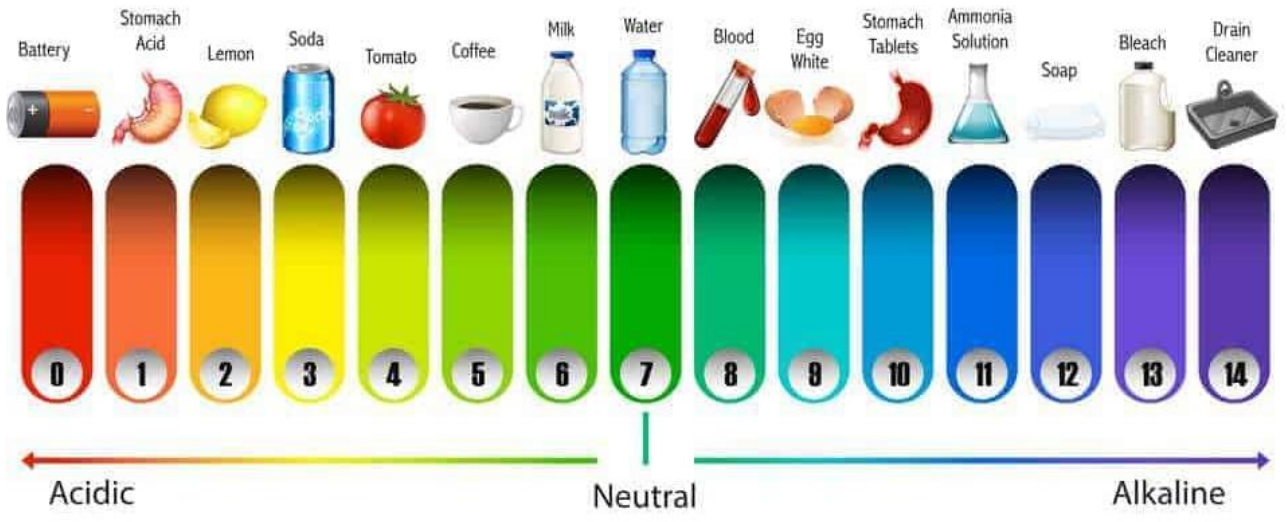
Tishk International University
Faculty of Applied Sciences
Nutrition and Dietetics Department
Principles of Food Science

Acids, Bases, and pH in Food Science



Lecture No.: 3 Assistant Lecturer: Pary Ameer 2025-2026

Outlines

- Quiz
- Previous Lecture
- What's Acid , Base and pH in Food
- Salt
- Buffer Solution

Learning Outcome

Describe the roles of acids and bases in food science

Demonstrate the ability to measure and interpret pH levels

Evaluate the impact of pH on the quality and safety of food

ACIDS

- An acid is any substance that dissociates (ionizes) in solution and releases hydrogen ions (H^+).

Acids have the following characteristics:

- Taste sour
- Turns litmus indicators red
- React with bases to form salts
- Cause some metals to liberate hydrogen

Examples of acids in the body include:

Hydrochloric acid (HCl): Found in stomach acid, helps in digestion.

Lactic acid ($C_3H_6O_3$): Produced in muscles during anaerobic respiration.

Phosphoric acid (H_3PO_4): Found in bones and teeth.

Carbonic acid (H_2CO_3): Forms when carbon dioxide dissolves in water (important in blood pH regulation).

Citric acid ($C_6H_8O_7$): Found in citrus fruits like lemons and oranges.

