國立成功大學 104 學年度碩士班招生考試試題

系所組別：生命科學系甲組

考試科目：生物化學及分子生物學　　考試日期：0212，節次：3

※ 考生請注意：本試題不可使用計算機。 請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

Part I (35 points):

Multiple Choice Questions

1. **(1 point)** Of the 20 standard amino acids, only _____ is not optically active. The reason is that its side chain _____.

(A) alanine; is a simple methyl group

(B) glycine; is a hydrogen atom

(C) glycine; is unbranched

(D) lysine; contains only nitrogen

(E) proline; forms a covalent bond with the amino group

2. **(1 point)** Which of the following statements about *cystine* is correct?

(A) Cystine forms when the —CH_2—SH R group is oxidized to form a —CH_2—S—S—CH_2— disulfide bridge between two cysteines.

(B) Cystine is an example of a nonstandard amino acid, derived by linking two standard amino acids.

(C) Cystine is formed by the oxidation of the carboxylic acid group on cysteine.

(D) Cystine is formed through a peptide linkage between two cysteines.

(E) Two cystines are released when a —CH_2—S—S—CH_2— disulfide bridge is reduced to —CH_2—SH.

3. **(1 point)** The uncommon amino acid selenocysteine has an R group with the structure —CH_2—SeH ($pK_a \approx 5$). In an aqueous solution, pH = 7.0, selenocysteine would:

(A) be a fully ionized zwitterion with no net charge.

(B) be found in proteins as D-selenocysteine.

(C) never be found in a protein.

(D) be nonionic.

(E) not be optically active.

4. **(1 point)** Titration of valine by a strong base, for example NaOH, reveals two p*K*'s. The titration reaction occurring at pK_2 ($pK_2 = 9.62$) is:

(A) —COOH + OH^- → —COO^- + H_2O.

(B) —COOH + —NH_2 → —COO^- + —NH_2^+.

(C) —COO^- + —NH_2^+ → —COOH + —NH_2.

(D) —NH_3^+ + OH^- → —NH_2 + H_2O.

(E) —NH_2 + OH^- → —NH^- + H_2O.

5. **(1 point)** The average molecular weight of the 20 standard amino acids is 138, but biochemists use 110 when estimating the number of amino acids in a protein of known molecular weight. Why?

(A) The number 110 is based on the fact that the average molecular weight of a protein is 110,000 with an average of 1000 amino acids.
(B) The number 110 reflects the higher proportion of small amino acids in proteins, as well as the loss of water when the peptide bond forms.
(C) The number 110 reflects the number of amino acids found in the typical small protein, and only small proteins have their molecular weight estimated this way.
(D) The number 110 takes into account the relatively small size of nonstandard amino acids.
(E) The number 138 represents the molecular weight of conjugated amino acids.

6. **(1 point)** Kendrew's studies of the globular myoglobin structure demonstrated that:
(A) "corners" between a-helical regions invariably lacked proline residue.
(B) highly polar or charged amino-acid residues tended to be located interiorally.
(C) myoglobin was completely different from hemoglobin, as expected.
(D) the structure was very compact, with virtually no internal space available for water.
(E) the helix predicted by Pauling and Corey was not found in myoglobin.

7. **(1 point)** Protein S will fold into its native conformation only when protein Q is also present in the solution. However, protein Q can fold into its native conformation without protein S. Protein Q, therefore, may function as a _____ for protein S.
(A) proteasome
(B) molecular chaperone
(C) protein precursor
(D) structural motif
(E) supersecondary structural unit

8. **(1 point)** Which of the following statements about protein-ligand binding is correct?
(A) The K_a is equal to the concentration of ligand when all of the binding sites are occupied.
(B) The K_a is independent of such conditions as salt concentration and pH.
(C) The larger the K_a (association constant), the weaker the affinity.
(D) The larger the K_a, the faster is the binding.
(E) The larger the K_a, the smaller the K_d (dissociation constant).

