Definitions of Acids & Bases

Outcomes:

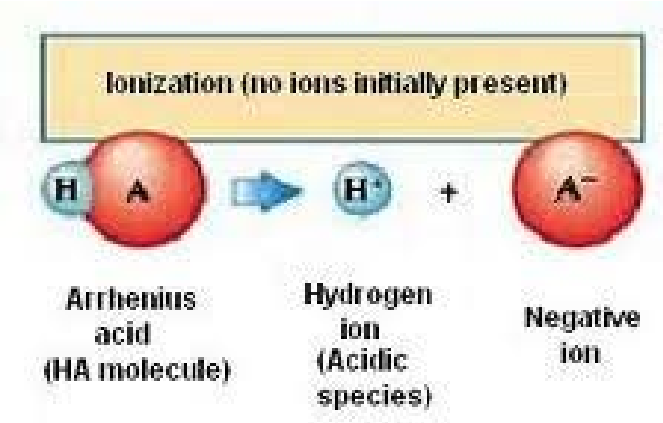
- Outline the historical development of acid-base theories. Include: Arrhenius, Lowry-Bronsted, Lewis.
- Write acid/base chemical equations. Include conjugate pairs, amphoteric behaviour.

Arrhenius Definition:

Acids:

- ***An acid is a substance that releases H^+ ions in water.***

Ex) $HCl_{(aq)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$



Bases :

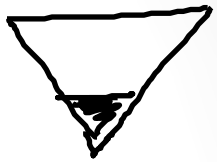
- ***A base is a substance that releases OH^- ions in water.***

Ex) $NaOH_{(aq)} \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$

$H_2O +$ $NH_{3(aq)} \rightarrow NH_4^+{}_{(aq)} + OH^-_{(aq)}$

Problems With Arrhenius' Definition:

- Arrhenius' definition says that acids and bases can only **OCCUR** in **WATER SOLUTIONS**.
- However, **HCl** reacts with **NH_3** in the **GAS PHASE**.
- This means that, as a **GAS**, **HCl** is an **ACID**, and **NH_3** is a **BASE**.
- There are also many substances that are **ACIDIC** or **BASIC**, but do not have a **H^+** ion or a **OH^-** ion.
- For Example:
  - **BAKING SODA** (***$NaHCO_3$***) turns **RED** litmus **BLUE**, but has no apparent **OH^-** ion.
  - **METAL** ions, (***Fe^{3+}, Al^{3+}***) turn **BLUE** litmus **RED**, but have no **H^+** ions.
- Arrhenius' definition does not account for these.



$NaHCO_3$

Lowry-Bronsted Theory:

Thomas Lowry and Johannes Bronsted developed a more general definition of acids and bases

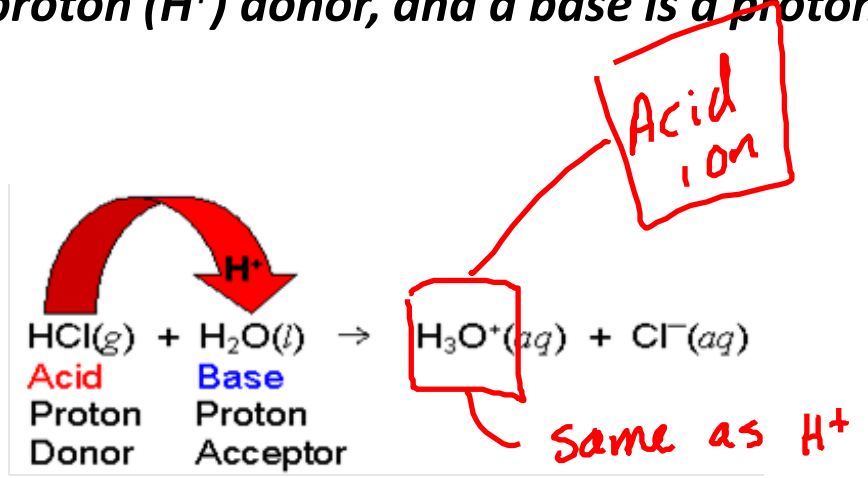
Hydrogen - $1p^+$

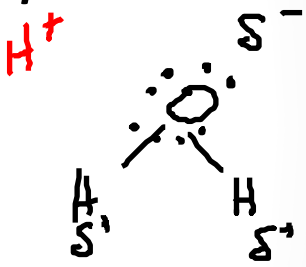
$1p^+$

They said:

- ***An acid is a proton (H^+) donor, and a base is a proton acceptor.***

For example:

