pH and Buffer

Acid- Base Balance

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Intended learning outcomes

- Explain the acid base balance
- Describe the role of buffers in maintaining the pH of a solution in body fluids
- Identify the most powerful buffer system in the body

Acid base balance

pH : is the negative log of the hydrogen ion concentration

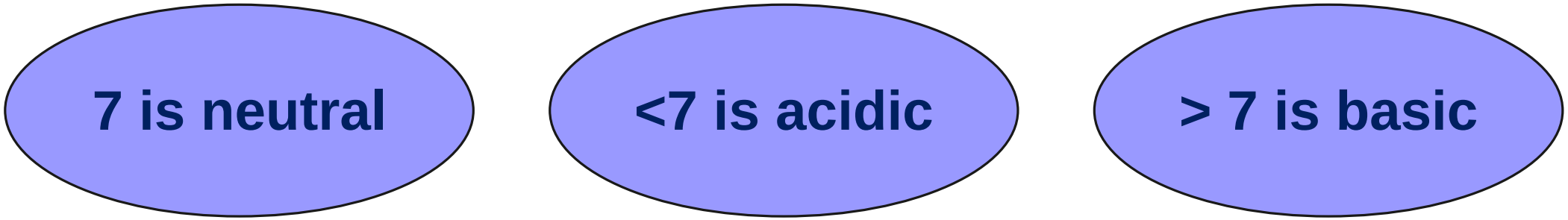
pH = - log [H+]

pH is a unit of measure which describes the degree of acidity or basicity of a solution

pH Value

- **The pH value of a substance is directly related to the ratio of the hydrogen ion and hydroxyl ion concentrations**
- **If the H+ concentration is higher than OH- the material is acidic**
- **If the OH- concentration is higher than H+ the material is basic.**

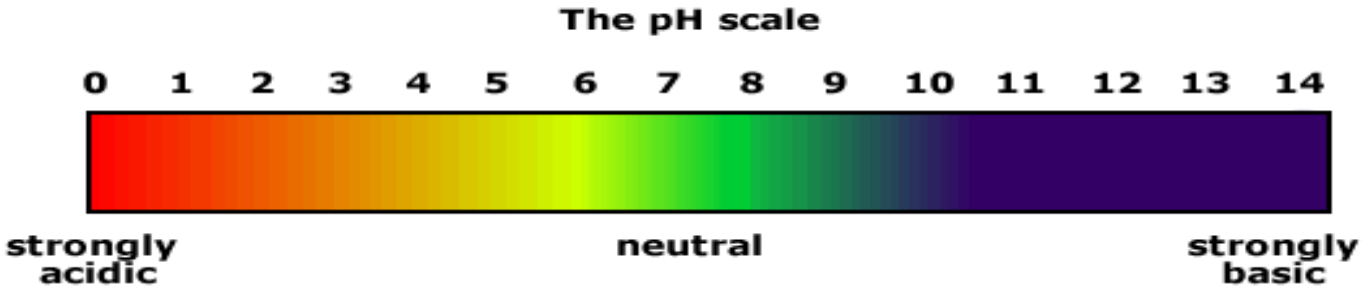
pH Value



- **High H+ ion concentration = low pH**
- **Low H+ ion concentration = high pH**

The pH scale

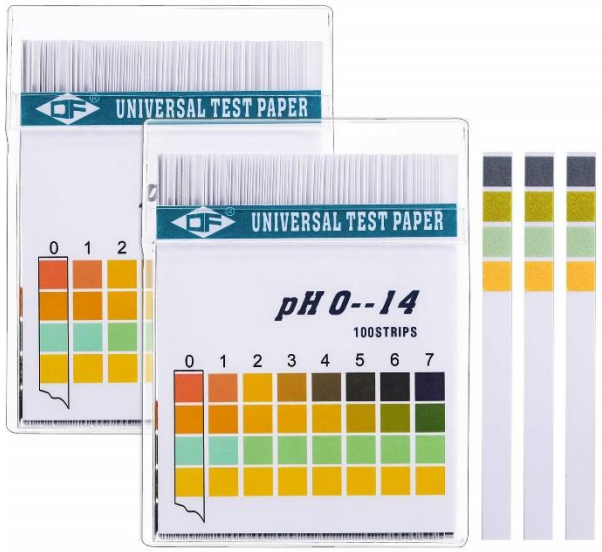
- The pH scale corresponds to the concentration of hydrogen ions
- Scale ranges from **1 to 14**
- The **pH of water is 7.0** which is neutral
- The normal range of the human body fluids is **7.35 - 7.45**