9. **(1 point)** Which of the following is *not* correct concerning 2,3-bisphosphoglycerate (BPG)?
(A) It binds at a distance from the heme groups of hemoglobin.
(B) It binds with lower affinity to fetal hemoglobin than to adult hemoglobin.
(C) It increases the affinity of hemoglobin for oxygen.
(D) It is an allosteric modulator.
(E) It is normally found associated with the hemoglobin extracted from red blood cells.

10. **(1 point)** A monoclonal antibody differs from a polyclonal antibody in that monoclonal antibodies:
(A) are labeled with chemicals that can be visualized.
(B) are produced by cells from the same organism that produced the antigen.
(C) are synthesized by a population of identical, or "cloned," cells.
(D) are synthesized only in living organisms.
(E) have only a single polypeptide chain that can recognize an antigen.

11. **(1 point)** The concept of "induced fit" refers to the fact that:
(A) enzyme specificity is induced by enzyme-substrate binding.
(B) enzyme-substrate binding induces an increase in the reaction entropy, thereby catalyzing the reaction.
(C) enzyme-substrate binding induces movement along the reaction coordinate to the transition state.
(D) substrate binding may induce a conformational change in the enzyme, which then brings catalytic groups into proper orientation.
(E) when a substrate binds to an enzyme, the enzyme induces a loss of water (desolvation) from the substrate.

12. **(1 point)** The steady state assumption, as applied to enzyme kinetics, implies:
(A) $K_m = K_s$.
(B) the enzyme is regulated.
(C) the ES complex is formed and broken down at equivalent rates.
(D) the K_m is equivalent to the cellular substrate concentration.
(E) the maximum velocity occurs when the enzyme is saturated.

13. **(1 point)** For the simplified representation of an enzyme-catalyzed reaction shown below, the statement "ES is in steady-state" means that:

$$E + S \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} ES \underset{k_{-2}}{\overset{k_2}{\rightleftharpoons}} E + P$$

(A) k_2 is very slow.
(B) $k_1 = k_2$.
(C) $k_1 = k_{-1}$.
(D) $k_1[E][S] = k_{-1}[ES] + k_2[ES]$.
(E) $k_1[E][S] = k_{-1}[ES]$.

14. **(1 point)** To calculate the turnover number of an enzyme, you need to know:
(A) the enzyme concentration.
(B) the initial velocity of the catalyzed reaction at [S] >> K_m.
(C) the initial velocity of the catalyzed reaction at low [S].
(D) the K_m for the substrate.
(E) both A and B.

15. **(1 point)** Phenyl-methane-sulfonyl-fluoride (PMSF) inactivates serine proteases by binding covalently to the catalytic serine residue at the active site; this enzyme-inhibitor bond is not cleaved by the enzyme. This is an example of what kind of inhibition?
(A) Irreversible
(B) Competitive
(C) Non-competitive
(D) Mixed
(E) pH inhibition

Short Answer Questions:

16. **(5 points)** What is the difference between general acid-base catalysis and specific acid-base catalysis? (Assume that the solvent is water.)

17. **(5 points)** Explain how the effects of sickle cell disease demonstrate that hemoblobin undergoes a conformational change upon releasing oxygen.

18. **(5 points)** Why do smaller molecules elute after large molecules when a mixture of proteins is passed through a size-exclusion (gel filtration) column?

19. **(5 points)** What is the role of ATP and ATP hydrolysis in the cycle of actin-myosin association and disassociation that leads to muscle contraction?

Part II (35 points)
Multiple Choice Questions

20. **(1 point)** The phosphodiester bond that joins adjacent nucleotides in DNA:
A) associates ionically with metal ions, polyamines, and proteins.
B) is positively charged.
C) is susceptible to alkaline hydrolysis.
D) Links C-2 of one base to C-3 of the next.
E) links C-3 of deoxyribose to N-1 of thymine or cytosine.