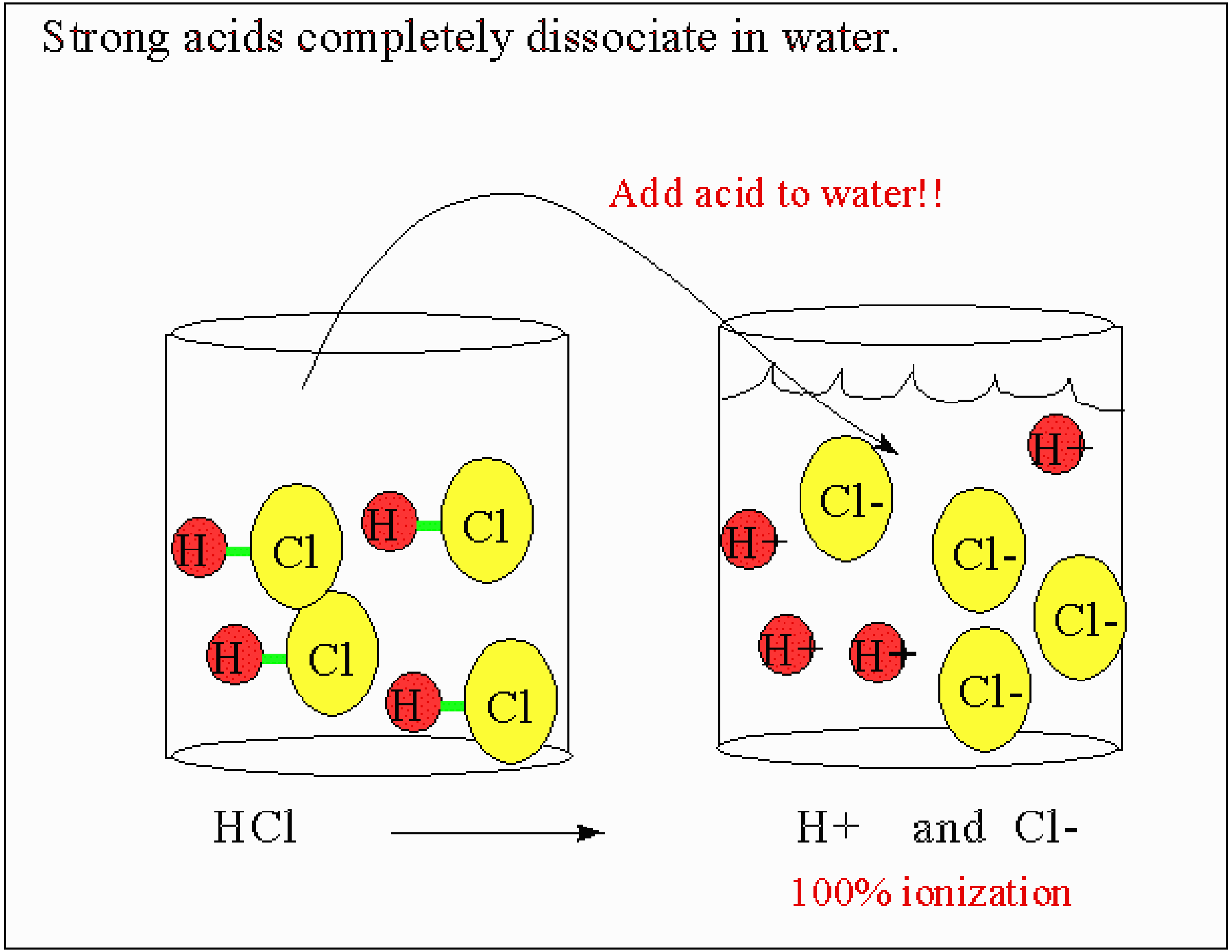
Carboxylic acids (R-COOH): Organic acids containing a carboxyl group, e.g., acetic acid (CH_3COOH), found in vinegar.

Strong Acid:

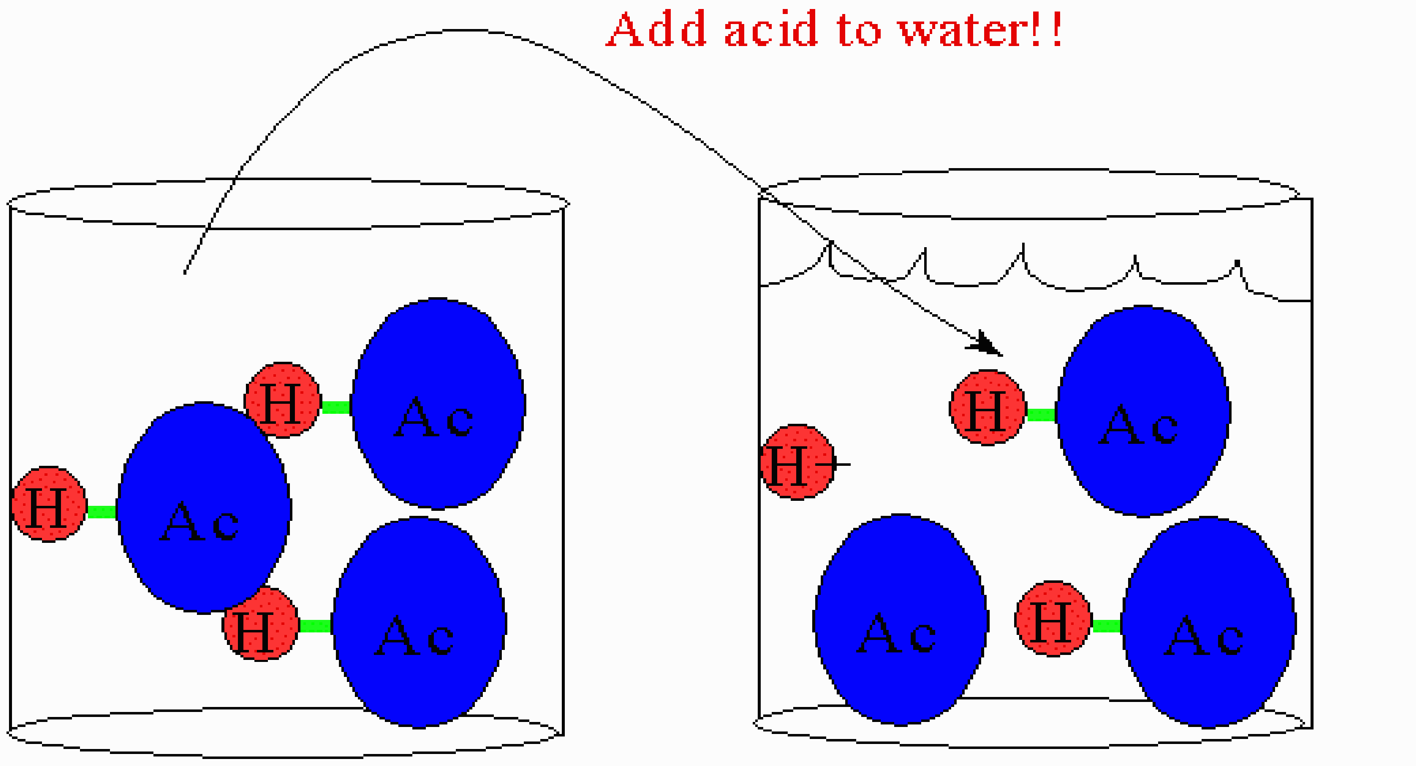
- A **strong acid** is an acid that completely dissociates (ionizes) in water, releasing all its hydrogen ions (H^+).
- It has a high concentration of H^+ ions in solution.
- **Example**: Hydrochloric acid (HCl), Sulfuric acid (H_2SO_4), Nitric acid (HNO_3).

