Physiological Acid Base Balance & Buffer System in body.

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→ It is the process by which the body maintain the pH level of blood within a narrow range.

→ It is the part of homeostasis in body.

✡ Maintenance of pH is important for biochemical reactions in the body.

eg. Pepsinogen ⟶ Pepsin (on acidic pH)

→ Most Metabolic reaction occurs only within a very narrow pH range of 7.38 to 7.42.

⇒ pH of body fluid as follows.

Blood → 7.35 to 7.45
below 7.35 → Acidosis
Above 7.45 → Alkalosis
Urine → 4.5 to 8
Gastric juice → 1.5 to 3.5
Bile juice → 6.0 to 8.5
Saliva → 4.5 to 7.5

⇒ Factors affecting Acidosis & Alkalosis

(1) Acidosis → i) excess CO_2 production
ii) excess Organic acid production
iii) ↑ intake of acidic product
iv) ↓ excretion of metabolic acids.

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2) Alkalosis

→ ↓ CO_2 production
→ ↑ HCO_3^- production
→ ↓ H^+ production
→ Intake of alkaline drug.

Regulation of Acid-Base Balance

→ Human body have different buffer system that are found generally in plasma and kidney.
→ It consist of weak acid & salt of that acid & act as a weak base.

following are buffer systems

- Chemical Buffer System
  - Bicarbonate buffer system
  - phosphate buffer system
  - Protein buffer system
- Physiological Buffers
  - Respiratory Mechanism (CO_2 excretion)
  - Renal Mechanism (H^+ excretion)

(1) Carbonic acid & Bicarbonate Buffer.
(Hemoglobin buffer system)

→ This system is due to exchange of CO_2 in lungs, plasma and tissue for oxygenation.

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→ CO_2 formed during respiration react ε H_2O in presence of carbonic anhydrase enzyme in plasma to form carbonic acid.

$$CO_2 + H_2O \xrightarrow{CAs} H_2CO_3$$

(plasma) (carbonic acid) (weak acid)

* H_2CO_3 is a weak acid ε provide H^+ & HCO_3^-.

→ Plasma protein act as buffer and can ↓ pH due to coagulation of H_2CO_3.
(acidic nature)

→ Oxyhemoglobin (HbO_2) of erythrocyte activate the bicarbonate ion & thus O_2 diffuse out of erythrocyte.

* AT TISSUE LEVEL

from tissue

In plasma

$$CO_2 + H_2O \xrightarrow{CAs} H_2CO_3$$

to tissue

at tissue level

$$H_2CO_3 + HbO_2 \xrightarrow{K^+} HCO_3^- + HHb + O_2 \uparrow$$

Carbonic acid — oxyhemo-globin (from blood) — Bicarbonate — deoxy Hb

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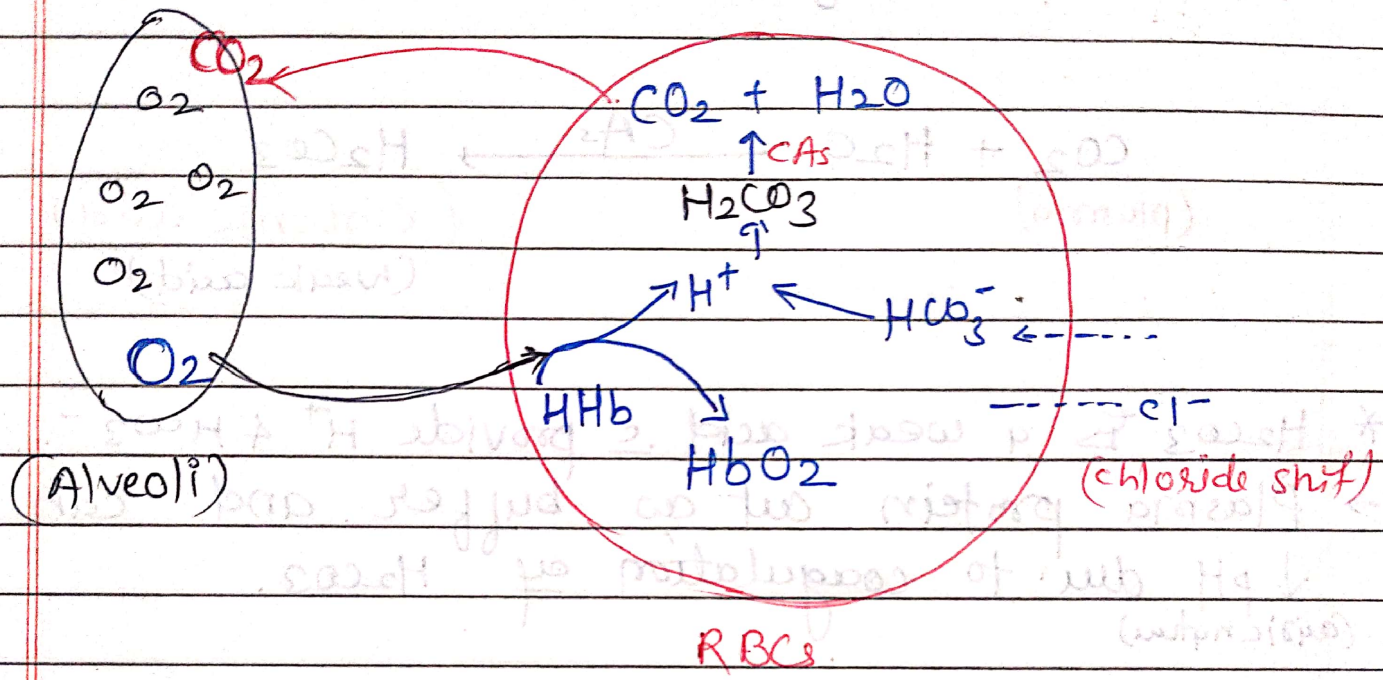
Lungs