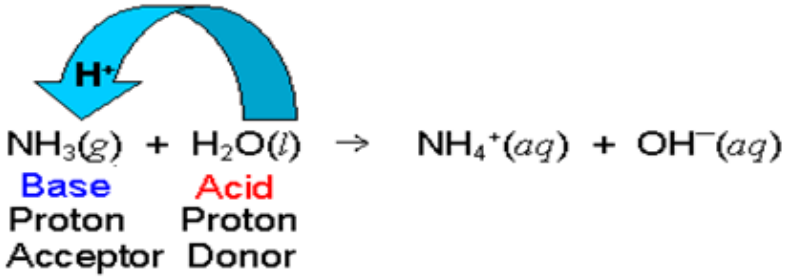




HCl reacts with water by **DONATING** a **PROTON**. Water acts as the base, **ACCEPTING** the **PROTON**. The result is the H_3O^+ ion called the **HYDRONIUM ION**.

Lowry-Bronsted Theory:

AMMONIA ACCEPTS a **PROTON** from **WATER**, making **AMMONIA** a **BASE** and **WATER** the **ACID**. The result is the **AMMONIUM ION** and the **HYDROXIDE ION**.



Lowry-Bronsted Theory:

A couple of important points:

- **ACIDS** do not "**DONATE**" protons **WILLINGLY**, **BASES** actually "**STEAL**" the **PROTON** away by **BREAKING** bonds in the **ACID**.
- Some substances (like water) can act as ***BOTH*** acids and bases. They are called **AMPHOTERIC**.
- **ALL ARRHENIUS** acids/bases are **LOWRY**-**BRONSTED** acids/bases, but **NOT ALL LOWRY**-**BRONSTED** acids/bases are **ARRHENIUS** acids/bases.

Problem with the Lowry-Bronsted Definition:

- Some compounds like Boron trifluoride exhibits acidic behaviour, but does not donate or accept protons.

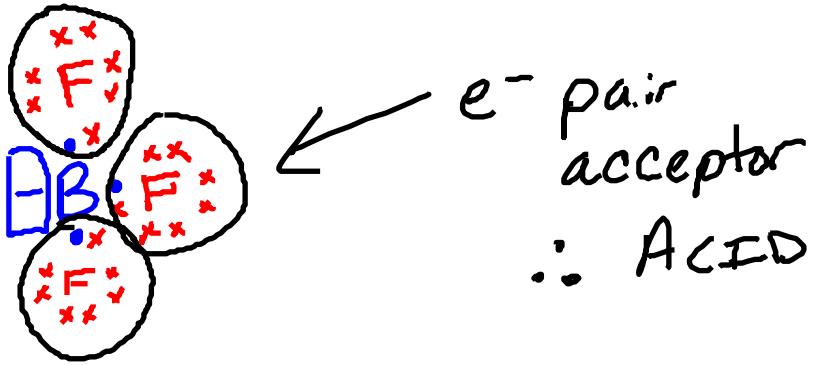
Lewis Model of Acids and Bases:

Gilbert Lewis proposed a new definition in the 1920's

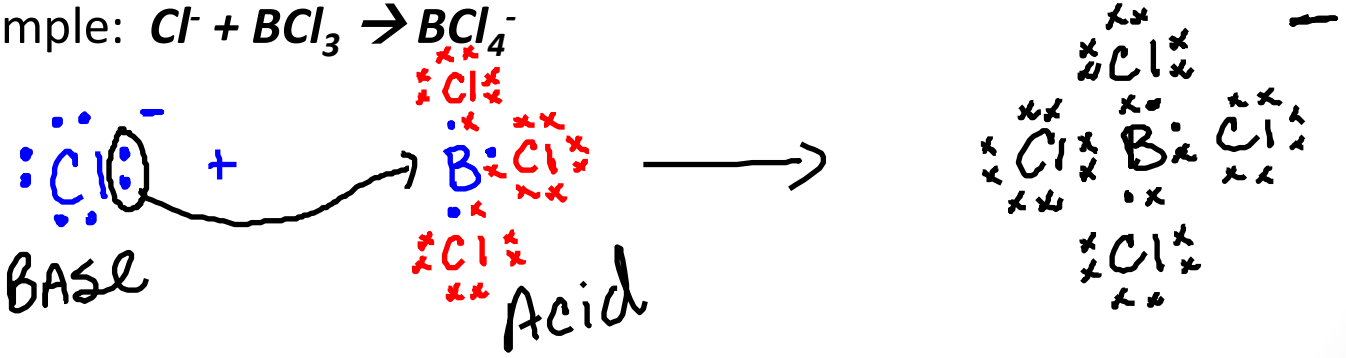
He said:

- ***An acid accepts an electron pair, and a base donates an electron pair during a reaction.***

Example: BF_3



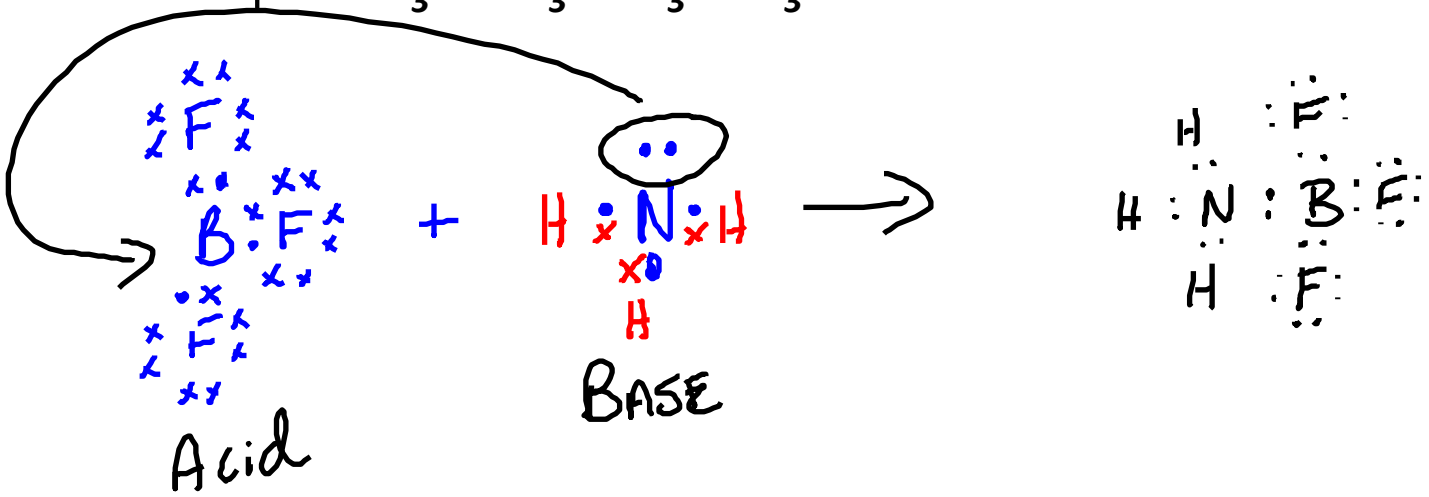
For example: ***$Cl^- + BCl_3 \rightarrow BCl_4^-$***



- The **BCl_3** acts as the Lewis **ACID** (**ACCEPTS** an **e^- pair**), and the **Cl^-** acts as a Lewis **BASE** (**DONATES** an **e^- pair**).

Lewis Model of Acids and Bases:

Another example: $BF_3 + NH_3 \rightarrow F_3BNH_3$

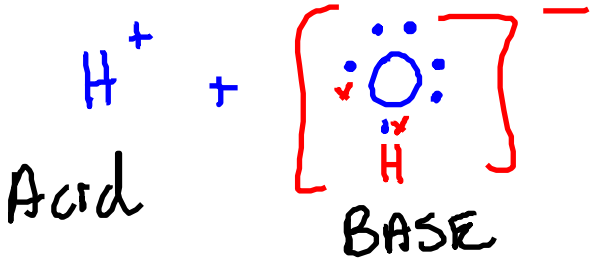


- **BORON** has an **EMPTY SPACE** for an **ELECTRON PAIR**, so it will **ACCEPT** the pair from **AMMONIA**. Therefore **BF_3** is a Lewis **ACID** and **AMMONIA** is a Lewis **BASE**.

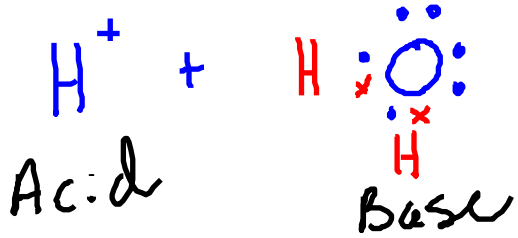
Try these ones:

Identify the following reactants as a Lewis acid or a Lewis base:

a) $H^+ + OH^- \rightarrow H_2O$



b) $H^+ + H_2O \rightarrow H_3O^+$



c) $AlCl_3 + Cl^- \rightarrow AlCl_4^-$