Measurement of pH

The pH can be measured by:

pH strips



pH indicators


Methyl orange solutions

pH meter

Measurement of pH

Some important indicators used in a clinical biochemistry laboratory are listed below:

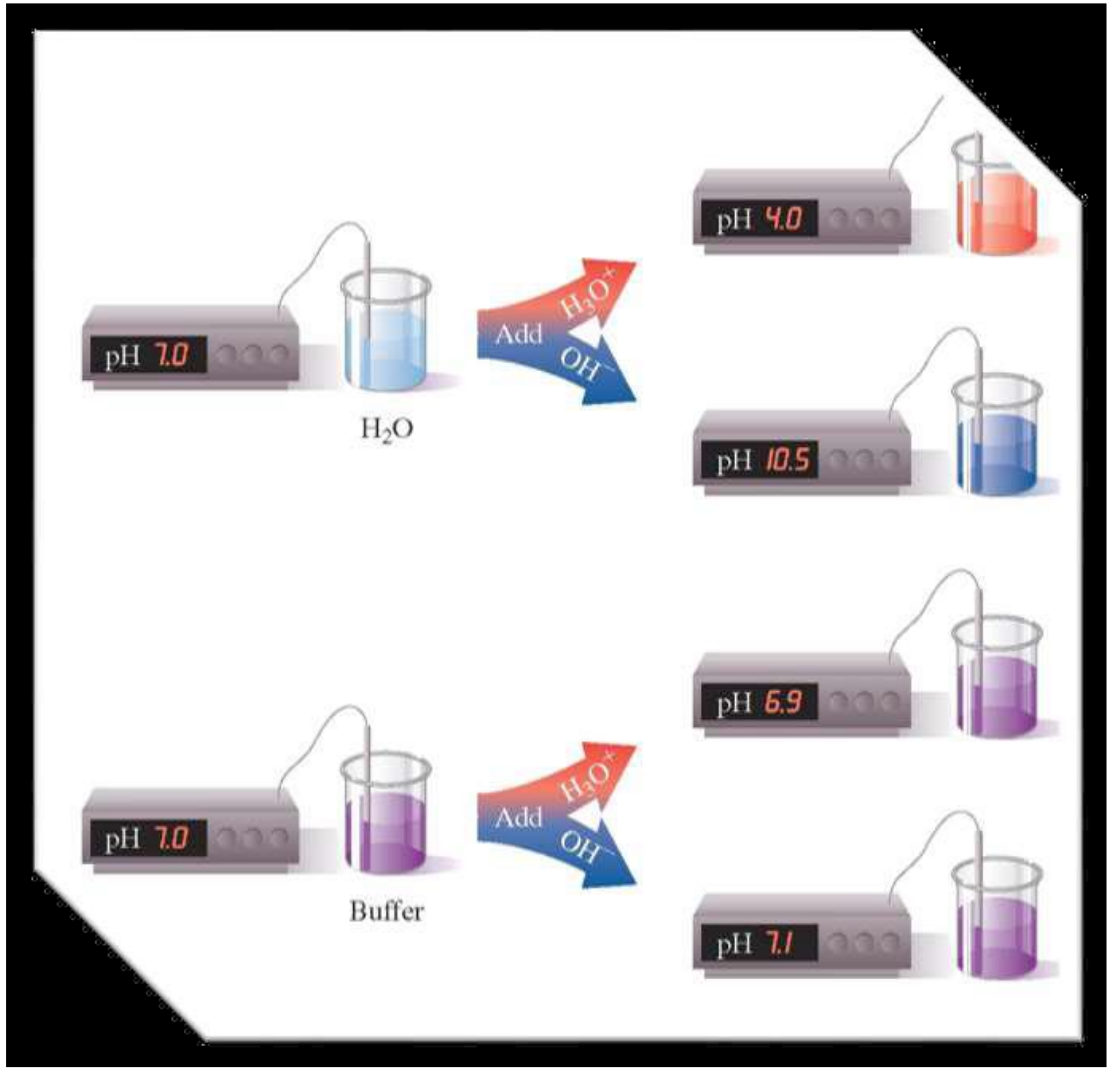
sr,. No.	INDICATOR	Ph range	Colour in acidic ph	Colour in basic ph
1	Phenophthalein	9.3-10.5	colourless	pink
2	Methyl orange	3.1-4.6	red	yellow
3	Bromophenol blue	3.0-4.6	yellow	blue
4	Methyl red	4.4-6.2	Red	yellow
5	Phenol red	6.8 – 8.4	yellow	red
6	Litmus	4.5-8.3	red	Blue

