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5-Acid and Base Chemistry .

5-1Introduction

Acids and bases are common solutions that exist everywhere. Almost every liquid that we encounter in our daily lives consists of acidic and basic properties, with the exception of water.

They have completely different properties and are able to neutralize to form H_2O, which will be discussed later in a subsection.

5-2 Arrhenius Acid / Base.

The earliest definition of acids and bases was suggested by Swedish chemist Svante Arrhenius.

An acid contains a hydrogen atom and dissolves in water to form a hydrogen ion, H^+

A base contains hydroxide and dissolves in water to form ^-OH

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By this definition, hydrogen chloride (HCl) is an acid because it forms aqueous H^+ and Cl^- when it dissolves in water.

Sodium hydroxide (NaOH) is a base because it contains (^-OH) and forms solvated Na^+ and(^-OH) ions when it dissolves in water.

H^+ is formed from HCl.

$$\underset{\text{acid}}{HCl(g)} \longrightarrow H^+(aq) + Cl^-(aq)$$

$$\underset{\text{base}}{NaOH(s)} \longrightarrow Na^+(aq) + {}^-OH(aq)$$

^-OH is formed from NaOH.

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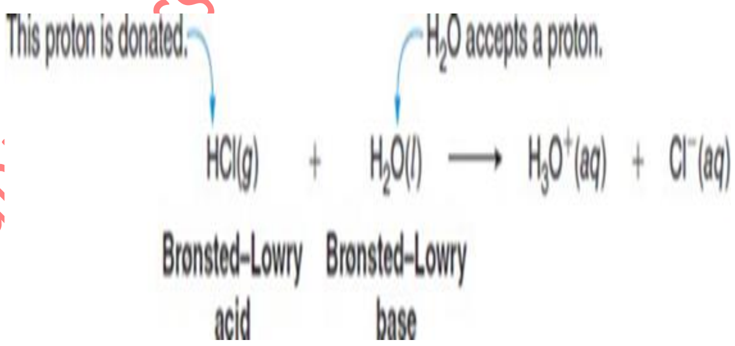
5-3Bronsted–Lowry Acid / Base

In the Bronsted–Lowry definition, acids and bases are classified according to whether they can donate or accept a proton—a positively charged hydrogen ion, H^+.

A Bronsted–Lowry Acid is a proton donor.

A Bronsted–Lowry base is a proton acceptor.

Consider what happens when HCl is dissolved in water.



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HCl is a Bronsted–Lowry acid because it donates a proton to the solvent water.

H_2O is a Bronsted–Lowry base because it accepts a proton from HCl.

A Bronsted–Lowry acid must contain a hydrogen atom.

HCl is a Bronsted–Lowry acid because it donates a proton (H^+) to water when it dissolves, forming the hydronium ion (H_3O^+) and chloride (Cl^-).

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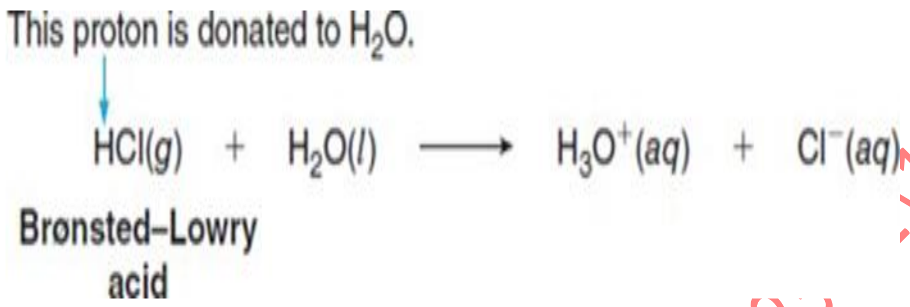
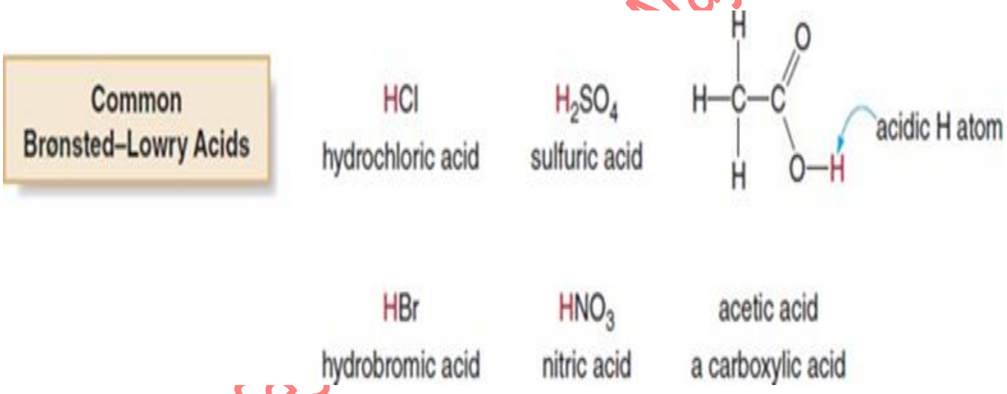

