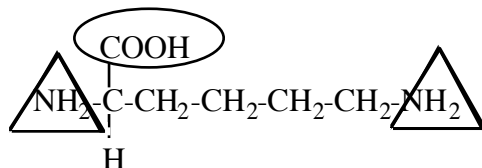
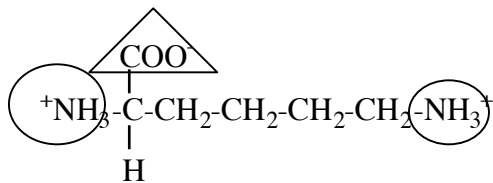


### THIRD PROBLEM SET-KEY

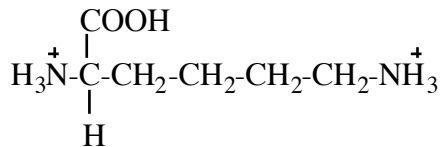
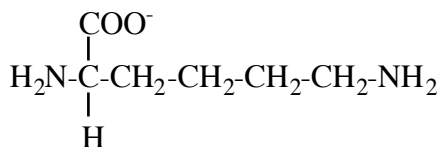
1.



a. These groups have a proton and, because of the equilibrium (dissociation) constant of the reaction  $\text{HA} \rightarrow \text{H}^+ + \text{A}^-$ , are likely to give it up under the conditions normally found in living things (i.e. pH 7)

b. These groups, again because of their dissociation constants, are likely to pick up a proton under the conditions normally found in living things.

c. At high pH (low  $\text{H}^+$ ), some groups that at normal pH might keep their proton, will lose it. Other groups which at normal pH might lose a proton, could gain one at very low pH where there are many more protons in the solution.



d. At pH 8.9 and above, an amino acid on this protein (isoleucine) has its  $\text{NH}_3^+$  group deprotonated (loses a proton). As a result it loses its + charge and becomes  $\text{-NH}_2$ . Then it is no longer attracted to a nearby amino acid (aspartate) which has a - charge. If the isoleucine is not pulled towards the aspartate, the protein is not in its normal shape and in this case, that shape change results in loss of activity.

2. After the reaction  $\text{A} \rightleftharpoons \text{B}$  has reached equilibrium:

- the rate at which A is converted to B is **constant**,
- the concentration of A is **constant and dependent on the  $\Delta G$  of the reaction**.
- the rate at which A is converted to B is **equal to** the rate at which B is converted to A.

3. The binding of hemoglobin and oxygen is governed by the equation

$$K_{eq} = \frac{[Hb] [O]}{[HbO]}$$

Thus the amount of hemoglobin binding oxygen [HbO] compared to that which has released its oxygen [Hb] is determined by the oxygen concentration [O] and the equilibrium constant ( $K_{eq}$ ). Since  $K_{eq}$  is constant, the binding is determined by the oxygen concentration. In the lungs it is high, so most of the Hb is in the HbO form (to keep the entire right side of the equation equal to  $K_{eq}$ .) In the leg, oxygen concentration is low, so most Hb will be in the Hb form form (to keep the entire right side of the equation equal to  $K_{eq}$ .) In order to get from one form to the other, it must release (in the legs) or bind (in the lungs) its oxygen.

4. The relative amount of these amino acids that is protonated (HA) rather than unprotonated(A) depends on the equilibrium constant and the  $[H^+]$  concentration.

$$K_{eq} = \frac{[A] [H^+]}{[HA]}$$

Since at pH 8 the  $[H^+]$  concentration is fixed, then the reason the isoleucine is in the HA form and histidine is in its A form is that they have different equilibrium constants i.e., they have different affinities for the  $H^+$ . Isoleucine has a higher affinity so it binds an  $H^+$  at a lower  $H^+$  concentration.

5 a. Acids such as lactic acid dissociate to produce free protons. pH, a measure of free proton concentration, decreases when the concentration of free protons increases.

b. In the muscles. The ratio of protonated Hb to unprotonated Hb depends on the equilibrium constant and the  $H^+$  concentration. The equilibrium constant is the same in lungs and muscles, (it is a constant). Since  $H^+$  is greater in the muscles, protonated  $HbH^+$  is greater there.

c. Protonated Hb should have a lower affinity for oxygen. This would allow it, at low pH, to “unload” more of its bound oxygen and to more efficiently deliver that oxygen to the muscles which require it. (The drop of 0.2 pH units allows the delivery of 10% more oxygen.)