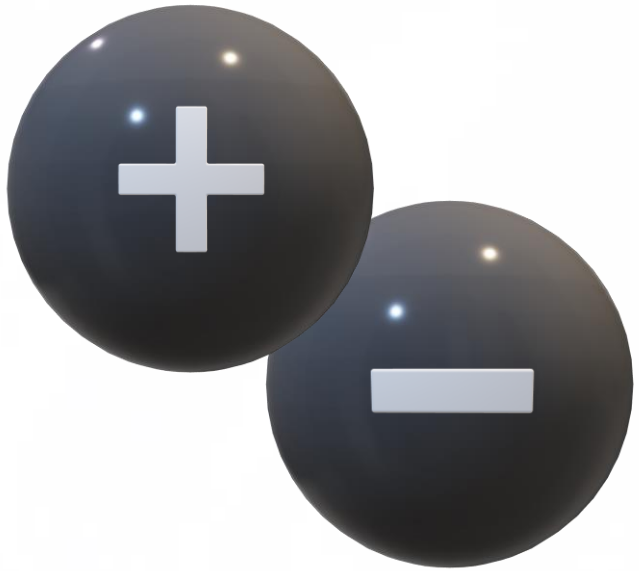
Physical Pharmacy



Ionic Equilibria

Contents

In this lecture, you'll learn:

- Definitions of Acids and Bases
  a. According to Arrhenius concept
  b. According to Brönsted–Lowry concept
  c. According to Lewis electronic theory.

- Relative Strength of Acids and Bases

- Classifications of Solvents(based on proton accepting and donating properties)

DR CUBE

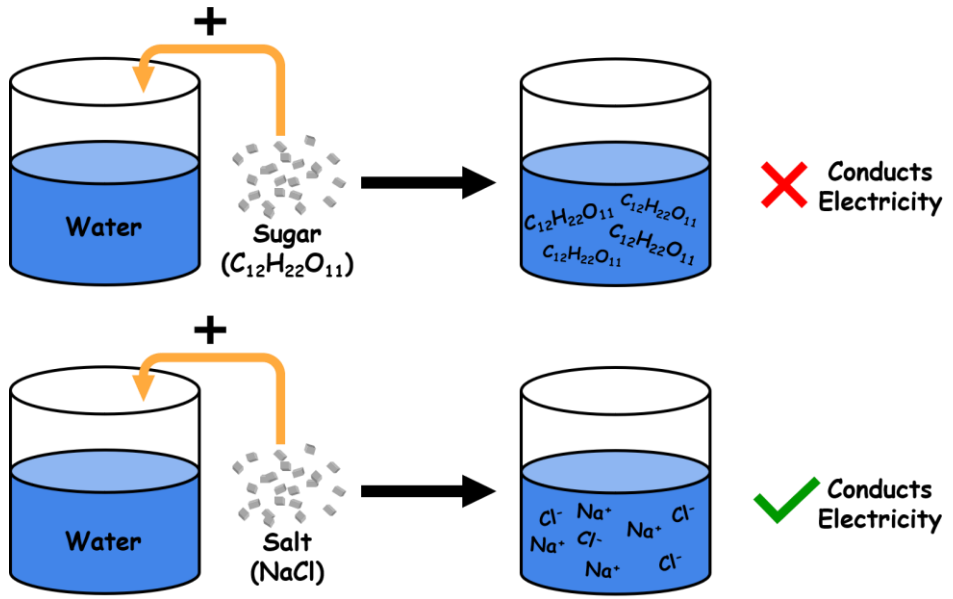
Introduction

- **Electrolytes** are substances containing free ions, thus rendering the substance electrically conductive.

- Electrolytes are classified broadly as:

a. **Strong electrolytes:** includes solutions of strong acids, strong bases, and most salts.

b. **Weak electrolytes:** includes weak acids and bases.