Weak Acid:

- A **weak acid** only partially dissociates (ionizes) in water, meaning only a small fraction of its hydrogen ions (H^+) are released.
- It has a low concentration of H^+ ions in solution.
- **Example**: Acetic acid (CH_3COOH), Carbonic acid (H_2CO_3), Citric acid ($C_6H_8O_7$).


Strong acids completely dissociate in water.
Add acid to water!!
H
Cl
H+
Cl-
HCl
H+ and Cl-
100% ionization

Weak acids DO NOT completely dissociate in water.



HAc → H+ and Ac and HAc

partial ionization

HAc = acetic acid = $H\text{-}O\text{-}C(=O)\text{-}CH_3$

BASES

A base is any substance that picks up or accepts H^+ to form hydroxide ions (OH^-) in water solutions.

Base or alkaline solutions have the following characteristics:

- Bitter taste
- Slippery to the touch
- Turns litmus indicators blue
- React with acids to form water

Examples of bases in the body include:

Sodium Hydroxide ($NaOH$):

- Rarely present as pure NaOH but contributes to maintaining alkalinity in certain processes.

Calcium Hydroxide ($Ca(OH)_2$):

- Found in bone structure and plays a role in pH regulation.

Ammonium Hydroxide (NH_4OH):

- Formed when ammonia dissolves in water; involved in metabolic processes.

Bicarbonate Ion (HCO_3^-):

- A key buffer in blood, helping maintain a slightly alkaline pH (7.35–7.45).

Phosphate Ion (PO_4^{3-}):