This proton is donated to H_2O.
$HCl(g) + H_2O(l) \longrightarrow H_3O^+(aq) + Cl^-(aq)$
Brønsted–Lowry acid


Common Brønsted–Lowry Acids
HCl
hydrochloric acid
H_2SO_4
sulfuric acid
acidic H atom
HBr
hydrobromic acid
HNO_3
nitric acid
acetic acid
a carboxylic acid

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Example 1

Which of the following species can be Brønsted-Lowry acids: (a) HF; (b) HSO_3^-; (c) Cl_2?

Analysis

A Brønsted-Lowry acid must contain a hydrogen atom, but it may be neutral or contain a net positive or negative charge.

Solution

a. HF is a Brønsted-Lowry acid since it contains a H.

b. HSO_3^- is a Brønsted-Lowry acid since it contains a H.

c. Cl_2 is not a Brønsted-Lowry acid because it does not contain a H.

PROBLEM 1

Which of the following species can be Brønsted-Lowry acids: (a) HI; (b) SO_4^{2-}; (c) $H_2PO_4^-$; (d) Cl^-?

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Fig.5.1: Examples of Bronsted–Lowry Acids in Food Products.

a)Acetic acid is the sour-tasting component of vinegar. The air oxidation of ethanol to acetic acid is the process that makes "bad" wine taste sour.

b)Citric acid imparts a sour taste to oranges, lemons, and other citrus fruits.

C) Carbonated beverages contain carbonic acid, H_2CO_3.

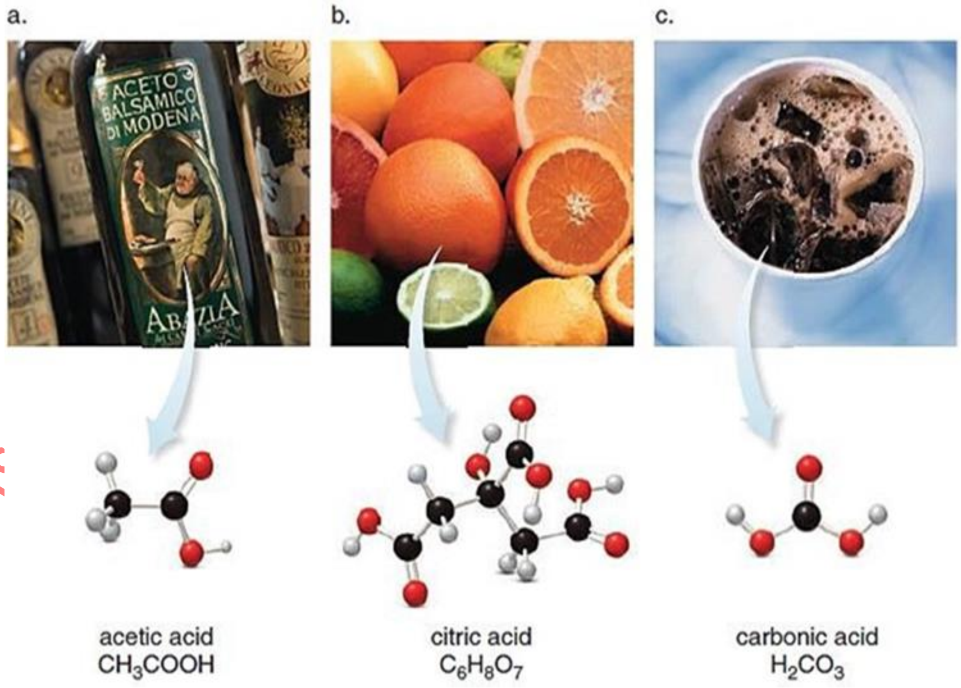

Fig.5.1: Examples of Bronsted–Lowry Acids in Food Products.

