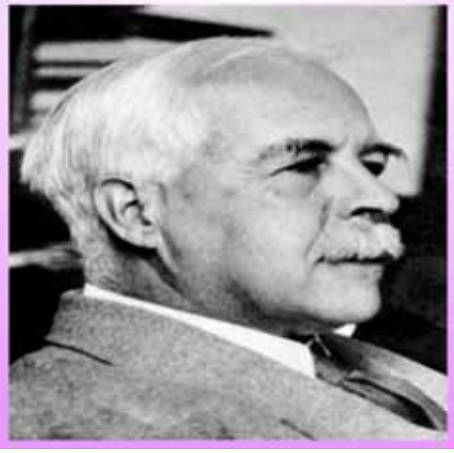
Lewis Acid-Base Concept



Learning Outcomes:

Students will be able to:

1. state and explain Lewis concepts of acids and bases.
2. classify substances as Lewis acids or bases.
3. explain the self ionization of water.

$$HA \xrightleftharpoons{H_2O} H^+_{(aq)} + A^-_{(aq)}$$

$$H^+ + H_2O \rightleftharpoons (H_3O^+)_{(aq)}$$

$$H_3N + H\text{-}OH \longrightarrow NH_4^+{}_{(aq)} + OH^-_{(aq)}$$

Acid Review **Base Review**

Introduction:

- In 1923 G.N. Lewis, American Chemist, put forward a more generalized acid-base concept.

  According to this concept,

- **An acid:**

  "is a species (charged or uncharged), which can accept a pair of electron."

- **A base:**

  "is a species (charged or uncharged), which can donate a pair of electron."

Electrophiles = Electron deficient species.

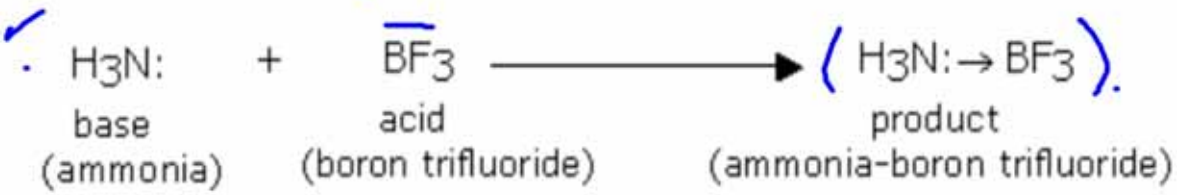
→ Lewis Acids

Nucleophiles = Electron rich species.

→ Lewis Bases

Thus, a Lewis acid is an electrophile, and a Lewis base is a nucleophile.

For example:



In the above reaction, NH_3 is a donor of electron pair and BF_3 accepts a pair of electron. So, according to the Lewis concept, NH_3 is a Lewis base, and BF_3 is a Lewis acid.

The boron atom in boron trifluride, BF_3, has only six electrons in its valence shell. Consequently, BF_3 is a very good Lewis acid and reacts with many Lewis bases; fluoride ion is the lewis base in the reaction:

In the following reaction, each of two ammonia molecules i.e. a Lewis base, donates a pair of electron to a silver ion i.e. Lewis acid.

In the following example, in which four ammonia molecules serve as Lewis bases. Each ammonia molecule donates a pair of electron to a copper ion that serves as the Lewis acid.

$4NH_3 + Cu^{2+}_{(aq)} \rightarrow [Cu(NH_3)_4]^{2+}_{(aq)}$

Bluish colour

Dark blue colour

Non-metal oxides act, as Lewis acids react with oxide ions; the Lewis base, to form oxyanions.

$O^{2-} + SO_3 \rightarrow [SO_4]^{2-}$

$Na_2O + SO_3 \longrightarrow Na_2SO_4$.

Classification of substances as Lewis Acids and Bases:

Lewis Acids:

1. Compounds having less than a full octet of electrons behave as Lewis acids.
   - BF_3, SO_3, $AlCl_3$ etc.
2. Positive ions are often considered as Lewis acids.
   - H^+, Ag^+, Co^{3+}, Cu^{2+} etc.
3. All molecules in which the central atom can acquire more than eight valence electrons.
   - $SiCl_4$, SiF_4, $SnCl_4$ etc.
4. Molecules with multiple bonds between atoms of different electronegativities.
   - CO_2, SO_2 etc.

Lewis Bases:

The following types of compounds or species are Lewis bases.

1. **All anions are Lewis bases.**

   OH^-, CN^- , CH_3COO^- etc.

2. **All molecules having lone-pairs of electrons.**

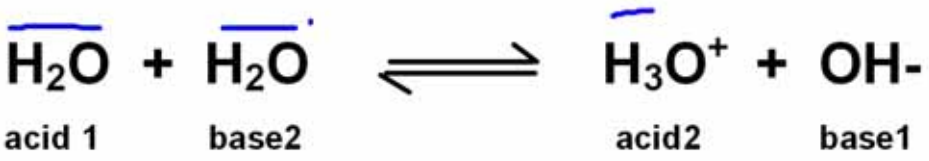
   :NH_3, H_2O:, CO:, and amines etc.

Self Ionization of Water: animation

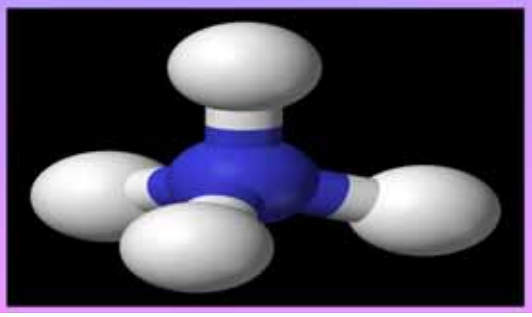
Water, as we know, is a unique solvent. One of its special properties is its ability to act both as an acid and as a base. Water functions as a base in reactions with acids such as HCl and CH_3COOH, and it functions as an acid in reactions with bases such as NH_3. Water is a very weak electrolyte, therefore a poor conductor of electricity, but it does undergo ionization to a small extent:

This reaction is sometimes called the *autoionization* of water. To describe the acid-base

properties of water in the Bronsted framework, we express its autoionization as



Multiple Choice Questions



1. Which of the following is a lewis acid?

A. H_2O
B. NH_3
C. H^+
D. Cl^-

2. Which of the following is **NOT** a Lewis Base?

A. NH_4^+
B. S^{2-}
C. H_2O
D. $CH_3\text{-}NH_2$

3. Which of the following reactions represent Lewis-acid-base reaction?

A. $CH4 + 2O2 \rightarrow CO_2 + 2H_2O$

B. $4Fe + 3O_2 \rightarrow 2Fe_2O_3$

C. $PbCO_3 \rightarrow PbO + CO_2$

D. $AlCl_3 + NH_3 \rightarrow AlCl_3NH_3$