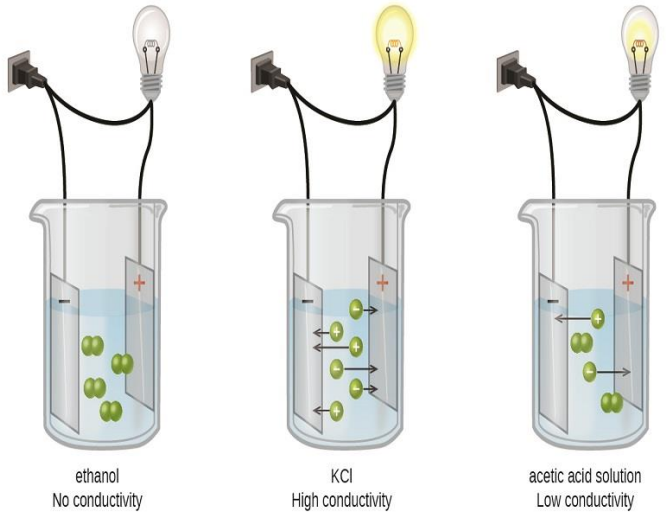
DR CUBE

Introduction

- The usual criterion for distinguishing between strong and weak electrolytes is the **extent of ionization**

- Strong electrolytes completely, or almost completely, dissociate into their ions in solution, and as such, it is difficult to determine an ionization constant for these.

- **Weak electrolytes**, which ionize weakly, exist both in the unionized (molecular) and ionized state in solution.



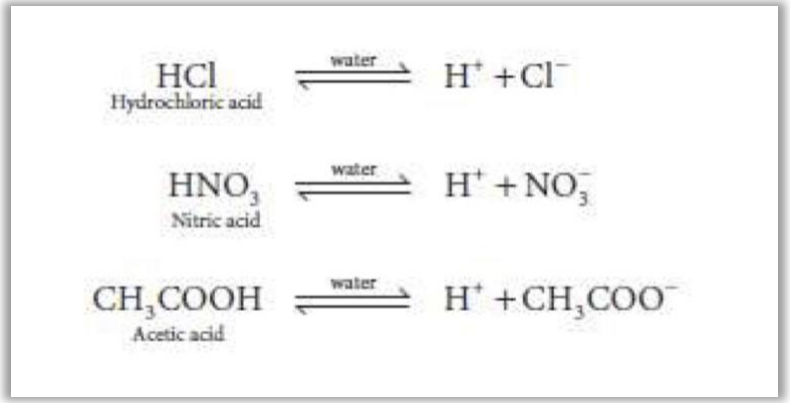
DR CUBE

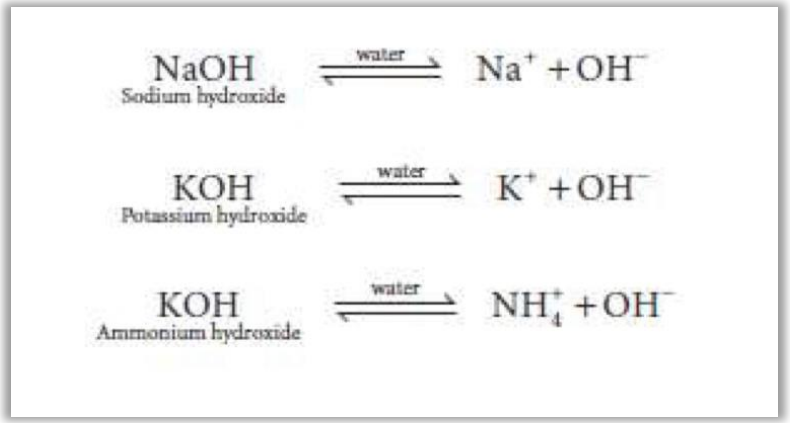
Definitions of Acids and Bases

Arrhenius concept:

- **Acid** : "A substance that liberates hydrogen ions on dissociation"