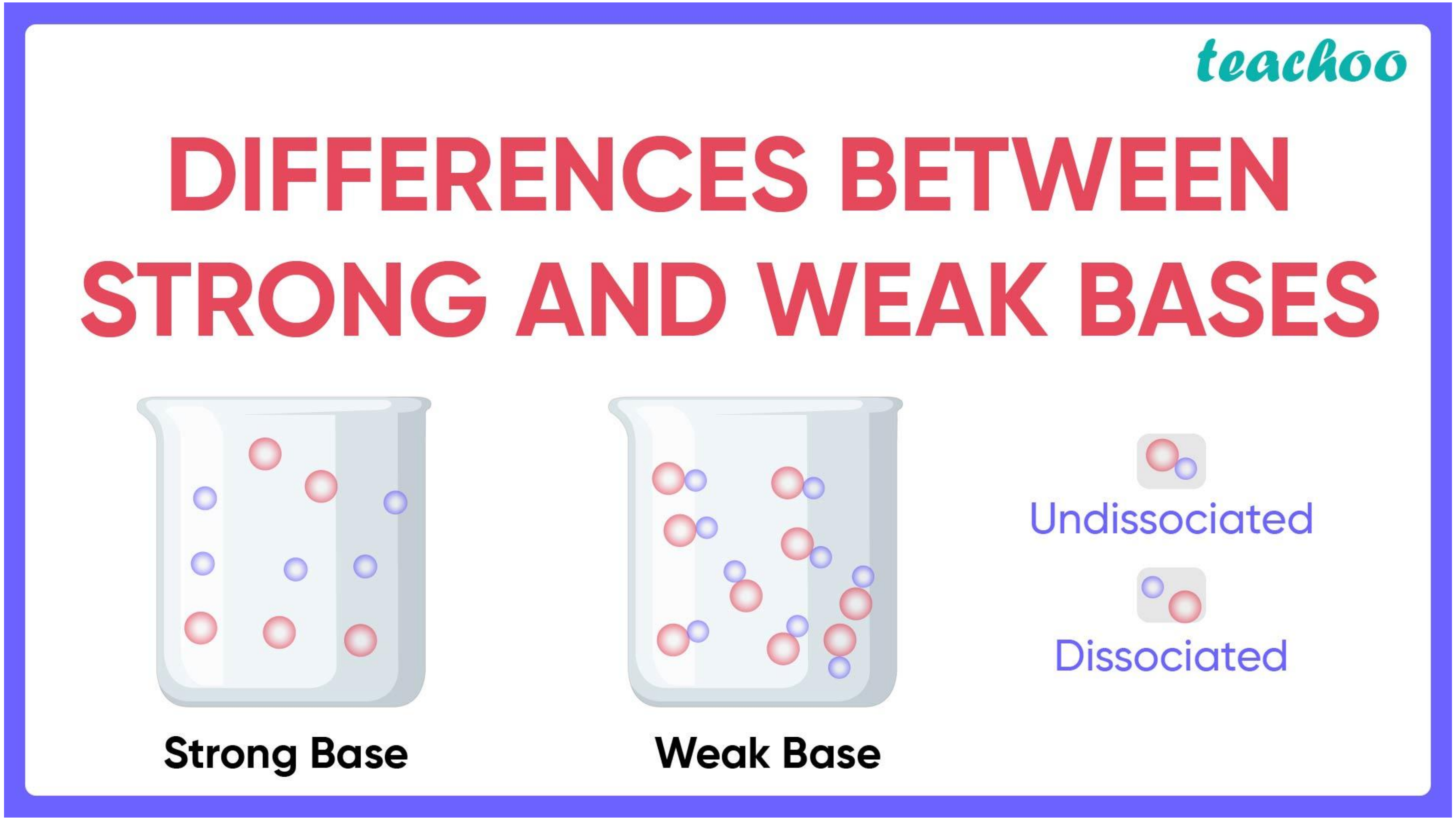
- Found in bones, teeth, and cellular fluids; helps regulate pH in the body.

Strong Base:

- A **strong base** is a base that completely dissociates (ionizes) in water, releasing all its hydroxide ions (OH^-).
- It has a high concentration of OH^- ions in solution.
- **Example**: Sodium hydroxide ($NaOH$), Potassium hydroxide (KOH), Calcium hydroxide ($Ca(OH)_2$).

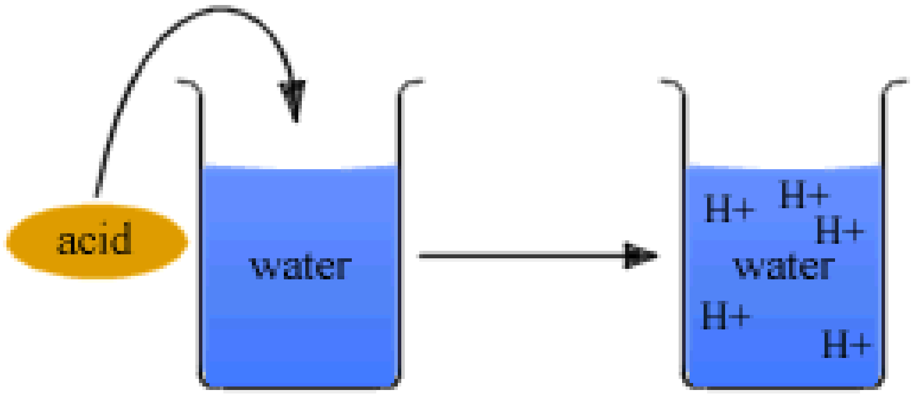
Weak Base:

- A **weak base** only partially dissociates (ionizes) in water, meaning only a small fraction of its hydroxide ions (OH^-) are released or it reacts partially with water to produce OH^- ions.
- It has a low concentration of OH^- ions in solution.
- **Example**: Ammonia (NH_3), Methylamine (CH_3NH_2), Aluminum hydroxide ($Al(OH)_3$).

