ACIDS AND BASES – 1 INTRODUCTION

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ACIDS BASES: PROPERTIES

Properties	Acids	Bases
Taste	Sour	Bitter
Sense		Slippery
Reaction	Corrosive	Caustic
pH	0-7	7-14
Chemically	Has H^+	Has OH^-
Litmus paper	Blue to red	Red to blue
Examples		
Inorganic Usually strong	HCl, H_2SO_4, HNO_3, H_3PO_4	NaOH, KOH, $Ca(OH)_2$, NH_4OH
Organic Usually weak	CH_3COOH	CH_3NH_2 and other carbon and nitrogen based compounds

ACIDS AND BASES: DEFINITIONS

Definition	Acid	Base
Arrhenius Definition	proton (H^+) donor E.g.: HCl	hydroxide (OH^-) donor E.g. : NaOH
Brønsted–Lowry Definition	proton (H^+) donor E.g.: HCl	proton (H^+) acceptor E.g.: NH_3
Lewis Definition	electron pair acceptor E.g.: BF_3	electron pair donor E.g.: NH_3

One thing to remember is that acid in water is H_3O^+ not H^+.

Amphoteric substances behave like acids and bases.

ACID BASE: REACTIONS

Typically: ACID + BASE gives SALT + WATER (for Arhenius acid/base)

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

But Bronsted Lowry are different.

$$HCl + NH_3 \longrightarrow NH_4Cl$$ (note: no water!)

REACTION OCCURS IN THE DIRECTION OF WEAKER ACID-BASE

Monoprotic acids: give one proton on ionization: HCl, HNO_3

Diprotic acid: give two protons on ionization – but one can write two ionization steps: H_2SO_4

$$H_2SO_4 + H_2O \longrightarrow HSO_4^- + H_3O^+ \rightleftharpoons SO_4^{2-} + H_3O^+$$

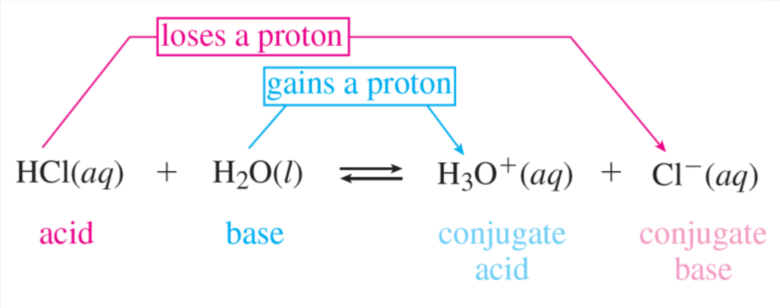
(Note: the first ionization is easy, but second is in equilibrium)

Triprotic acid: three acidic protons: H_3PO_4, with each ionization of a proton, the 2^{nd} one gets harder and harder.

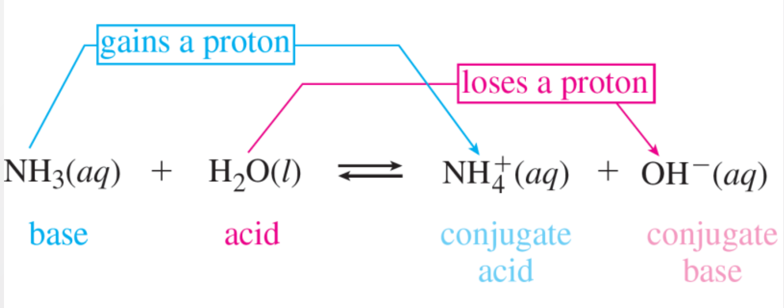
CONJUGATE ACIDS AND BASES

Substances in the acid–base reaction that differ by the gain or loss of a proton, H^+, are called a conjugate acid–base pair.

- ***Conjugate base*** – what remains of the acid after the donation of a proton
- ***Conjugate acid*** – newly formed protonated species (base)



Species	Conjugate Base
CH_3COOH	CH_3COO^-
H_2O	OH^-
NH_3	NH_2^-
H_2SO_4	HSO_4^-



Species	Conjugate Acid
NH_3	NH_4^+
H_2O	H_3O^+
OH^-	H_2O
H_2NCONH_2 (urea)	$H_2NCONH_3^+$

CONJUGATE ACID-BASE -STRENGTH

- Strong acids give weak conjugate base
- Weak acids give strong conjugate bases
- Strong bases give weak conjugate acid
- Weak bases give strong conjugate acid

