

Today's Topic: Role of Hb in pH balance & CO₂ transport

Date: - 28/04/2020

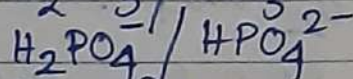
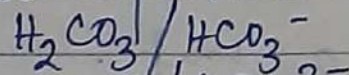
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Chemistry of Physiological Buffers :-

Acids and bases are produced in different metabolic processes. The acids are eliminated mainly through lungs and small amount from kidney.

Our system handles with such large amount of acids (~30 litre of 1 mol dm⁻³ of monobasic acid), but the pH of our blood remain 7.35-7.45. This is possible because of the presence of efficient buffers in blood.

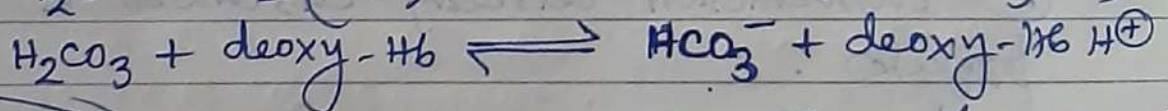
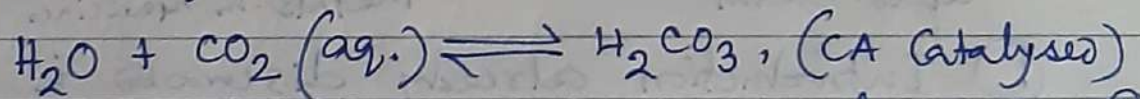
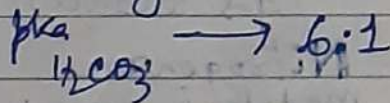
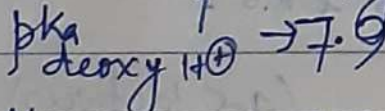
The important buffers in the blood are



Hemoglobin
proteins

The CO₂ produced in working tissues is hydrated to H₂CO₃ with the help of Zn(II) enzyme carbonic anhydrase (CA).

pKa value of deoxy Hb H⁺ is ^{higher} ~~less~~ than H₂CO₃.



Buffer equation

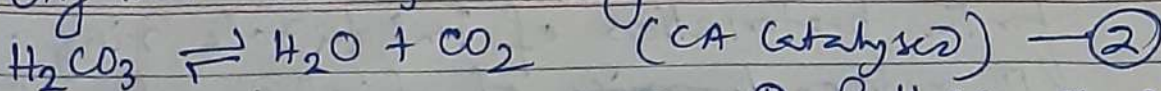
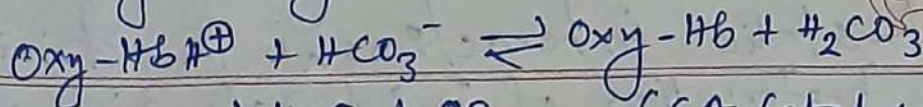
$$7.4 = 6.1 + \log \frac{[\text{HCO}_3^-]}{[\text{CO}_2]}$$

$$(pH = pK_a + \log \frac{[A^-]}{[A]})$$

From This equation we can calculate the value of

$$\frac{[\text{HCO}_3^-]}{[\text{CO}_2]} \approx 20 \text{ and thus } [\text{HCO}_3^-] \text{ is a predominates.}$$

In the Lungs, $\text{Oxy-Hb} \text{H}^+$ exists predominantly.



The acid strength of $\text{Oxy-Hb} \text{H}^+$ & H_2CO_3 are much comparable but the decomposition of H_2CO_3 is rapid by Carbonic anhydrase. So eqⁿ (1) is favorable towards ~~eqⁿ~~ forward direction.

* Role of Hb in pH balance and CO_2 transport \Rightarrow

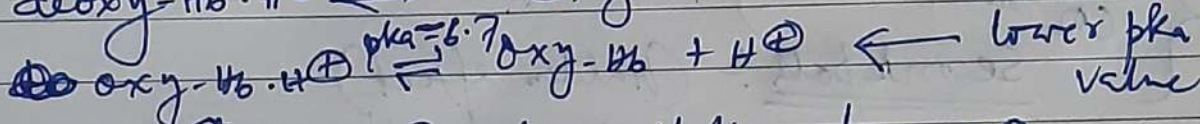
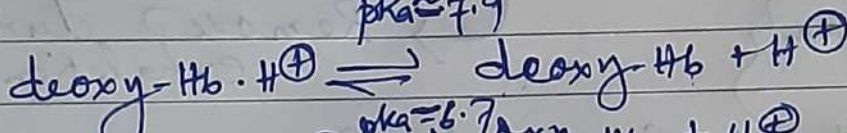
As deoxy Hb and oxy-Hb can act as weak Bronsted acids. For this reason it can act as a buffer to maintain biological pH. Besides this hemoglobin plays an important role in transporting CO_2 from the tissue.

First Pathway \Rightarrow

$$pK_a \text{ deoxy-Hb} = 7.9$$

$$pK_a \text{ oxy-Hb} = 6.7$$

$$pK_a \approx 7.9$$



↑ Stronger Bronsted acid than deoxy-H⁺.

