with prefix hydro- ⇒ no polyatomic ions!
2. Root of name of second element follows this prefix
3. Name ends with suffix –ic. Add the word acid.

EXAMPLES:

1. HBr hydrobromic acid
2. H_3N hydronitric acid

Oxyacids are acid compounds of hydrogen, oxygen, and a third element. (H + polyatomic) Usually the oxyacid is one or more hydrogen followed by a polyatomic anion.

RULES:

1. NO PREFIX ⇒ no hydro!
2. Look at the polyatomic anion:
   a. if name ends in ate then the suffix is changed to ic.
   b. if name ends in ite then the suffix is changed to ous.
3. Add the word acid at the end.
4. NO HYDRO prefix!
5. Hint: Watch out for the dread disease called *Ate-ic ite-ous* ☺

EXAMPLES:

1. H_2SO_4 – Sulfuric Acid
2. H_2SO_3 – Sulfurous Acid

Table: Conventions for Naming Oxyacids

Relationship	General name	Example name	Example formula
one more oxygen atom than (root)ic	per(root)ic acid	perchloric acid	$HClO_4$
	(root)ic acid	chloric acid	$HClO_3$
one less oxygen atom than (root)ic	(root)ous acid	chlorous acid	$HClO_2$
two less oxygen atoms than (root)ic	hypo(root)ous acid	hypochlorous acid	HClO

Time to Practice!

1. H_2CO_3 carbonic acid
2. HNO_2 nitrous acid
3. HCl hydrochloric acid
4. $HBrO_2$ bromous acid
5. nitric acid HNO_3
6. phosphoric acid H_3PO_4
7. hydroiodic acid HI
8. sulfurous acid H_2SO_3