pH meter

- The **pH meter** is a laboratory equipment which used to measure acidity or alkalinity of a solution
- The pH meter measures the concentration of hydrogen ions [H+] using an ion-sensitive electrode
- It is the most reliable and convenient method for measuring pH

Buffers

- Adding an acid or a base to **water** changes the pH drastically
- A **buffer** solution is a solution which resists changes in pH when a small amount of acid or base is added



Type of Buffers

- **Acidic buffers:** Solution of a mixture of a weak acid and a salt of this weak acid with a strong base.

e.g. $CH_3COOH + CH_3COONa$

(weak acid) (Salt)

- **Basic buffers:** Solution of a mixture of a weak base and a salt of this weak base with a strong acid.

e.g. $NH_4OH + NH_4Cl$

(Weak base) (Salt)

Buffers

- blood contains buffers that maintain a consistent pH of about 7.4
- If the pH of the blood goes slightly above or below 7.4, changes in oxygen levels and metabolic processes can be drastic enough to cause death
- Even though we obtain acids and bases from foods and cellular reactions, the buffers in the body absorb those compounds so effectively that the pH of the blood remains essentially unchanged

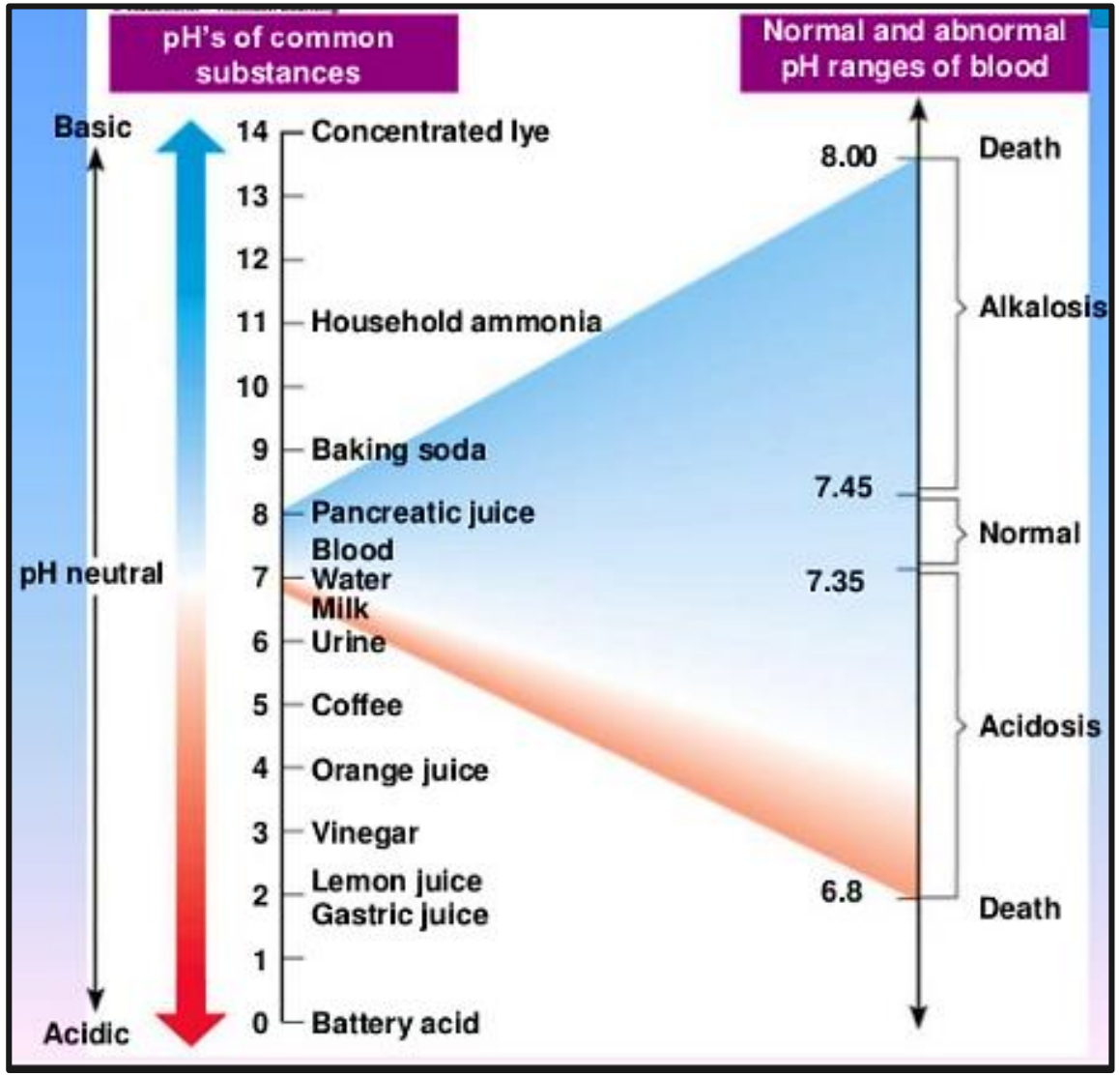
Buffers

Alkalosis or alkalemia: arterial blood pH rises above 7.45

Acidosis or acidemia: arterial pH drops below 7.35