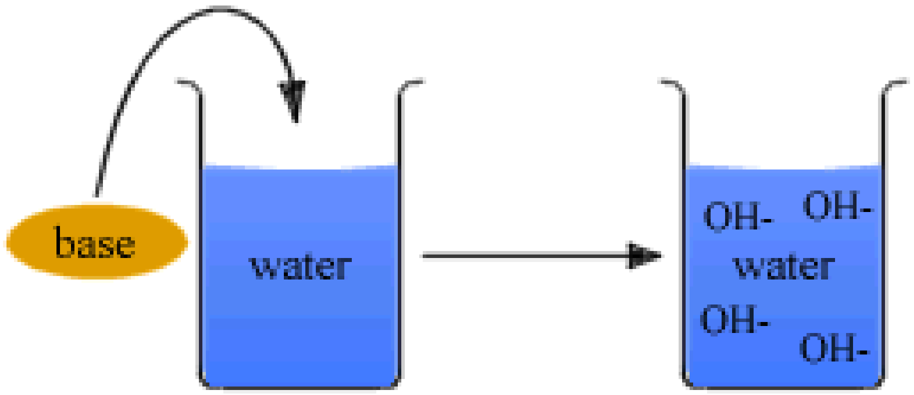

teachoo
DIFFERENCES BETWEEN
STRONG AND WEAK BASES
Undissociated
Dissociated
Strong Base
Weak Base

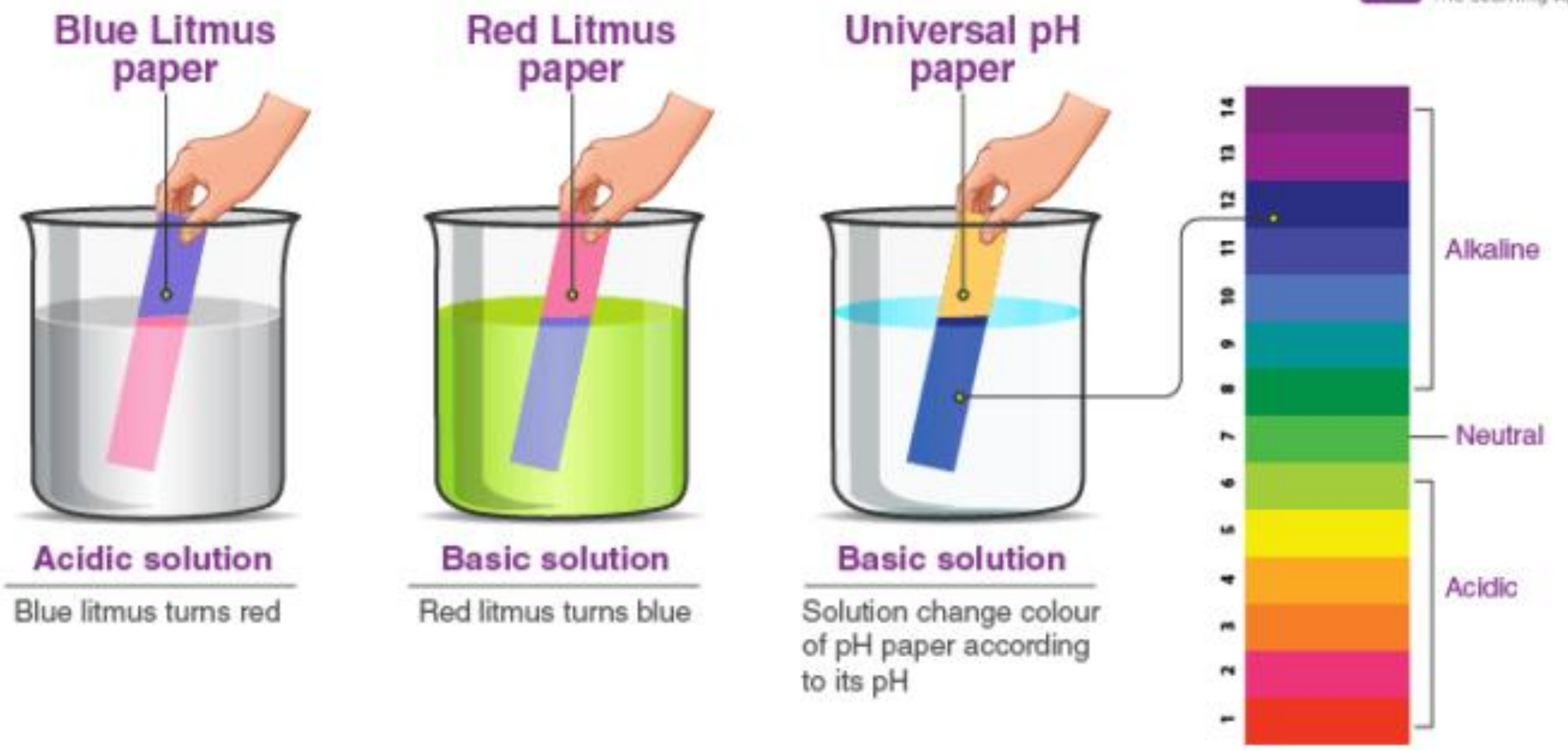
Ions: Acids & Bases

An acid is any ionic compound that releases hydrogen ______ (H^+) in solution.