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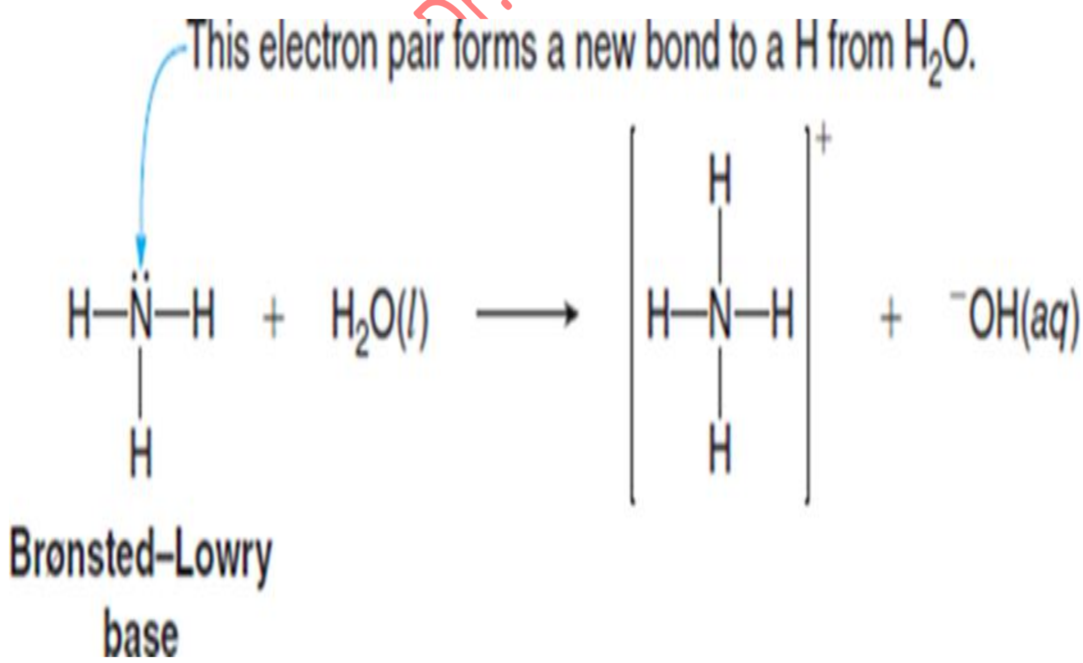
Bronsted–Lowry Bases

A Bronsted–Lowry base is a proton acceptor and as such, it must be able to form a bond to a proton.

Because a proton has no electrons, a base must contain a lone pair of electrons that can be donated to form a new bond.

Thus, ammonia (NH_3) is a Bronsted–Lowry base because it contains a nitrogen atom with a lone pair of electrons.

When (NH_3) is dissolved in water, its N atom accepts a proton from H_2O, forming an ammonium cation (NH^{4+}) and hydroxide (^-OH).