- **Base:** "A substance that supplies hydroxyl ions on dissociation"





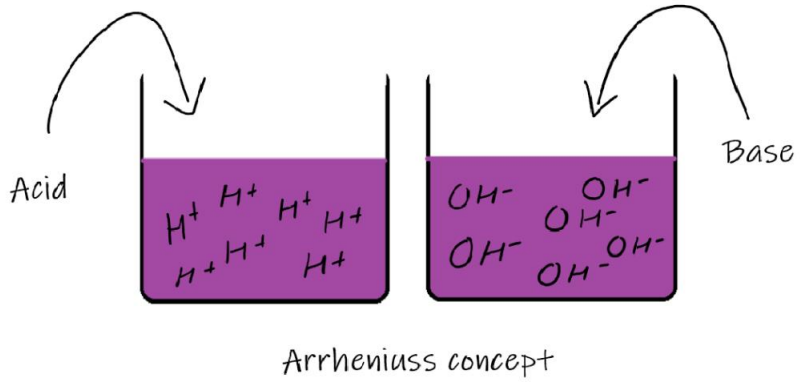
DR CUBE

Definitions of Acids and Bases

Arrhenius concept: Limitation of Arrhenius Theory

- There are substances such as NH3, CaO, etc., which do not contain the hydroxyl group but can still act as bases, Similarly, there are substances, such as carbon dioxide, which cannot, by themselves, dissociate to form hydrogen ions but even then act as acids in aqueous solution.

- The concept was limited to only one solvent that is water, so it is only applicable to water soluble compounds.



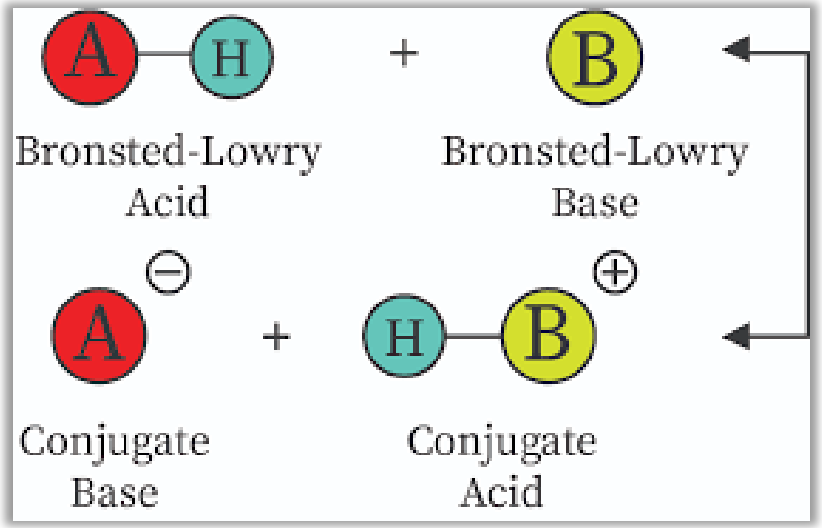
Arrheniuss concept

DR CUBE

Definitions of Acids and Bases

Brönsted–Lowry concept : “proton transfer theory of acids and bases”

- **Acid = proton donor:** “A substance, charged or uncharged, that is capable of donating a proton
- ”**HCl** is an acid because it donates a proton to water
- **Base = proton acceptor“**A substance, charged or uncharged, that is capable of accepting a proton from an acid”.
- **Ammonia** is a base because it accepts a proton from water.