A base is any ionic compound that releases hydroxide ______ (^-OH) in solution.





Blue Litmus paper
Red Litmus paper
Universal pH paper
Acidic solution
Blue litmus turns red
Basic solution
Red litmus turns blue
Basic solution
Solution change colour of pH paper according to its pH
14
13
12
11
10
9
8
7
6
5
4
3
2
1
Alkaline
Neutral
Acidic


ALKALINE
ACID

pH: Potential of Hydrogen

pH refers to a solution's concentration of protons or H^+.

Solutions with relatively more OH^- than H^+ have a pH above 7.0 and are called basic or alkaline.

Conversely, solutions with more H^+ than OH^- have a pH below 7.0 and are termed as acidic.

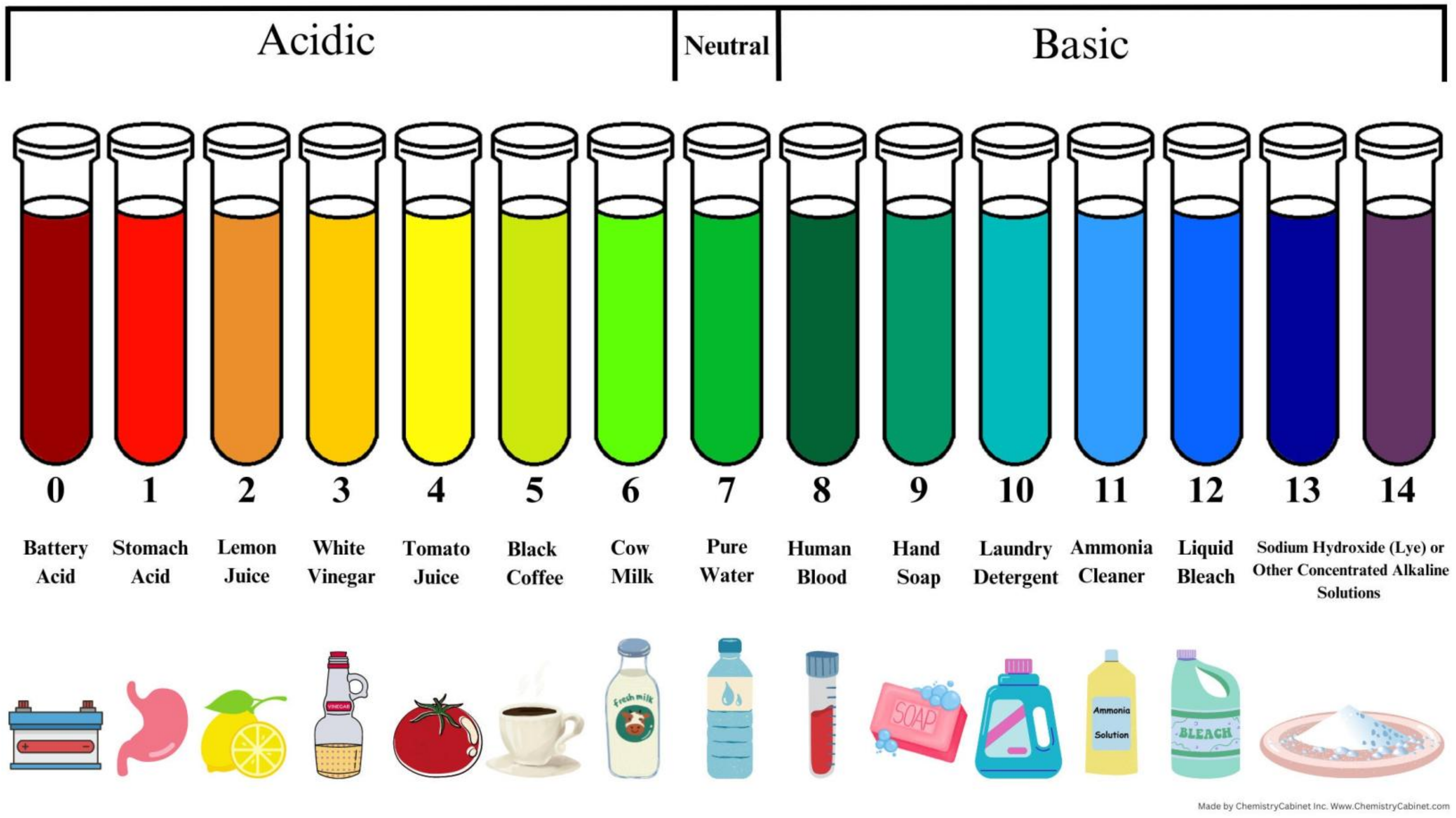
Chemically pure (distilled) water has a pH of 7.0 (neutral) with equal amounts of H^+ and OH^-.

