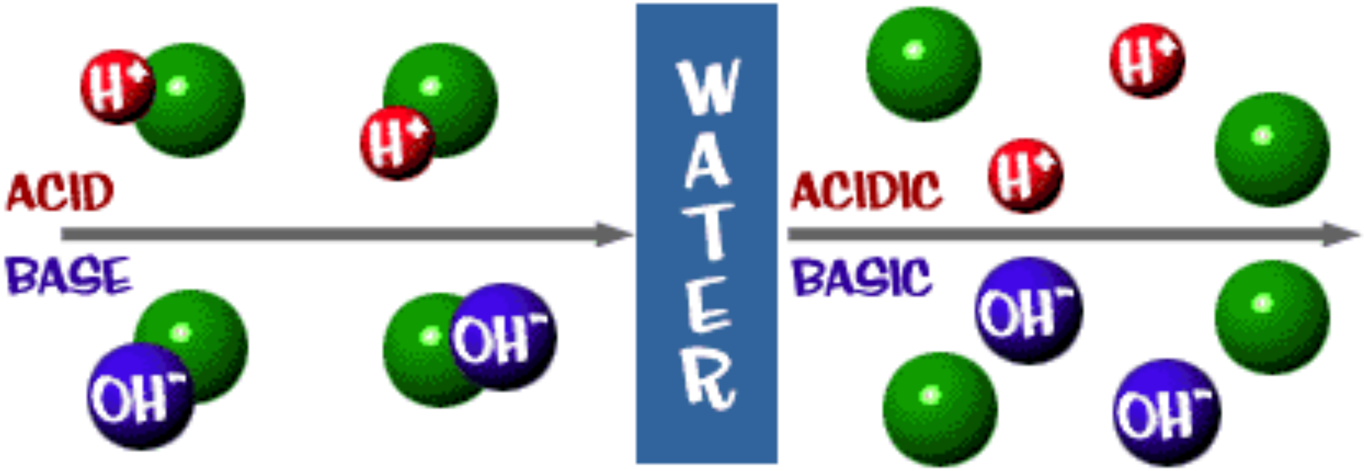
Chapter 8
Acids and Bases
Lecture 11



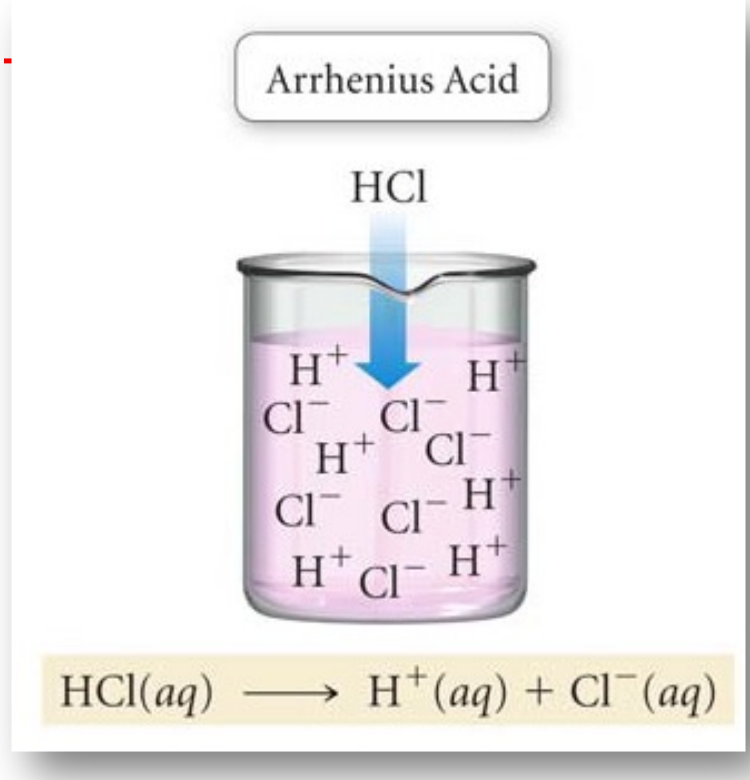
8.1 Introduction

Definition of acids according to Arrhenius

- Acids “These are the substances which produce Hydronium ions (H_3O^+) in aqueous solutions”.