DR CUBE

Definitions of Acids and Bases

Brönsted–Lowry concept:

Note:

a. For an acid to act as a proton donor, a base (proton acceptor) must be present to receive proton.

b. For example, acetic acid or **HCl** acts as an acid in water but not in benzene because benzene does not accept proton.

c. According to Brönsted–Lowry concept , since acid-base reactions involve a transfer of a proton, they are known as "**protolytic reactions**" or "**protolysis**"

d. In the reaction between HCl and water, HCl is the acid and water the base:

DR CUBE

Definitions of Acids and Bases

Brönsted–Lowry concept:

- Acid-base reactions may be of different types as follows :

	Acid1		Base2		Acid2		Base1
Neutralization	NH_4^+	+	OH^-	=	H_2O	+	NH_3
Neutralization	H_3O^+	+	OH^-	=	H_2O	+	H_2O
Neutralization	HCl	+	NH_3	=	NH_4^+	+	Cl^-

- In a neutralization reaction, there is a combination of the shape of intainer H* ions lost from an acid with and OH- ions and wil form water.

- When all the acid has been neutralized there are no molecules of the acid (or hydrogen ions produced by dissociation of the molecule) left in solution

DR CUBE

Definitions of Acids and Bases

Brönsted–Lowry concept:

- Hydrolysis is any chemical reaction in which a molecule of water breaks one or more chemical bonds

	Acid1		Base2		Acid2		Base1
Hydrolysis	H_2O	+	CH_3COO^-	=	CH_3COOH	+	OH^-
Hydrolysis	NH_4^+	+	H_2O	=	H_3O^+	+	NH_3

DR CUBE

Definitions of Acids and Bases

Brönsted–Lowry concept:

- Displacement reaction occurs when a more reactive element displaces, or pushes out, a less reactive element from a compound that contains the less reactive element.

- After a displacement reaction, the less reactive element is now pure and left uncombined.

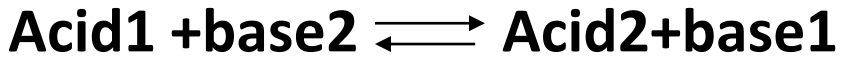
	Acid1		Base2		Acid2		Base1
Displacement	HCl	+	CH_3COO^-	=	CH_3COOH	+	Cl^-

DR CUBE

Definitions of Acids and Bases

Brönsted–Lowry concept: Conjugate Acid-Base Pairs

- Whenever an acid and base reacts, a new pair of acid and base is formed.
- In general, each acid base reaction involves two pairs of conjugate acids and bases.
- These are labelled as 1 and 2 as shown below:



- conjugate pair of an acid and a base differs by a proton only, i.e.

DR CUBE

Definitions of Acids and Bases

Brönsted–Lowry concept: Conjugate Acid-Base Pairs

Acid1		Base2		Acid2		Base1
Hcl	+	H2O	⟷	$H3O^+$	+	Cl^-
H2o	+	NH3	⟷	$NH4^+$	+	$O\bar{H}$
Hcl	+	NH3	⟷	$NH4^+$	+	Cl^-

DR CUBE

Definitions of Acids and Bases

Brönsted–Lowry concept: Conjugate Acid-Base Pairs

- To determine whether a substance is an acid or a base, count the hydrogens on each substance before and after the reaction.
- If the number of hydrogens has decreased that substance is the acid (donates hydrogen ions).
- If the number of hydrogens has increased that substance is the base (accepts hydrogen ions).
- These definitions are normally applied to the reactants on the left.
- If the reaction is viewed in reverse a new acid and base can be identified.
- The substances on the right side of the equation are called conjugate acid and conjugate base compared to those on the left.
- Also note that the original acid turns in the conjugate base after the reaction is over.

DR CUBE

Definitions of Acids and Bases

Brönsted–Lowry concept: Relative Strength of Acids and Bases

- According to Bronsted–Lowry concept, the strength of an acid depends upon its tendency to lose protons while the strength of a base depends upon its tendency to gain protons.

Consider the reaction of hydrochloric acid with water:

$$\underset{\text{Strong acid}}{HCl} + H_2O \rightleftharpoons H_3O^+ + \underset{\text{Weak conjugate base}}{Cl^-}$$

- HCl, being a strong acid, is highly ionized and thus the equilibrium shifts towards the righthand side.
- On the other hand, Cl- (conjugated base of HCl) has a less tendency to accept a proton.
- Thus, a strong acid has a weak conjugate base.