Alteration outside these boundaries affects all body systems

Can result in coma, cardiac failure, and circulatory collapse



Buffers

- The body constantly produces acids through metabolism.
- These acids must be constantly eliminated from the body.

Three systems perform this task

1. Buffer system
2. Respiratory system
3. Renal system

Buffer systems in body fluids

Buffers are the first line of defense

Two most common chemical buffer groups:

1. Bicarbonate-Carbonic Acid Buffer

$$NaHCO_3 + HCl \rightarrow H_2CO_3 + NaCl$$

(sodium bicarbonate) + (strong acid) → (weak acid) + (salt)

$$H_2CO_3 + NaOH \rightarrow HCO_3^- + H_2O$$

(weak acid) + (strong base)→(bicarbonate) + (water)

Buffer systems in body fluids

2. Non bicarbonate (Hemoglobin, protein and phosphate)

For example: phosphate buffer

$$HCl + Na_2HPO_4 \rightarrow NaH_2PO_4 + NaCl$$

(strong acid) + (weak base) → (weak acid) + (salt)

$$NaOH + NaH_2PO_4 \rightarrow Na_2HPO_4 + H_2O$$

(strong base) + (weak acid) → (weak base) + (water)

Blood buffer systems act instantaneously

Regulate pH by binding or releasing H^+

Respiratory system

- The lungs eliminate excess CO2 by increasing respirations, causing a decrease in H+ and an increase in pH.
- The lungs can retain more CO2 by slowing respirations, causing an increase in H+ and a decrease in pH.