NOTE:-
 CO_2 is produced in
Krebs's cycle

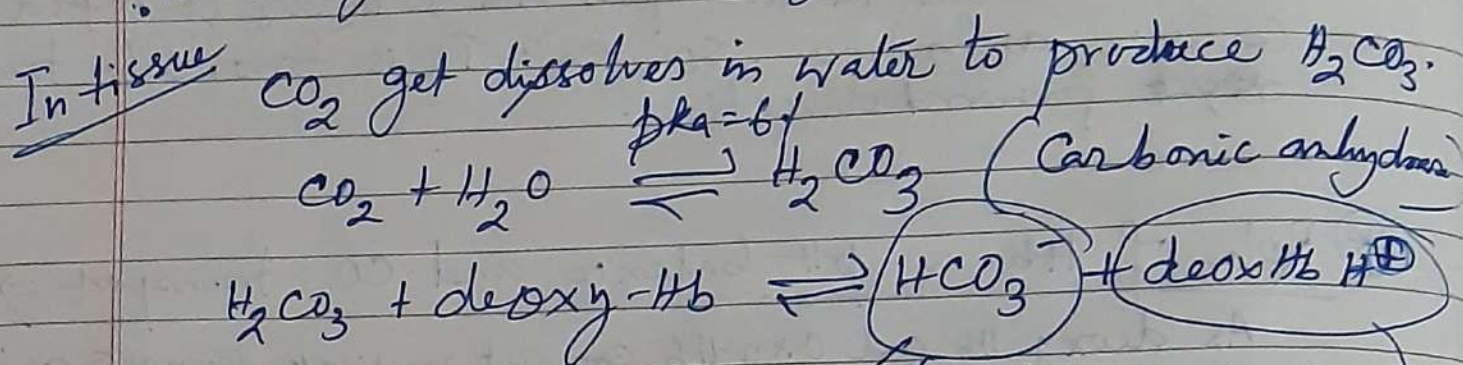
i) In oxy-Hb (R-form), histidine 146 residue of β chain rotates freely.

ii) But in deoxy-Hb the positively charged histidine residue participate in salt bridge interaction to form T-form.

iii) Electrostatic interaction between protonated imidazole ring and carboxylate group of aspartate-94 on the same β -chain

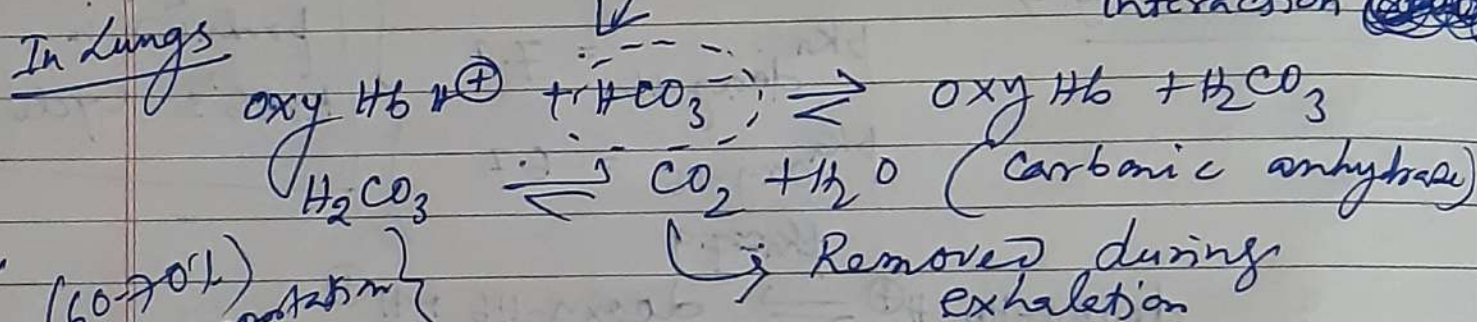
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Electrostatic interactions in the driving force for the protonation of imidazole ring. This is the reason ~~because~~ of higher value of ~~deoxy~~ pK_a in deoxy Hb H^+ than oxy Hb.



→ transports to lungs through blood plasma.

← Salt bridge interaction

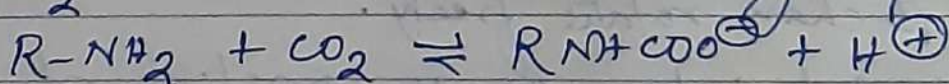


{ (60-70%) CO_2 transportation }

Second path :- (Halden effect)

In this process hemoglobin act as the main carrier of CO_2 transport.

CO_2 Combines with α -amino groups of globin chain.



deoxy Hb has more thermodynamic affinity to form Carbamino Compound and stabilise it form (through Salt bridge).

This process contributes only 10% CO_2 transportation

Related topic to be discussed in next lecture:-

Basic
concepts

① Buffer capacity

② Salt bridge interaction

③ $\text{Cl}^- \rightarrow \text{HCO}_3^-$ balance (for electroneutrality)
plasma \leftrightarrow erythrocyte
 Cl^- shift

* ④ protonation sites in globin protein chain. (Explanation of salt bridge interaction, T state etc.)

exam purposes