MCB 11 M. D. Alper
Spring 2006 Quiz 2 -Key March16, 2006

1. (15 pts) A student observes the binding of oxygen to hemoglobin in the lungs and the release of that oxygen in the brain. Recognizing that systems in nature move towards lower energy, he assumes that HbO is at a lower energy than Hb +O in the lungs while Hb + O is at a lower energy than HbO in the brain.

a. Is this true? Explain.

NO. The free energy difference between two molecules or groups of molecules is characteristic only of the nature of the molecules themselves, not their amounts or environment.

b. Is there any (other, depending on the answer to part a) factor that is different in the lungs and the brain that can (assist) in the efficient delivery of oxygen from the lungs to the brain.

The major factor here is the concentration of oxygen. Given the fixed equilibrium constant

Keq = [Hb] [O] / [HbO]

then at high [O] in the lungs, the majority of the Hb is in the HbO form, while at low [O] in the brain, the majority is in the Hb form. Thus, in the lungs the Hb binds oxygen and in the brain it releases it.

c. If carbon monoxide is added to a solution of fully oxygenated hemoglobin (all Hb is in the HbO form) will it promote or inhibit the release of oxygen. Explain.

CO binds Hb much more tightly than O. Thus in a competition for binding to Hb, the Hb will disproportionately bind CO, and thus favor the release of O.

2. (15 pts) Changing the pH of a solution containing a protein can have a significant effect on the structure and function of that protein.

a. Define pH

pH is a measure of the concentration of H+ ions in a solution. High pH is relatively low concentration, low pH a high concentration.

b. Describe the effect that an increase in pH can have on the charge of a protein.

Increasing pH lowers the H+ concentration, thus fewer amino acid side chains or terminal groups will have the H+ attached. Thus, those that would have a positive charge with an H+ bound will be neutral and those that would have a neutral charge with the H+ bound will be negatively charged.

c. Do you think it is possible to predict the number of charge changes that will occur when the pH is raised from one known level to another. Explain

It is. If we know the affinity of each side chain or end group for H+ in its particular location in the protein (the equilibrium constant) then we will know the pH at which half of each particular group will have the H+ and half will not. If we also knew the

exact amino acid composition of the protein, we would know how many would gain the proton at the particular pH in question.