$$H_2O_{(\ell)} + HCl_{(aq)} \rightleftharpoons H_3O^+ + Cl^-$$

$$H^+(aq) + H_2O(\ell) \longrightarrow H_3O^+(aq)$$



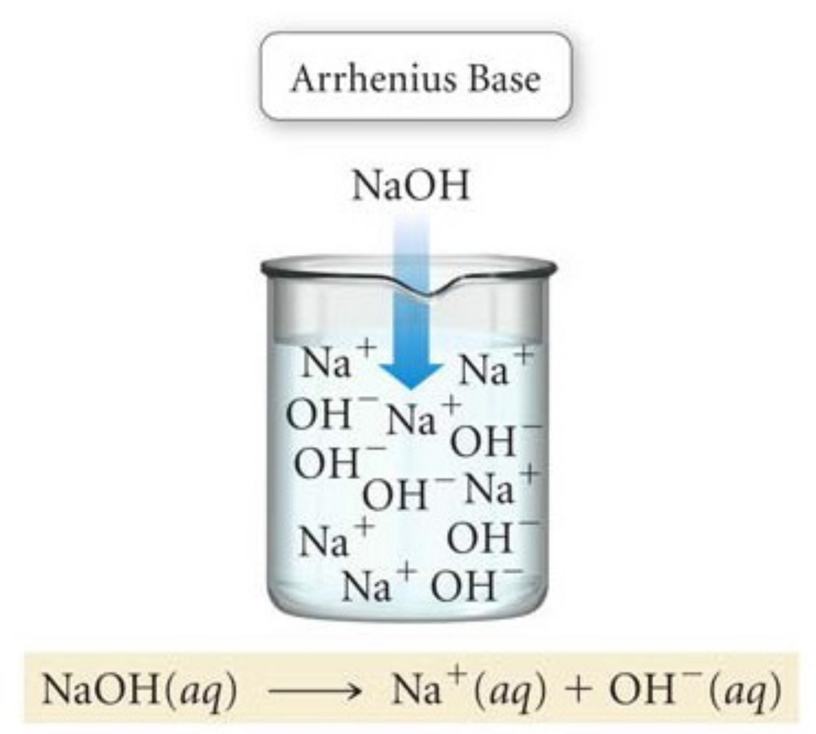
$$HCl(aq) \longrightarrow H^+(aq) + Cl^-(aq)$$

Definition of base according to Arrhenius

- Bases “These are the substances which produce hydoxide ions OH^- in aqueous solutions”.

$$NaOH(s) \xrightarrow{H_2O} Na^+(aq) + OH^-(aq)$$

Note: Ammonia is not hydroxide but it dissolves in water producing hydroxide ion OH^-.



$NaOH(aq) \longrightarrow Na^+(aq) + OH^-(aq)$

$$NH_3(g) + H_2O(\ell) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

8.2 Acid and Base Strength

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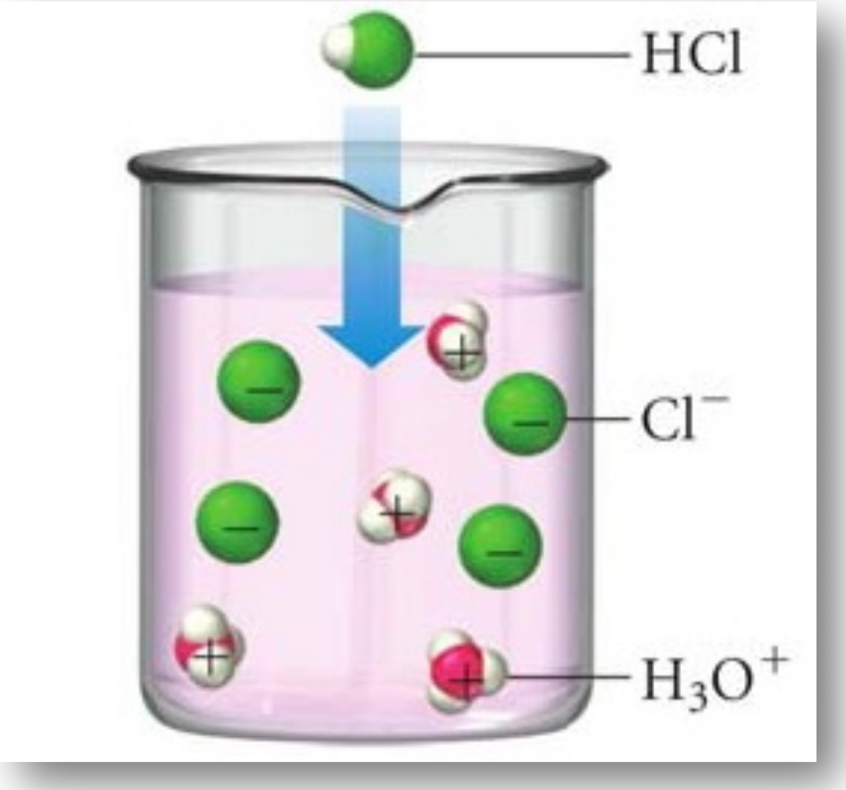
- According to Arrhenius definition:
- **Strong Acid:** “It is the acid that is completely ionized in water”