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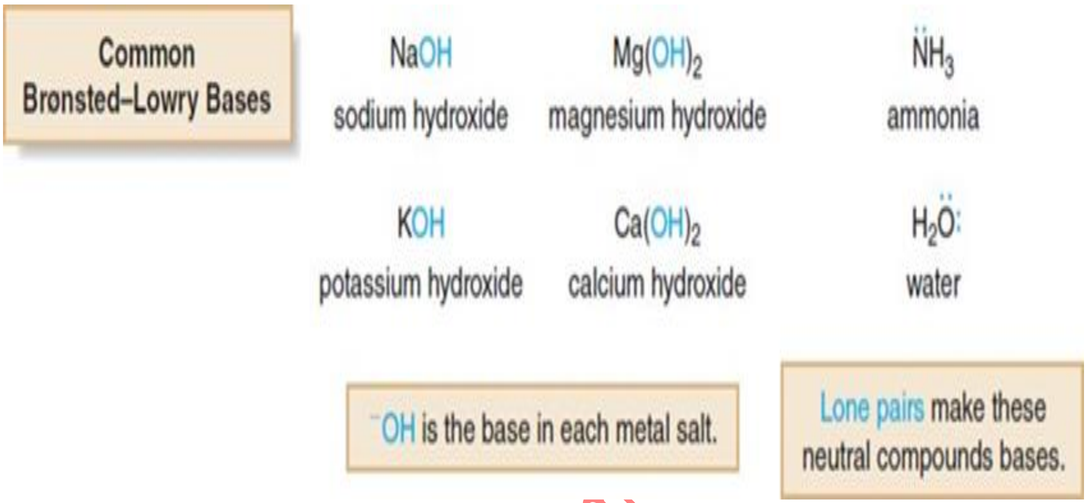
Common Brønsted–Lowry Bases
NaOH
sodium hydroxide
Mg(OH)2
magnesium hydroxide
NH3
ammonia
KOH
potassium hydroxide
Ca(OH)2
calcium hydroxide
H2O:
water
⁻OH is the base in each metal salt.
Lone pairs make these neutral compounds bases.

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SAMPLE 2

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.

PROBLEM 2

Which of the following species can be Brønsted–Lowry bases: (a) $Al(OH)_3$; (b) Br^-; (c) NH_4^+; (d) ^-CN?

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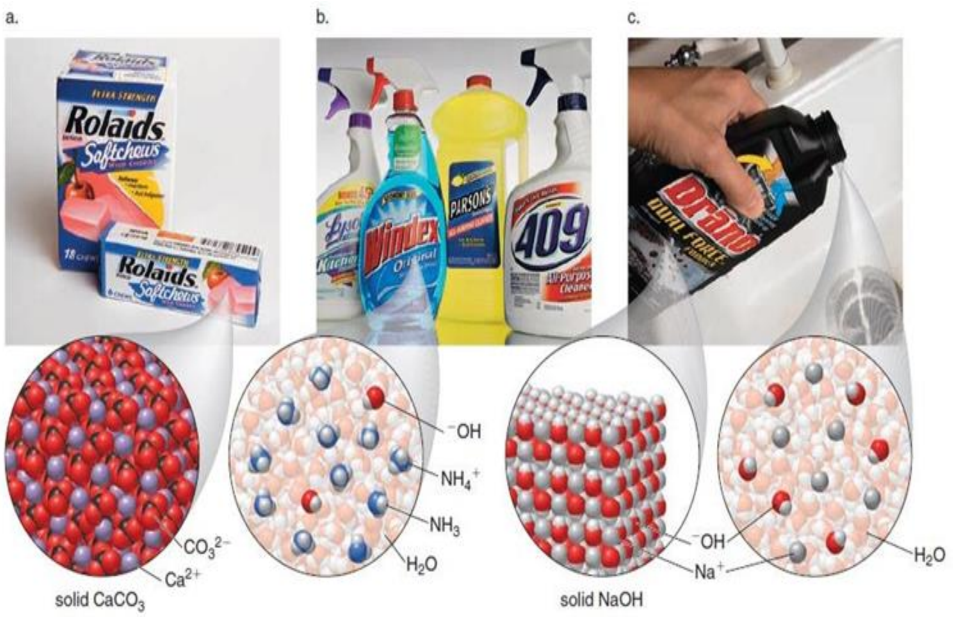

Fig.5.2 Examples of Bronsted–Lowry Bases in Consumer Products.

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a) Calcium carbonate ($CaCO_3$), a base, is the active ingredient in the antacid Rolaids.

b)Windex and other household cleaners contain ammonia (NH_3) dissolved in water, forming $NH4^+$ cations and ^-OH anions.

c)Drain cleaners contain pellets of solid sodium hydroxide (NaOH), which form Na^+ cations and ^-OH anions when mixed with water.