For monoprotic mineral acids, the ionization is good i.e. all protons are in solution (ionized); but for diprotic acids, the first ionization is good, but 2nd ionization becomes harder because the conjugate base that forms is weaker acid than the original acid.

$$H_2SO_4 + H_2O \longrightarrow HSO_4^- + H_3O^+ \rightleftharpoons SO_4^{2-} + H_3O^+$$

$H_2SO_4 + H_2O$	$HSO_4^- + H_3O^+$	$SO_4^{2-} + H_3O^+$
SA	weak CB	weakest CB
	weak acid	weaker CB

STRENGTH OF ACIDS AND BASES

- It is important to know the strength of acids and bases so you can predict the direction of reactions.
- Strong acids ionize completely; weak acids will be in equilibrium.
- The conditions that determine strength of acids and bases: (Keep in mind: a strong acid is one in which protons are in solution i.e. ionized.)
  - Atomic size
  - Polar bonds (electronegativity)
  - Number of oxygen (polarity)

STRENGTH – ATOMIC SIZE

- This has to do with bond strength. The better the overlap of bonds the stronger the bond – the less the H^+ will be able to ionize.

  So for haloacids: HF << HCl < HBr < HI

- HI bond is not strong because atomic size of I is too large when compared to H, so the bond is not strong.
- The same principle is used for H_2O and H_2S. H_2S is stronger because sulfur is larger in atomic size than oxygen so bond strength is not good for H-S but good for H-O.

STRENGTH – POLAR BONDS AND OXYGEN

Polarity

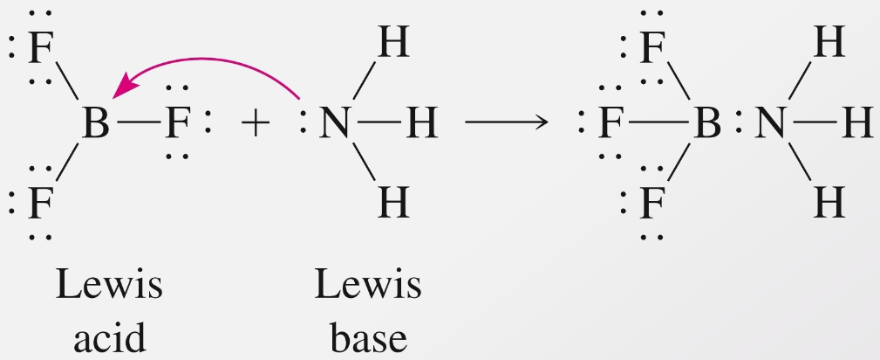
- Comparing HCl with H_2S will HCl more acidic because H-Cl bond is more polar than H-S bond.
- Comparing HClO and HBrO: the former is stronger than the latter because Cl makes the H-O bond more polar.

Number of Oxygen: As the number of oxygen atoms increase in an acid, the polarity increases between H and O.

- E.g. CH_3OH and CH_3COOH: the second CH_3COOH (acetic acid) is more acidic because of two oxygen atoms.
- E.g. H_2SO_4 and H_2SO_3: sulfuric acid is stronger than sulfurous because of higher number of oxygen atoms.

LEWIS ACID AND BASE

- A Lewis acid can form a covalent bond by accepting an electron pair.
- A Lewis base can form a covalent bond by donating an electron pair.



FORMATION OF ACIDS AND BASES

- Acids are made from dissolving non metal oxides in water.
  - Example: SO_3 gives H_2SO_4, CO_2 gives H_2CO_3 etc.

$$N_2O_5(g) + H_2O(l) \rightleftharpoons 2HNO_3(aq)$$

- Bases are made from dissolving metal oxides in water.
  - Example: K_2O gives KOH, MgO gives $Mg(OH)_2$ etc.

$$Na_2O(s) + H_2O(l) \longrightarrow 2NaOH(aq)$$

- Amphoteric solutions/substances are made from metalloid oxides.
  - Example: Al_2O_3 gives $Al(OH)_3$, SnO_2 gives $Sn(OH)_2$ etc.
  - Below are reactions of aluminum hydroxide with acid and base.

$$Al(OH)_3(s) + 3H^+(aq) \longrightarrow Al^{3+}(aq) + 3H_2O(l)$$

$$Al(OH)_3(s) + OH^-(aq) \longrightarrow Al(OH)_4^-(aq)$$

KEY CONCEPTS

- Properties of acids and bases
- Conjugate acids and bases
- Strength of acids and bases
- Identify different types of acids and bases
- Writing simple acid base equations
- Identifying acidic and basic oxides