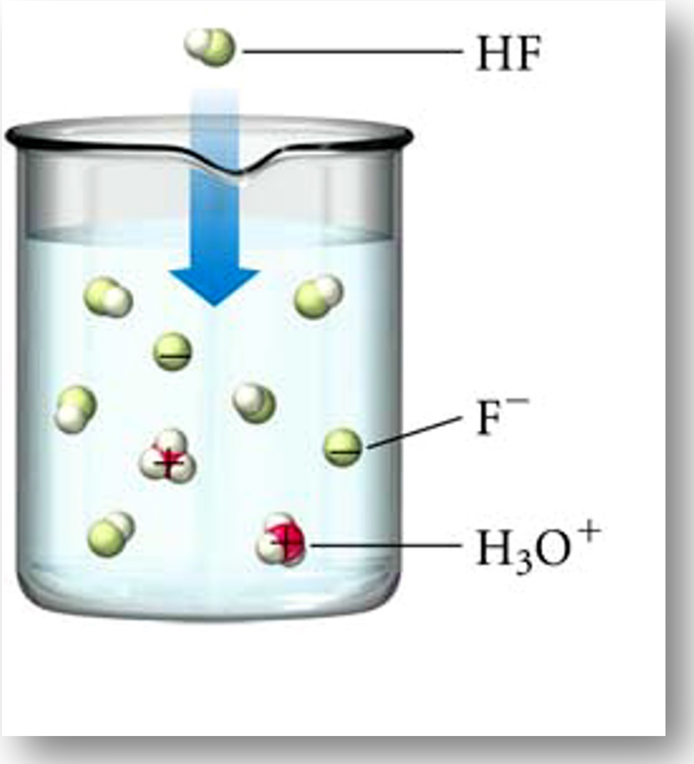
$$HCl(aq) \xrightarrow{H_2O} H^+(aq) + Cl^-(aq)$$



- **Weak acid** “ It is the acid which is partially ionized in water”

$$CH_3COOH(aq) + H_2O \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq)$$

- Also, bases can be classified into strong and weak.



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Names of Some Acid and Bases

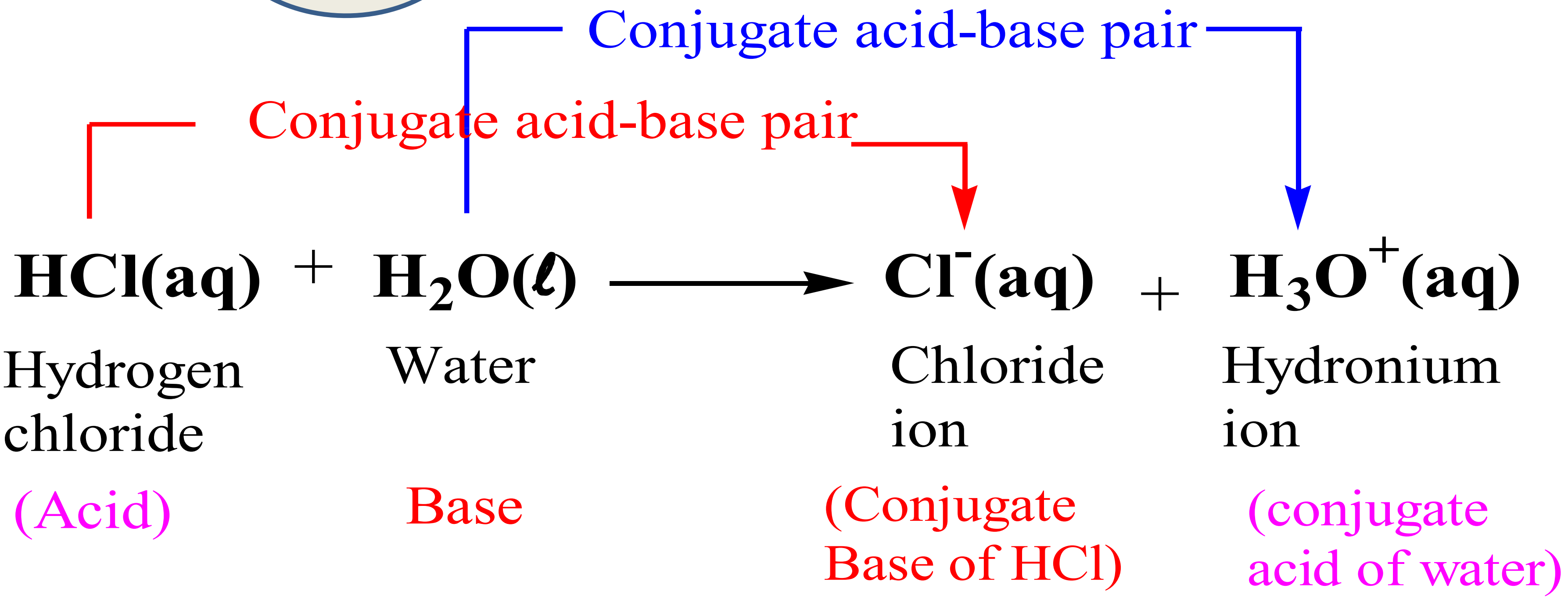
Formula	Name	Formula	Name
HCl	Hydrochloric acid	$LiOH$	Lithium hydroxide
HBr	Hydrobromic acid	$NaOH$	Sodium hydroxide
HI	Hydroiodic acid	KOH	Potassium hydroxide
HNO_3	Nitric acid	$Ba(OH)_2$	Barium hydroxide
H_2SO_4	Sulphuric acid		
$HClO_4$	Perchloric acid		