The pH scale, devised in 1909 by Danish chemist Soren Sorenson, ranges from +1.0 to +14.0.

pH Scale

- The pH scale is a measure of the acidity or basicity of a solution. It ranges from 0 to 14, with 7 being neutral.
- **pH < 7:** Acidic solution
- **pH = 7:** Neutral solution
- **pH > 7:** Basic (or alkaline) solution

The pH Scale


Acidic
Neutral
Basic
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Battery Acid
Stomach Acid
Lemon Juice
White Vinegar
Tomato Juice
Black Coffee
Cow Milk
Pure Water
Human Blood
Hand Soap
Laundry Detergent
Ammonia Cleaner
Liquid Bleach
Sodium Hydroxide (Lye) or Other Concentrated Alkaline Solutions
SOAP
Ammonia Solution
BLEACH
Made by ChemistryCabinet Inc. Www.ChemistryCabinet.com

A **salt** is an **ionic compound** that forms when an acid reacts with a base through a **neutralization reaction**.

It consists of:

- A **positive ion (cation)** from the base.
- A **negative ion (anion)** from the acid.

Formation of Salt

- The general reaction for the formation of a salt is:
- **Acid + Base → Salt + Water**
- For example:
- Hydrochloric acid (HCl) + Sodium hydroxide (NaOH) → Sodium chloride (NaCl) + Water (H_2O)

Types of Salts

- **Neutral Salts:**
  - Formed when a strong acid reacts with a strong base.
  - Example: Sodium chloride ($NaCl$).
- **Acidic Salts:**
  - Formed when a strong acid reacts with a weak base.
  - Example: Ammonium chloride (NH_4Cl).
- **Basic Salts:**
  - Formed when a strong base reacts with a weak acid.
  - Example: Sodium bicarbonate ($NaHCO_3$).

Importance of Salts

- **In Daily Life:**
  - Sodium chloride (table salt) is essential for food and health.
- **Biological Systems:**
  - Salts like potassium chloride (KCl) regulate nerve function and muscle contraction.
- **Industrial Use:**
  - Used in making fertilizers, chemicals, and soaps.

Importance of pH in Food Science

Food Safety:

- **Microbial Growth:** Most bacteria thrive in neutral or slightly alkaline environments. Acidic conditions can inhibit bacterial growth, which is why many food preservation methods rely on acidification.
- **Enzyme Activity:** Enzymes are biological catalysts that drive many chemical reactions in food. Their activity is highly influenced by pH. Maintaining the optimal pH for enzyme activity is crucial for processes like ripening, fermentation, and enzymatic browning.

Food Quality:

- **Flavor:** pH affects the taste of food. Acidic foods taste sour, while basic foods taste bitter or soapy.
- **Texture:** pH influences the texture of food. For instance, the gel formation in jams and jellies is dependent on the pH of the fruit.
- **Color:** pH can affect the color of certain foods. For example, the vibrant red color of strawberries is due to anthocyanins, pigments that change color depending on pH.

Importance of pH in Food Science

Food Processing:

- **Preservation:** Acidification is a common food preservation method. Adding acids like vinegar or lactic acid lowers the pH, making it unfavorable for microbial growth.
- **Fermentation:** Fermentation processes, such as yogurt and cheese production, rely on controlled pH changes to create the desired product.
- **Baking:** The pH of the dough influences the activity of leavening agents like baking soda and baking powder, affecting the final texture and volume of baked goods.