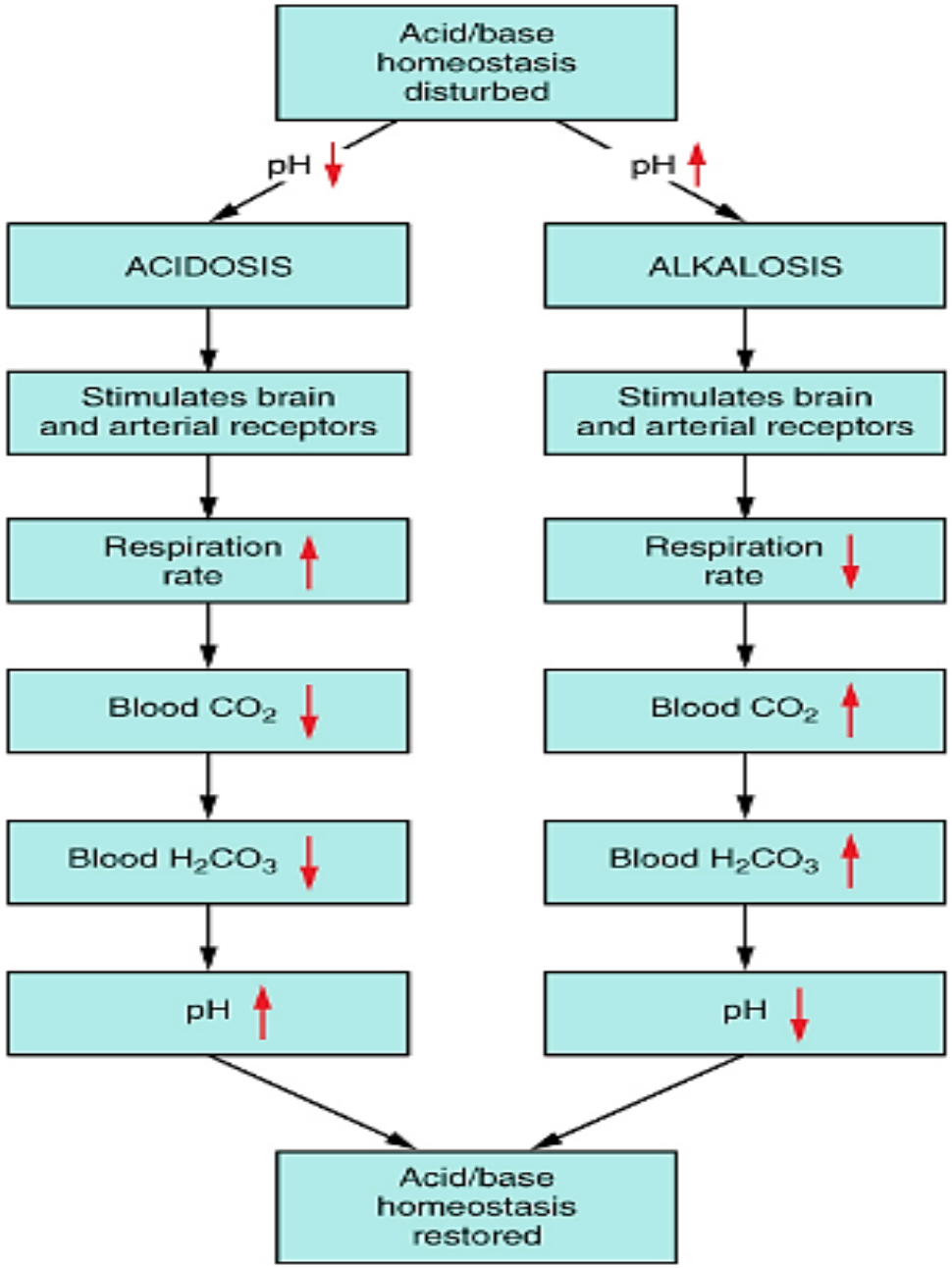
Respiratory center:

- if pH rises, respiratory rate decreases
- if pH falls, respiratory rate increases

Respiratory system

Respiratory Regulation of Blood pH:

The respiratory system can reduce blood pH by removing CO2 from the blood.



