國立清華大學 100 學年度碩士班入學考試試題

系所班組別：生醫工程與環境科學系　甲組(分子生醫光電組)

考試科目（代碼）：生物化學 2502

*請依題序，順序在【答案卷、卡】作答， 每題十分　　共 3 頁，第 1 頁

1.

(a) Explain the metabolic significance of reactions that function near equilibrium and reactions that function far from equilibrium

(b) With your best knowledge, explains the mechanisms in the control of metabolic flux through the rate-determining step in a metabolic pathway.

(c) In the cell, the substance concentrations for the reaction ATP + creatine $\rightleftharpoons$ phosphocreatine + ADP are [ATP] = 4 mM, [ADP] = 0.15 mM, [creatine] = 1 mM, and [phosphocreatine] = 2.5 mM. The free energy at standard state ($\Delta G^{0\prime}$) is 12.6 kJ $mole^{-1}$ and the gas constant (R) is 8.3145 J·K $mole^{-1}$. Calculate ΔG for the reaction and using this reaction as an example to describe the ways an exergonic process can drive an endergonic process.

2. The following DNA fragment was sequenced by the Sanger method. The asterisk indicates a fluorescent label.

*5′——— 3′ -OH
3′——— ATTACGCAAGGACATTAGAC 5′

(a) Please describe the DNA sequencing procedure in detail.

(b) Please also draw the possible fluorescent bands on the gel resulting from the nucleotide mixtures separated by gel electrophoresis.

3.

(a) Why is it important that weak forces, not strong forces, mediate biomolecular recognition?

(b) What are the important factors that stabilize the secondary structure of DNA?

(c) Most globular proteins are denatured and lose their activity when briefly heated to 65℃. However, globular proteins that contain multiple disulfide bonds often must be heated longer at higher temperatures to denature them. One such protein is bovine pancreatic trypsin inhibitor (BPTI), which has 58 amino acid residues in a single chain and contains three disulfide bonds. On cooling a solution of denatured BPTI, the activity of the protein is restored. What is the molecular basis for this property?

4. Control of blood pH by respiration rate

(a) The partial pressure of CO_2 in the lungs can be varied rapidly by the rate and depth of breathing. For example, a common remedy to alleviate hiccups is to increase the concentration of CO_2 in the lungs. This can be achieved by holding one's breath, by very slow and shallow breathing (hypoventilation), or by breathing in and out of a paper bag. Under such conditions, the partial

pressure of CO_2 in the air space of the lungs rises above normal. Qualitatively explain the effect of these procedures on the blood pH.

(b) A common practice of competitive short-distance runners is to breathe rapidly and deeply (hyperventilation) for about half a minute to remove CO_2 from their lungs just before running in, say, a 100 m dash. Their blod pH may rise to 7.60. Explain why the blood pH increases.

(c) During a short–distance run the muscles produce a large amount of lactic acid ($CH_3CH(OH)COOH$, $K_a = 1.38 \times 10^{-4}$) from their glucose stores. In view of this fact, why might hyperventilation before a dash be useful?

5. Enzyme A follows simple Michaelis-Menten kinetics.
   (a) The K_m of enzyme A for its substrate S is $K_m^S = 1$ mM. Enzyme A also acts on substrate T and its $K_m^T = 10$ mM. Is S or T the preferred substrate for enzyme A?
   (b) The rate constant k_2 with substrate S is 2×10^4 sec^{-1}; with substrate T is 4×10^5 sec^{-1}. Does Enzyme A use substrate S or substrate T with greater catalytic efficiency?
6. Fructose bisphosphate adolase in animal muscle is a class I aldolase, which forms a Schiff base intermediate at the active site.
   (a) Write the structure of a substrate of this enzyme and how this substrate forms a Schiff base intermediate with the key amino acid within the enzyme active site.
   (b) Provide an experimental approach to demonstrate the existence of this intermediate.
7. In most cells, fatty acids are synthesized from acetates.
   (a) Where are fatty acids synthesized? And what are the primary sources of acetate units in the cells?
   (b) How do cells convert and transport acetate to become substrate for fatty acid synthesis?
   (c) What coenzymes might be required to run this process?
   (d) Which of the reactions in this process might require energy input?
8. To being with a diagram with fructose-6-phosphate,
   (a) draw a diagram to produce maximum large amounts of ribose-5phophate
   (b) which carbon atoms in ribose-5-phosphate are derived from carbon atoms in positions 1, 3, and 6 of fructose-6-phophate?
   (c) How many ATPs are required in your diagram?

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9. Starting from glutamine, aspartate, glycine, CO_2, and N^{10}-formyl-THF,
   (a) Draw a diagram to the synthesis of UTP
   (b) How many ATP equivalents are expended in the synthesis of ATP, GTP, and CTP, respectively?
10. Covalent modifications on histone tails are critical for DNA : histone interactions.
   (a) Illustrates the various common covalent modifications on histone tails
   (b) How might each of these modifications influence DNA : histone interactions?