注意：考試開始鈴響前，不得翻閱試題，並不得書寫、畫記、作答。

國立清華大學 115 學年度碩士班考試入學試題

系所班組別：生命科學暨醫學院
乙組(化學與生醫工程組)

科目代碼：0501

考試科目：生物化學

—作答注意事項—

1. 請核對答案卷（卡）上之准考證號、科目名稱是否正確。
2. 考試開始後，請於作答前先翻閱整份試題，是否有污損或試題印刷不清，得舉手請監試人員處理，但不得要求解釋題意。
3. 考生限在答案卷上標記「▼由此開始作答」區內作答，且不可書寫姓名、准考證號或與作答無關之其他文字或符號。
4. 答案卷用盡不得要求加頁。
5. 答案卷可用任何書寫工具作答，惟為方便閱卷辨識，請儘量使用藍色或黑色書寫；答案卡限用 2B 鉛筆畫記；如畫記不清（含未依範例畫記）致光學閱讀機無法辨識答案者，其後果一律由考生自行負責。
6. 提早交卷者不可攜出試題，請將試題連同答案卷(卡)交予監考人員，攜出將以違規論處。當節考試結束後試題將置於講台，可自行取回，本試場不負保管責任。
7. 其他應考規則、違規處理及扣分方式，請自行詳閱准考證明上「**國立清華大學試場規則及違規處理辦法**」，無法因本試題封面作答注意事項中未列明而稱未知悉。

國立清華大學 115 學年度碩士班考試入學試題

系所班組別：生命科學暨醫學院甲組、乙組、丁組

考試科目（代碼）：生物化學(0401、0501、0701)

Part 1 選擇題，25 題單選題 (每題 2 分，共 50 分)，答錯不倒扣

1. Protein X becomes more active in an acidic environment. When the surrounding pH decreases, protein X undergoes a conformational change, leading to its activation. Which of the following amino acid residues is most likely responsible for this pH-dependent regulation?

A. Alanine
B. Leucine
C. Histidine
D. Valine
E. Phenylalanine

2. A research team is studying a mutation in protein Y associated with a genetic disorder. They discover that a single amino acid substitution causes a loss of α-helical structure in a critical domain of protein Y, leading to the protein misfolding and loss of function. Which of the following amino acid substitutions is most likely responsible for disrupting the α-helix in this protein?

A. Alanine → Leucine
B. Leucine → Valine
C. Alanine → Glutamic acid
D. Leucine → Proline
E. Valine → Isoleucine

3. A systems biologist examines how biological processes operate over vastly different time scales, from molecular events to cellular functions.
Which of the following processes occurs on the "shortest" time scale?

A. Cell division during tissue renewal
B. Protein synthesis from mRNA
C. Folding of a newly synthesized protein
D. Chromatin remodeling during gene regulation
E. Enzyme-catalyzed bond formation at the active site

4. A 0.02 M solution of monoprotic acid HA has a pH of 4.0. What are the values of the acid dissociation constant $K_a$and pK_a?

A. $K_a = 5.0 \times 10^{-7}$, $pK_a = 6.30$
B. $K_a = 5.0 \times 10^{-9}$, $pK_a = 8.30$
C. $K_a = 1.0 \times 10^{-4}$, $pK_a = 4.00$
D. $K_a = 2.0 \times 10^{-6}$, $pK_a = 5.70$
E. $K_a = 1.0 \times 10^{-5}$, $pK_a = 5.00$

5. Which statement about the functions of O-linked and N-linked glycosylation is CORRECT?

A. N-linked glycosylation mainly controls the cytoskeleton, while O-linked glycosylation controls protein folding in the ER.
B. O-linked glycosylation promotes protein folding in the ER, while N-linked glycosylation is not needed for quality control.
C. N-linked glycosylation is essential for protein folding, ER quality control, and secretion, while O-linked glycosylation affects protein stability and cell interactions.
D. Both mainly serve as energy storage with little effect on protein function.
E. O-linked glycosylation sends misfolded proteins to the proteasome, while N-linked glycosylation mainly presents antigens.