8.3 Bronsted-Lowry Acids and Bases

- According to Bronsted-Lowry:
- Acid "It is a proton donor
- Base " It is a proton acceptor.
- **Acid-base reaction** "It is a proton transfer reaction"
- **Conjugate Base** "It is the substance formed when an acid donates its proton to another molecule or ion"

	Acid	Name of acid	Conjugate Base	Name of ion	
Strong Acids	HI	Hydroiodic acid	I^-	Iodide	Weak Bases
	HCl	Hydrochloric acid	Cl^-	Chloride	
	H_2SO_4	Sulfuric acid	HSO_4^-	Hydrogen sulfate	
	HNO_3	Nitric acid	NO_3^-	Nitrate	
	H_3O^+	Hydronium ion	H_2O	Water	
	HSO_4^-	Hydrogen sulfate ion	SO_4^{2-}	Sulfate	
	H_3PO_4	Phosphoric acid	$H_2PO_4^-$	Dihydrogen phosphate	
	CH_3COOH	Acetic acid	CH_3COO^-	Acetate	
	H_2CO_3	Carbonic acid	HCO_3^-	Bicarbonate	
	H_2S	Hydrogen sulfide	HS^-	Hydrogen sulfide	
	$H_2PO_4^-$	Dihydrogen phosphate	HPO_4^{2-}	Hydrogen phosphate	
	NH_4^+	Ammonium ion	NH_3	Ammonia	
	HCN	Hydrocyanic acid	CN^-	Cyanide	
	C_6H_5OH	Phenol	$C_6H_5O^-$	Phenoxide	
	HCO_3^-	Bicarbonate ion	CO_3^{2-}	Carbonate	
	HPO_4^{2-}	Hydrogen phosphate ion	PO_4^{3-}	Phosphate	
Weak Acids	H_2O	Water	OH^-	Hydroxide	Strong Bases
	C_2H_5OH	Ethanol	$C_2H_5O^-$	Ethoxide	

When an acid transfers a proton to a base, the acid is converted to its conjugate base.