Renal system

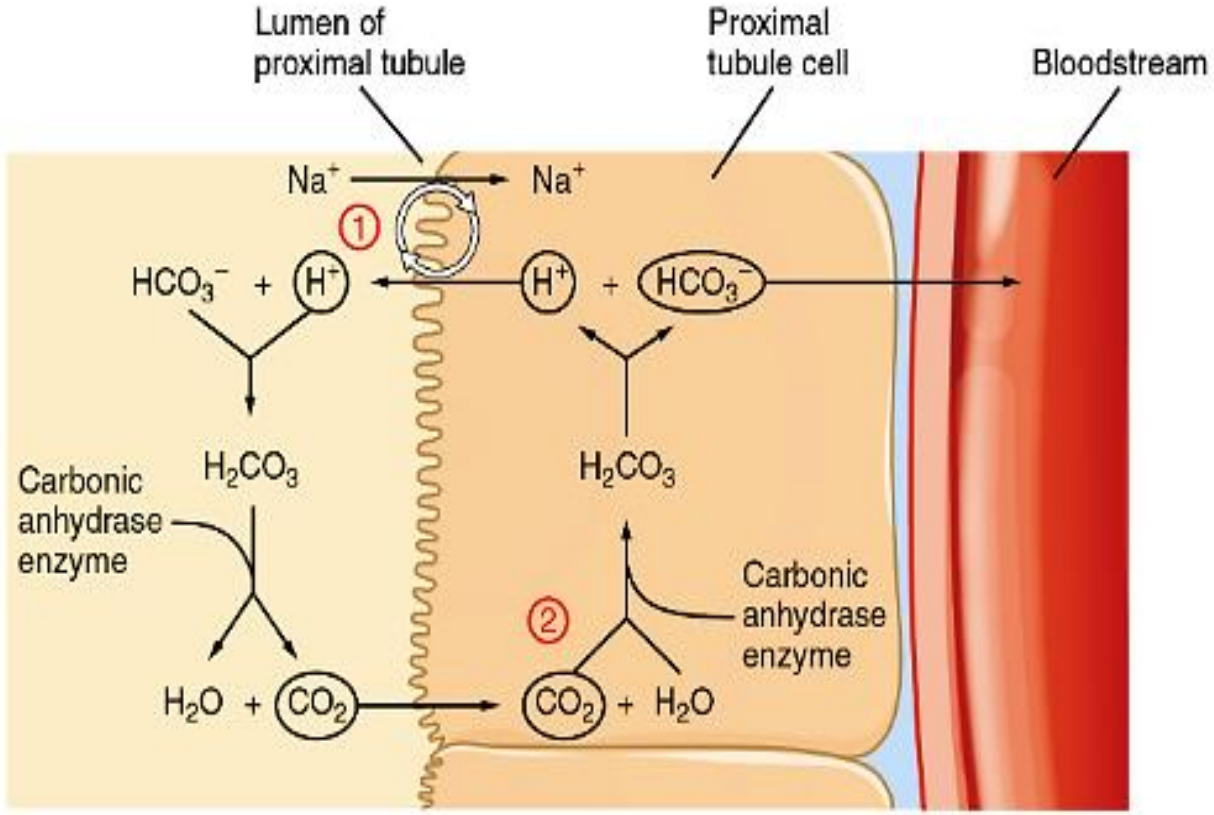
- Kidneys can retain bicarbonate ion, causing a decrease in H+ and an increase in pH
- Kidneys can excrete bicarbonate ion, causing an increase in H+ and a decrease in pH.

Kidneys

- if pH rises, distal tubule decreases H+ secretion into the urine and decreases HCO3- absorption into the blood (more H2CO3 will dissociate into H+ and HCO3-)
- if pH falls, distal tubule increases H+ secretion into the urine and increases HCO3- absorption into the blood

Renal system

Conservation of Bicarbonate in the Kidney. Tubular cells are not permeable to bicarbonate; thus, bicarbonate is conserved rather than reabsorbed. Steps 1 and 2 of bicarbonate conservation are indicated



THANK YOU !

ANY QUESTIONS ??

PLEASE ASK