6. Which of the following statements about lipids in biological membranes is **correct**?

A. The hydrophobic tails of phospholipids are primarily composed of fatty acid chains.
B. Saturated fatty acids contain double bonds and increase membrane fluidity.
C. Cholesterol increases membrane fluidity at all temperatures.
D. Lipids in biological membranes cannot be modified by sugars and therefore do not participate in cell recognition.
E. Natural unsaturated fatty acids commonly contain trans double bonds.

7. Which statement about primary active transporters is **correct**?

A. They use the electrochemical gradient of another ion to drive solute transport.
B. They directly hydrolyze ATP to move substrates against their concentration gradients.
C. They transport substrates only down their concentration gradients.
D. They function exclusively as symporters in biological membranes.
E. They do not require energy input for substrate transport.

8. Lipids, sugars, and amino acids can be chiral. Which statement about their stereochemical properties in nature is **correct**?

A. All naturally occurring amino acids in proteins are chiral and have the L-configuration.
B. Fatty acids in biological membranes are predominantly chiral and exist mainly as L-enantiomers.
C. Naturally occurring sugars and amino acids both predominantly adopt the L-configuration.
D. Most monosaccharides in biological systems have the D-configuration, and glycerol-based membrane lipids are synthesized from sn-glycerol-3-phosphate with defined stereochemistry.
E. Biological systems contain racemic mixtures of sugars, amino acids, and lipids due to spontaneous chemical reactions.

9. Which statement correctly describes the effects of competitive, noncompetitive, and uncompetitive enzyme inhibitors on kinetic parameters?

A. Competitive inhibitors decrease Vmax but do not affect Km.
B. Noncompetitive inhibitors increase Km but do not change Vmax.
C. Uncompetitive inhibitors decrease both Vmax and Km.
D. Competitive inhibitors decrease both Vmax and Km.
E. Uncompetitive inhibitors increase Vmax by stabilizing the enzyme–substrate complex.

10. In transmembrane proteins, which amino acid is most commonly enriched at the water–lipid interface of the membrane?

A. S
B. P
C. A
D. F
E. W

11. Which of the TCA cycle intermediates **is not** a four-carbon molecule?

A. Succinate
B. Fumarate
C. Malate
D. Citrate
E. Oxaloacetate

12. Which of the following enzyme complexes links glycolysis to the TCA cycle?

A. Pyruvate dehydrogenase complex
B. α-ketoglutarate dehydrogenase complex
C. Glyceraldehyde-3-phosphate dehydrogenase
D. Pyruvate kinase complex
E. Phosphoglycerate kinase complex

13. Which of the following molecules **cannot** stimulate glycolytic flux?

A. AMP
B. ADP
C. Fructose-2,6-bisphosphate
D. Insulin
E. Citrate

14. Which of the following enzyme complexes links the TCA cycle to the electron transport chain in the inner mitochondrial membrane?

A. NADH ubiquinone oxidoreductase complex
B. Ubiquinol-cytochrome c reductase complex
C. Succinate dehydrogenase complex
D. Pyruvate dehydrogenase complex
E. Phosphoglycerate kinase complex

15. The linear photosynthesis electron chain **does not** involve the transport of electrons to:

A. Photosystem I
B. Photosystem III
C. Cytochrome b_6f complex
D. Plastoquinone
E. Ferredoxin

16. Which of the following biomolecule is a crossroad between glycolytic pathway and pentose phosphate pathway?

A. Glucose 6-phosphate
B. Glyceraldehyde 3-phosphate
C. Pyruvate
D. Acetyl-CoA
E. Fructose 1,6-bisphosphate

17. Which of the following reaction would favor cellular gluconeogenesis in the fasted state?

A. AMP activates phosphfructokinase 1
B. Fructose 2,6-bisphosphateactivates pyruvate kinase
C. Acetyl-CoA activates pyruvate carboxylase
D. NAD^+ activates glyceraldehyde 3-phosphate dehydrogenase
E. None of the above.

18. Which of the following urine component can be used as a biomarker to monitor DNA turnover?

A. beta-aminoisobutyrate
B. ammonium ion
C. beta-alanine
D. cytidine
E. AMP

19. Which of the following amino acid is a pure ketogenic amino acid means its carbon skeleton can be used for the synthesis of ketone bodies but not glucose?