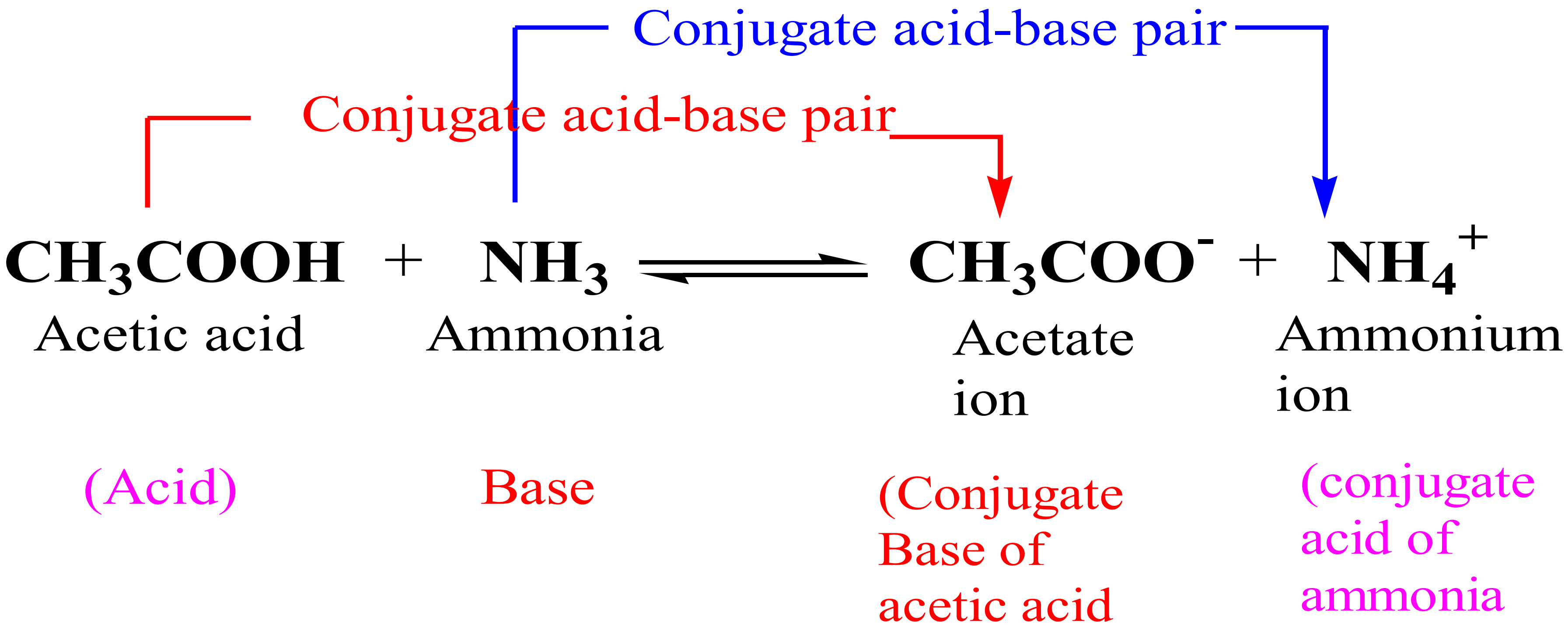
Conjugate acid-base pair

Conjugate acid-base pair

$$HCl(aq) + H_2O(\ell) \longrightarrow Cl^-(aq) + H_3O^+(aq)$$

Hydrogen chloride	Water	Chloride ion	Hydronium ion
(Acid)	Base	(Conjugate Base of HCl)	(conjugate acid of water)

When a base accepts proton, it is converted to its conjugate acid.



Conjugate acid-base pair

Conjugate acid-base pair

$$CH_3COOH + NH_3 \rightleftharpoons CH_3COO^- + NH_4^+$$

Acetic acid	Ammonia	Acetate ion	Ammonium ion
(Acid)	Base	(Conjugate Base of acetic acid	(conjugate acid of ammonia

Examples of Common acids and their conjugate bases

- An acid can be positively charged, neutral or negatively charged. H_3O^+, H_2CO_3 and $H_2PO_4^-$

- Acids are classified as Monoprotic, diprotic or triprotic acids. E.g. HCl, CH_3COOH, H_2SO_4, H_2CO_3, and H_3PO_4

Revision questions

☐ Which of the following species can be Brønsted–Lowry bases: (a) LiOH; (b) Cl^- (c) CH_4?

- ANALYSIS A Brønsted–Lowry base must contain a lone pair of electrons, but it may be neutral or have a net negative charge.
- SOLUTION

a. **LiOH** is a base since it contains hydroxide, –OH, which has three lone pairs on its O atom.

b. **Cl^-** is a base since it has four lone pairs.

c. **CH_4** is not a base since it has no lone pairs.

- Draw the conjugate acid of each base:
- (a) F^-; (b) NO_3^-.
- SOLUTION (add a Proton H^+)

a. **F^- + H^+** gives HF as the conjugate acid. HF has no charge since a proton with a +1 charge is added to an anion with a –1 charge.

b. **NO_3^- + H^+** gives HNO_3 (nitric acid) as the conjugate acid. HNO_3 has no charge since a proton with a +1 charge is added to an anion with a –1 charge.

❑ Draw the conjugate base of each acid: (a) H_2O; (b) HCO_3^-.

- **ANALYSIS** To draw a conjugate base from an acid, remove a proton, H^+. This adds –1 to the charge of the acid to give the charge on the conjugate base.
- **SOLUTION**
- a. Remove H^+ from H_2O to form – OH^-
- b. Remove H^+ from HCO_3^- to form CO_3^{2-}, the conjugate base. CO_3^{2-} .

END OF THE LECTURE