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AT LUNGS LEVEL

→ In the lungs deoxy Hb get oxydized & Bicarbonate ion takes H^+ to form H_2CO_3.

Lungs ⟹ $O_2 + HHb + HCO_3^- \longrightarrow HbO_2 + H_2CO_3$

(deoxy Hb; Bicarbonate; (oxy Hb); carbonic acid)

$H_2CO_3 \xrightarrow[\text{Anhydrase}]{\text{Carbonic}} H_2O + CO_2 \uparrow$ (expelled out)

Conditions

(1) Acidosis : When there is an excess of H^+, then HCO_3^- act as weak base and accept H^+ to form carbonic acid (W.A.)

$H^+ + HCO_3^- \longrightarrow H_2CO_3$

(strong acid) (weak base) (weak acid)

(pH - ↑)

(2) Alkalosis : when ↓ H^+, then H_2CO_3 release H^+ ion & dissociate into HCO_3^-

$H_2CO_3 \longrightarrow H^+ + HCO_3$ (pH - ↓)

✡ So these acts as buffer system & maintain acid-base balance.

(2) Phosphate Buffer System

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→ This system is found in cells and kidney.

→ Here phosphate in buffer system are

* Monohydrogen phosphate → HPO_4^{2-}

* Dihydrogen phosphate → $H_2PO_4^-$

→ These buffers are formed in combination with sodium (from Tubular cell of kidney)

So

$HPO_4^{2-} \xrightarrow{2Na^+} Na_2HPO_4$ (disodium monohydrogen phosphate)

$H_2PO_4^- \xrightarrow{Na^+} NaH_2PO_4$ (sodium dihydrogen phosphate)

conditions

(1) Acidosis : When excess of H^+ occurs, then HPO_4^{2-} (Na_2HPO_4) act as weak base & accept H^+.

H^+ (strong acid) + Na_2HPO_4 (W.B.) $\xrightarrow{Na^+}$ NaH_2PO_4 (W.A.) + Na^+

Na^+ taken by HCO_3^-

(2) Alkalosis : When H^+ get reduced, then $H_2PO_4^-$ (NaH_2PO_4) act as weak acid & neutralized alkaline condition.

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$NaH_2PO_4 \xrightarrow{Na^+} Na_2HPO_4 + H^+$

(w.A.) (w.B.) (strong acid)

Summary

Acidosis : $Na_2HPO_4 + H^+ \xrightarrow{Na^+} Na^+ + NaH_2PO_4$

Alkalosis : $NaH_2PO_4 \xrightarrow{Na^+} Na_2HPO_4$

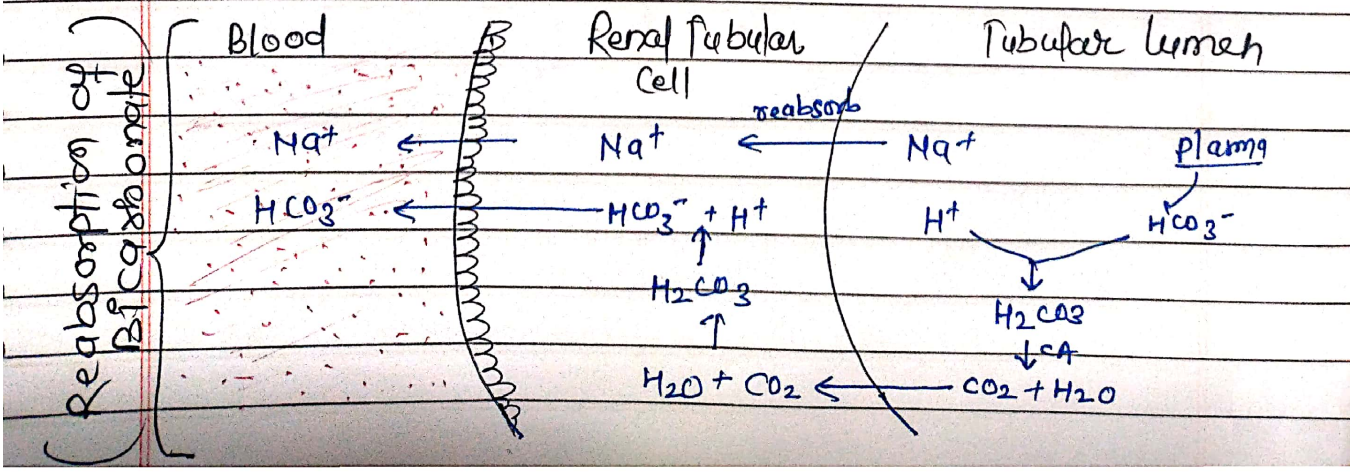
✡. Na^+ formed in acidosis is accepted by HCO_3^- in kidney tubules & formed

$Na^+ + HCO_3^- \longrightarrow NaHCO_3$

(Sod. bicarbonate)

→ This $NaHCO_3$ passes into blood & kidney, also synthesise new HCO_3^- & reabsorbs some HCO_3^- thus not lost in urine.

