1. (1) The $H_2PO_4^-$/HPO_4^{2-} pair has a pKa of 6.86, explain its characteristics as a buffer by the Henderson-Hasselbalch equation. (5%)

   (2) Describe the significance of buffers in biological systems. (5%)

2. Given the following facts:

Protein	Isoionic pH	Molecular weight
Chymotrypsinogen	9.4	23,200
Hemoglobin	7.0	64,500
Lysozyme	11.1	14,100
Ovalbumin	4.9	45,000

   (1) Draw the elution profile for a mixture of these four proteins that would be obtained by passing them through Sephadex® G-150 (fractionation range 5,000-300,000). (5%)

   (2) What would be the order of elution of these four proteins from an ion exchange column of diethylaminoethyl cellulose [cellulose-CH_2-CH_2-$^\oplus NH(C_2H_5)_2$] eluted with a gradient of increasing ionic strength at (1) pH8.0 (2) pH4.0. (5%)

3. Suppose that you determined experimentally that a cellular transport system for glucose, driven by symport of Na^+, could accumulate glucose to concentrations 25 times greater than in the external medium, while the external [Na^+] was only ten times greater than the intracellular [Na^+]. Is this a violation of the laws of thermodynamics? If not, how do you explain this observation? (10%)

4. The reaction velocity is half-maximal when the enzyme is one-half saturated with substrate. Show that this is true algebraically. (10%)

5. Describe the structure characteristics of A form, B-form, and Z-form DNA. (10%)

6. How are glycolysis and gluconeogenesis coordinately regulated? (10%)

7. What processes affect the steady-state concentration of a protein? (10%)

8. Explain how ATP energizes active transport across membranes via the $Na^+ K^+$ ATPase. (10%)

9. The half-life of most hormones in the blood is relatively short. For example, if radioactively labeled insulin is injected into an animal, one can determine that within 30 min half the hormone has disappeared from the blood.

   (1) What is the importance of the relatively rapid inactivation of circulating hormones? (5%)

   (2) In view of this rapid inactivation, how can the circulating hormone level be kept constant under normal conditions? (5%)

10. Outline in a flow chart for expressing a heterologous protein in E. coli system. (10%)