Examples of pH in Food Science

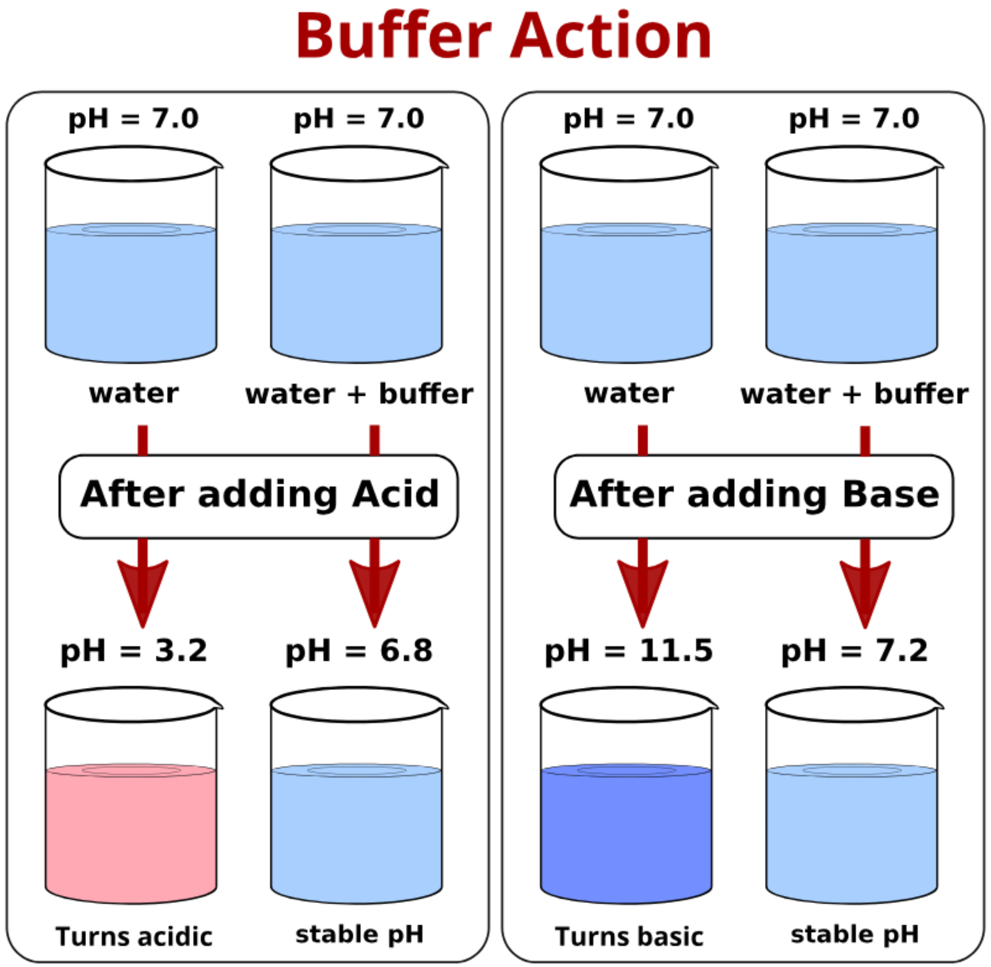
- **Pickling:** Vegetables are preserved by immersing them in a brine solution containing vinegar or other acids. The low pH inhibits microbial growth.
- **Yogurt Production:** Bacteria convert lactose in milk into lactic acid, lowering the pH and causing milk proteins to coagulate, forming yogurt.
- **Winemaking:** The pH of grapes and the fermentation process influence the final acidity and flavor of wine

A **buffer solution** is a solution that **resists changes in pH** when small amounts of acid (H^+) or base (OH^-) are added.

It helps maintain a stable pH, making it essential for biological, chemical, and industrial processes.

- CH_3COOH
- NH_3

Buffer = weak acid/base + its salt



Understanding the Principles of Acids, Bases, and pH in Food Science:

Impact on Food Safety:

- Controlling pH helps prevent the growth of harmful microorganisms.
- Acidic environments (low pH) inhibit bacterial growth, ensuring food safety.

Role in Food Quality:

- pH affects the color, texture, and flavor of food.
- For example, the pH of meat impacts its tenderness and appearance.

pH in Food Preservation:

- Low pH is essential for preserving foods like pickles, yogurt, and jams.
- High acidity prevents spoilage and extends shelf life.

Importance in Food Processing:

- pH control is critical in processes like fermentation and enzymatic reactions.
- Example: The pH of dough influences yeast activity in bread-making.

Enhancing Flavor Profiles:

- Acids contribute to the tangy taste in foods like citrus fruits and vinegar.
- Balancing pH ensures the desired flavor in food products.

Texture Modification:

- The pH of dairy products affects protein interactions, impacting cheese texture.
- Alkaline solutions are used in processes like nixtamalization to soften corn.

Color Preservation:

- Maintaining the right pH helps retain the natural colors of fruits and vegetables.
- Example: Anthocyanins in berries change color based on pH.

Ensuring Nutrient Stability:

- Proper pH control minimizes nutrient degradation during processing and storage.

Some educational Videos

1. Video
2. PH- Scale


thank
you