Consider the reaction of acetic acid with water:

$$\underset{\text{Weak acid}}{CH_3COOH} + H_2O \rightleftharpoons H_3O^+ + \underset{\text{Strong conjugate base}}{CH_3COO}$$

- CH3COOH, being a weak acid, is only slightly ionized and thus the equil-brium shifts towards the left-hand side.
- On the other hand, CH3COO- (conjugate acid of CH3COOH) has a greater tendency to accept a proton.
- Thus, a weak acid has a strong conjugate base.

DR CUBE

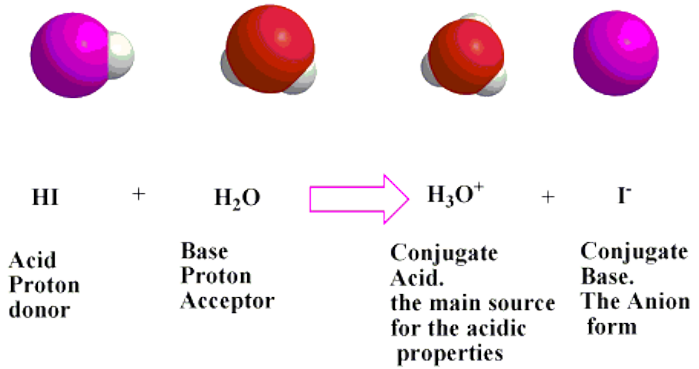
Definitions of Acids and Bases

Brönsted–Lowry concept: Conjugate Acid-Base Pairs

- Acid base properties are closely connected with the properties of solvents
- The strength of an acid depends also on the ability of solvent to accept proton from an acid.
- This is called **“the basic strength of the solvent”.**
- **For example:**

a. HCl is a weak acid in glacial acetic acid

b. Acetic acid is a strong acid in liquid ammonia



DR CUBE

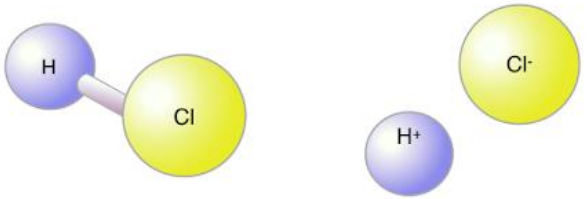
Definitions of Acids and Bases

Brönsted–Lowry concept: Limitation of Bronsted—Lowry Theory

- Fails to explain the acidic and basic nature of compounds having no tendency to lose or accept protons, as in the following example:

$$CaO + SO_3 \longrightarrow CaSO_4$$

- Can not explain reactions taking place in non-aqueous solvents



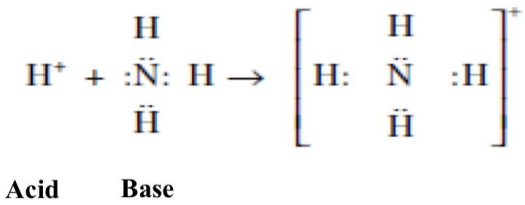
- Can not explain the basic nature of compounds having (OH-) ions such as **NaOH, KOH, etc.**

DR CUBE

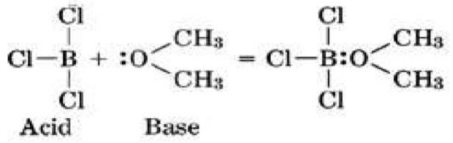
Definitions of Acids and Bases

Lewis Elcectronic Theory:

- **Acid :** A molecule or an ion that accepts an electron pair to form a covalent coordinate bond”



- **Base:** “A substance that provides the pair of unshared electrons by which the base coordinates with an acid”.