A. Lysine
B. Glycine
C. Proline
D. Methionine
E. Tryptophan

20. Carnitine transport of fatty acids from the cytosol to the mitochondria is important for fatty acid catabolism. Which of the following statement is not true?

A. the reaction is energy required
B. free carnitine and acyl-carnitine can be exchanged across mitochondrial inner membrane
C. release of CoASH from fatty acyl CoA in the cytosol side
D. carnitine:acylcarnitine translocase plays essential role in this reaction
E. carnitine palmitoyl transferase 1 and 2 located on outer- and inner-mitochondrial membrane, respectively.

21. G-proteins are associated with which receptor superfamily?

A. oligomeric ligand-gated ion channels
B. 7-transmembrane segment (7-TMS) receptors
C. cell adhesion protein receptors
D. single-transmembrane segment catalytic receptors
E. none of the above

22. The second messenger produced from the hydrolysis of PIP_2 that activates the increase of Ca^{++} concentrations in the cytoplasm is:

A. diacylglycerol (DAG).
B. phosphatidylinositol (PI).
C. phosphatidylinositol-4,5-*bis*phosphate (PIP_2).
D. inositol-1,4,5-*tris*phosphate (IP_3).
E. inositol-1,4-*bis*phosphate (IP_2).

23. Which of the following is NOT a second messenger?

A. cGMP
B. norepinephrine
C. nitric oxide
D. diacylglycerol
E. Ca^{2+}

24. A highly conserved protein that is involved in protein degradation is:

A. ricin
B. met-aminopeptidase
C. ubiquitin
D. degradase
E. peptidyl transferase

25. Mitochondrial and chloroplastic ribosomes resemble ____ ribosomes.

A. prokaryotic
B. lower eukaryotic
C. higher eukaryotic
D. no other
E. none are true

Part 2 簡答題 5 題 (每題 10 分，共 50 分)

1. In a cell at 37 °C (310 K), ATP hydrolysis is:

$$\mathrm{ATP} + \mathrm{H_2O} \rightarrow \mathrm{ADP} + P_i$$

Given:

- $\Delta G^{\circ\prime} = -30.5$ kJ / mole
- [ATP] = 5.0 mM
- [ADP] = 0.50 mM
- $[P_i] = 1.0$ mM

and assume activity of water ≈ 1.

(a) Calculate the reaction quotient Q. **(5%)**
(b) Compared with standard biochemical conditions, is ATP hydrolysis more favorable, less favorable, or equally favorable in this cell? Briefly justify. **(5%)**

2. The initial velocity of an enzyme-catalyzed reaction was measured at various substrate concentrations in the absence and in the presence of inhibitor Y at a fixed concentration. The results are shown below.

Kinetic Data

[S] (mM)	v_0 (no inhibitor) (μmol·min^{-1})	v_0 (+ inhibitor Y) (μmol·min^{-1})
0.5	20	10
1	33	16
2	50	25
5	71	36
10	83	42

(a) Based on the data, how does inhibitor Y affect Vmax and Km? **(4%)** **(b)** What type of inhibition does inhibitor Y most likely exhibit? Explain briefly using the kinetic data. **(4%)** **(c)** If the substrate concentration were increased to a very high level, would the inhibition by Y be overcome? Why or why not? **(2%)**

3. Please explain the definition **(2%)**, process **(4%)**, and mechanism **(4%)** of photorespiration.

4. **(a)** What is the salvage pathway of purine? **(b)** What reactions (substrates & products) are involved? **(c)** What is the key enzyme in response to this process? **(d)** What disease is caused by the deficient of this key enzyme? **(e)** What is the outcome of the disease?

5. The folding cycle of the GroES-GroEL complex in E. coli involves the following steps: Please consider these steps and arrange them in the correct order for the folding cycle.

A. ATP binding to GroEL
B. GroES dissociates from the complex
C. Partially folded protein hydrophobic residues bind GroEL
D. GroES is recruited to GroEL
E. GroES promotes ATP hydrolysis and α-subunits undergo a conformational change that buries the hydrophobic patches