✡ H^+ in alkalosis are replaced by Na^+, hence passes in urine, thus kidney balance the pH by acidification of urine.



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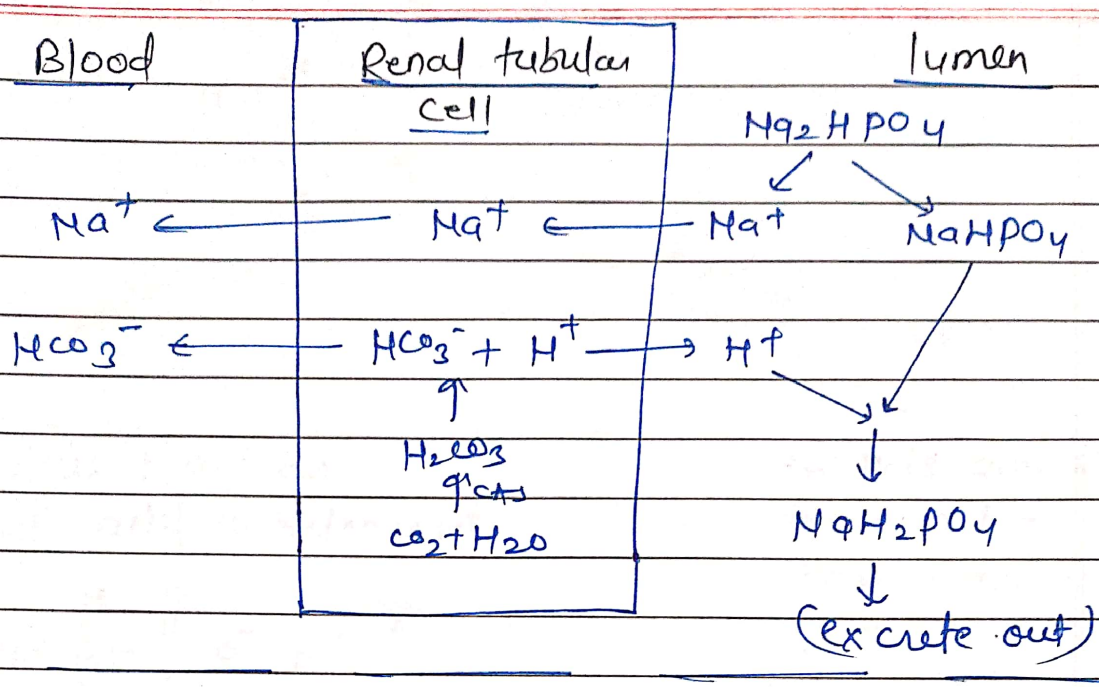


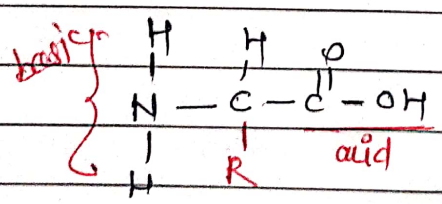
3. Protein Buffer System

→ This is mostly found in cell + plasma.

→ Proteins are composed of amino acids. & have two functional group. to stabilize the pH of cells.

→ Groups are $-COOH$ (Carboxyllic) (weak Acid)
$-NH_2$ (Amino) (weak base)

Structure



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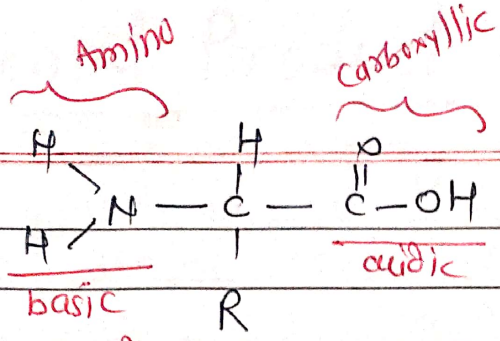
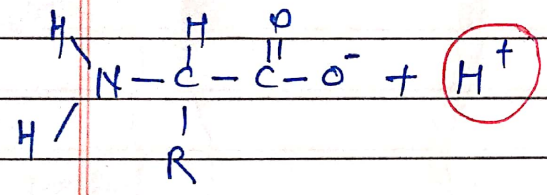


Alkalosis (H^+ ↓)

Acidosis (H^+ ↑)

In this it act as weak acid & release H^+



In this amino group act as weak base & accept H^+