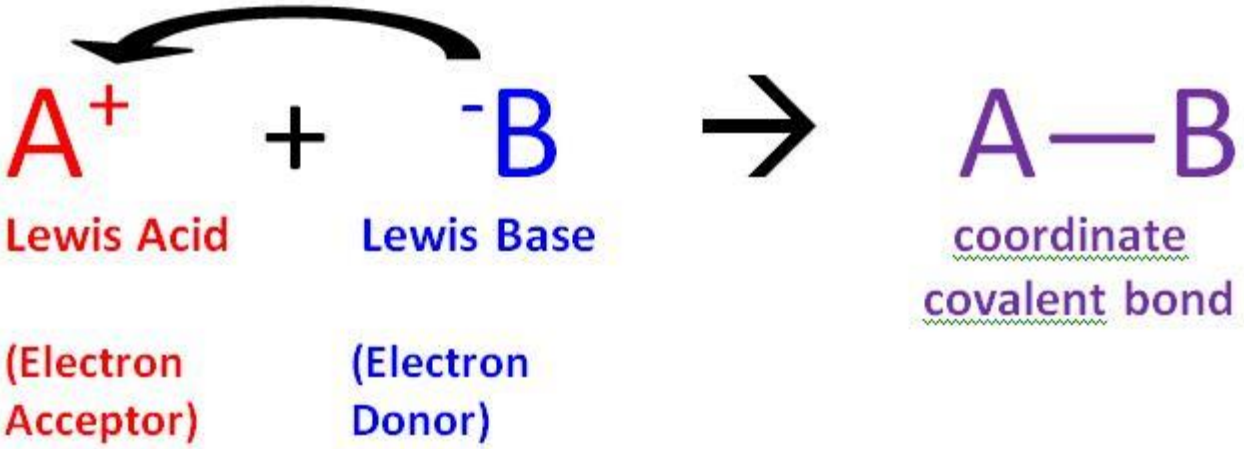
Examples

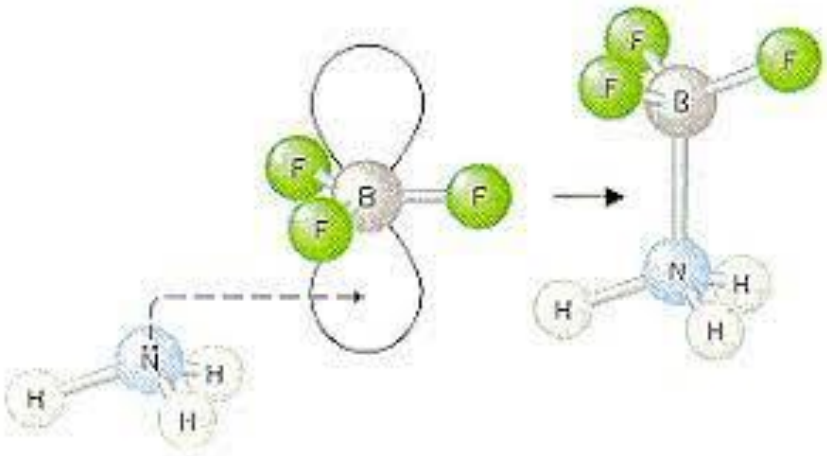
- The Lewis theory is finding increasing use for describing the mechanism of many organic and inorganic reactions

DR CUBE

Definitions of Acids and Bases

Lewis Elcectronic Theory:





DR CUBE

Classification Of Solvent

Based on the proton donating and accepting ability of the solvent

- Aprotic Solvents or non protonic solvents:are those solvents which neither donate nor accept protons. Hence they are neither acids nor bases (neutral)

