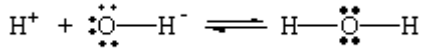
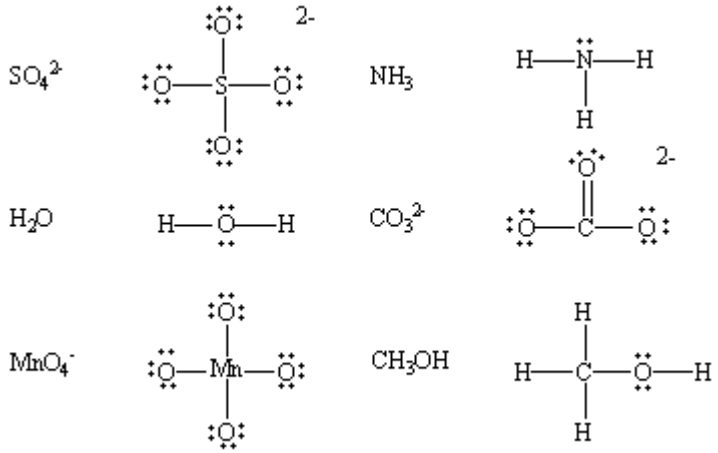
The Brønsted Definition of Acids and Bases

- The Brønsted, or Brønsted-Lowry, model is based on a simple assumption: **Acids donate H^+ ions to another ion or molecule, which acts as a base**. The dissociation of water, for example, involves the transfer of an H^+ ion from one water molecule to another to form H_3O^+ and OH^- ions.
    - $2H_2O(l) \Leftrightarrow H_3O^{+1}(aq) + OH^{-1}(aq)$
- According to this model, HCl doesn't dissociate in water to form H^+ and Cl^{-1} ions. Instead, an H^+ ion is transferred from HCl to a water molecule to form H_3O^+ and Cl^- ions, as shown in the figure below
    - $HCl(g) + H_2O(l) \Leftrightarrow H_3O^{+1}(aq) + Cl^{-1}(aq)$
- According to this theory, an H^+ ion is transferred from an HCl molecule to a water molecule when HCl dissociates in water
    - $HCl(g) + H_2O(l) \Leftrightarrow H_3O^{+1}(aq) + Cl^{-1}(aq)$
- HCl acts as an H^+-ion donor in this reaction, and H_2O acts as an H^+ ion-acceptor
- A Brønsted **acid** is therefore any substance (such as HCl) that can donate an H^+ ion to a base
- A Brønsted **base** is any substance (such as H_2O) that can accept an H^+ ion from an acid
- From the perspective of the Brønsted model, reactions between acids and bases always involve the transfer of an H^+ ion from a proton donor to a proton acceptor.
- Acids can be neutral molecules. $\underset{\text{acid}}{HCl(aq)} + \underset{\text{base}}{NH_3(aq)} \rightleftharpoons NH_4^+(aq) + Cl^-(aq)$
- They can also be positive ions $\underset{\text{acid}}{NH_4^+(aq)} + \underset{\text{base}}{OH^-(aq)} \rightleftharpoons NH_3(aq) + H_2O(l)$
- or negative ions. $\underset{\text{acid}}{H_2PO_4^-(aq)} + \underset{\text{base}}{H_2O(l)} \rightleftharpoons HPO_4^{2-}(aq) + H_3O^+(aq)$

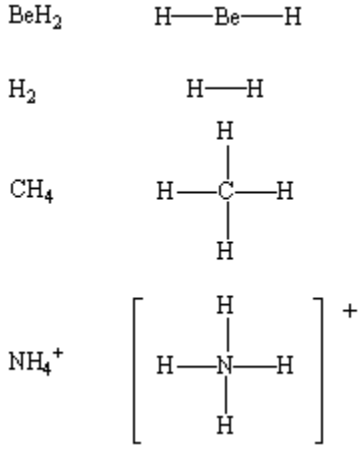
- According to the Brønsted model, a base is any ion or molecule that can accept a proton.
    - To understand the implications of this definition, look at how the prototypical base, the OH^- ion, accepts a proton.



- The only way to accept an H^+ ion is to form a covalent bond to it. In order to form a covalent bond to an H^+ ion that has no valence electrons, the base must provide both of the electrons needed to form the bond. Thus, only compounds that have pairs of nonbonding valence electrons can act as H^+-ion acceptors, or Brønsted bases.
- The following compounds, for example, can all act as Brønsted bases because they all contain nonbonding pairs of electrons.



- The Brønsted model expands the list of potential bases to include any ion or molecule that contains one or more pairs of nonbonding valence electrons.
- The Brønsted definition of a base applies to so many ions and molecules that it is almost easier to count substances, such as the following, that can't be Brønsted bases because they don't have pairs of nonbonding valence electrons.



- A product formed as a result of an acid losing a proton is called a **conjugate base**
- A product formed as a result of a base gaining a proton is called a **conjugate acid**
- A pair a substances that differ only by a proton is called a **conjugate acid-base pair**

eg) $HC_2H_3O_2(aq) + H_2O(l) \rightarrow H_3O^{+1}(aq) + C_2H_3O_2^{-1}(aq)$

acid	base	conjugate acid	conjugate base

eg) $HBr(aq) + H_2O(l) \rightarrow H_3O^{+1}(aq) + Br^{-1}(aq)$

acid	base	conjugate acid	conjugate base

- A substance that appears to act as a Brønsted-Lawry acid in some reactions and a Brønsted-Lowry base in other reactions is called **amphiprotic**

$HCO_3^{-1}(aq) + H_3O^{+1}(aq) \rightarrow H_2CO_3(aq) + H_2O(l)$

base acid

$HCO_3^{-1}(aq) + OH^{-1}(aq) \rightarrow CO_3^{-2}(aq) + H_2O(l)$

Acid base

The Advantages of the Brønsted Definition

The Brønsted definition of acids and bases offers many advantages over the Arrhenius and operational definitions.

- It expands the list of potential acids to include positive and negative ions, as well as neutral molecules.
- It expands the list of bases to include any molecule or ion with at least one pair of nonbonding valence electrons.
- It explains the role of water in acid-base reactions: Water accepts H^+ ions from acids to form the H_3O^+ ion.
- It can be expanded to include solvents other than water and reactions that occur in the gas or solid phases.
- It links acids and bases into conjugate acid-base pairs.
- It can explain the relationship between the strengths of an acid and its conjugate base.
- It can explain differences in the relative strengths of a pair of acids or a pair of bases.

It can explain the leveling effect of water — the fact that strong acids and bases all have the same strength when dissolved in water.