- **Example**

  C_6H_6 , CCl_4

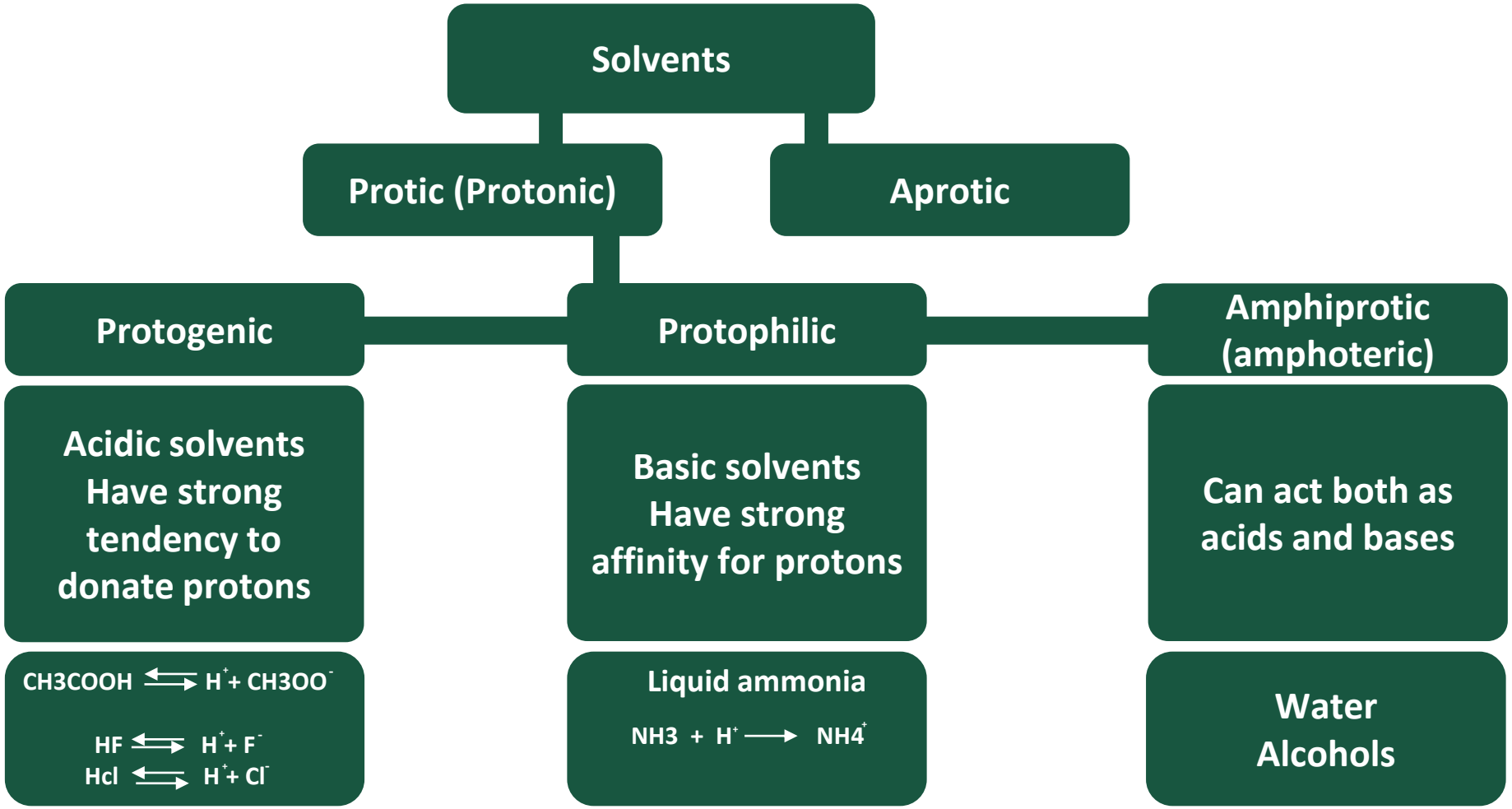
- Protic or protonic solvents: are those solvents which contain replacable hydrogen atom.

- They can be further calssified into 3 types as shown in the diagram

DR CUBE

Classification Of Solvent

Based on the proton donating and accepting ability of the solvent



DR CUBE

DR CUBE

Thank You !

https://t.me/Dr_Cube