21. **(1 point)** In the Watson-Crick model of DNA structure:
A) both strands run in the same direction, 3′ → 5′; they are parallel.
B) phosphate groups project toward the middle of the helix, where they are protected from interaction with water.
C) T can form three hydrogen bonds with either G or C in the opposite strand.
D) the distance between the sugar backbone of the two strands is just large enough to accommodate either two purines or two pyrimidines.
E) the distance between two adjacent bases in one strand is about 3.4 Å.

22. **(1 point)** In comparison with DNA-DNA double helices, the stability of DNA-RNA and RNA-RNA helices is:
A) DNA-DNA > DNA-RNA > RNA-RNA.
B) DNA-DNA > RNA-RNA > DNA-RNA.
C) RNA-DNA > RNA-RNA > DNA-DNA.
D) RNA-RNA > DNA-DNA > DNA-RNA.
E) RNA-RNA > DNA-RNA > DNA-DNA.

23. **(1 point)** The "energy carrier" ATP is an example of a(n):
A) deoxyribonucleoside triphosphate
B) di-nucleotide
C) peptide
D) ribonucleotide
E) ribonucleoside triphosphate

24. **(1 point)** When a DNA molecule is described as replicating bidirectionally, that means that it has two:
A) chains.
B) independently replicating segment.
C) origins.
D) replication forks.
E) termination points.

25. **(1 point)** An Okazaki fragment is a:
A) fragment of DNA resulting from endonuclease action.
B) fragment of RNA that is a subunit of the 30S ribosome.
C) piece of DNA that is synthesized in the 3′ ® 5′ direction.
D) segment of DNA that is an intermediate in the synthesis of the lagging strand.
E) segment of mRNA synthesized by RNA polymerase.

26. **(1 point)** In contrast to bacteria, eukaryotic chromosomes need multiple DNA replication origins because:
A) eukaryotic chromosomes cannot usually replicate bidirectionally.
B) eukaryotic genomes are not usually circular, like the bacterial chromosome is.
C) the processivity of the eukaryotic DNA polymerase is much less than the bacterial enzyme.
D) their replication rate is much slower, and it would take too long with only a single origin per chromosome.
E) they have a variety of DNA polymerases for different purposes, and need a corresponding variety of replication origins.

27. **(1 point)** Which one of the following statements about enzymes that interact with DNA is true?
A) *E. coli* DNA polymerase I is unusual in that it possesses only a 5′® 3′ exonucleolytic activity.
B) Endonucleases degrade circular but not linear DNA molecules.
C) Exonucleases degrade DNA at a free end.
D) Many DNA polymerases have a proofreading 5′® 3′ exonuclease.
E) Primases synthesize a short stretch of DNA to prime further synthesis.

28. **(1 point)** Which of the following statements about *E. coli* RNA polymerase (core enzyme) is *false*?
A) In the absence of the s subunit, core polymerase has little specificity for where initiation begins.
B) The core enzyme contains several different subunits.
C) The core enzyme has no polymerizing activity until the s subunit is bound.
D) The RNA chain grows in a 5′® 3′ direction.
E) The RNA product is complementary to the DNA template.

29. **(1 point)** The sigma factor of *E. coli* RNA polymerase:
A) associates with the promoter before binding core enzyme.
B) combines with the core enzyme to confer specific binding to a promoter.
C) is inseparable from the core enzyme.
D) is required for termination of an RNA chain.
E) will catalyze synthesis of RNA from both DNA template strands in the absence of the core enzyme.

30. **(1 point)** "Footprinting," or DNase protection, is a technique used to identify:
A) a region of DNA that has been damaged by mutation.
B) *E. coli* cells that contain a desired, cloned piece of DNA.
C) the position of a particular gene of a chromosome.
D) the position of internally double-stranded regions in a single-stranded DNA molecule.

E) the specific binding site of a repressor, polymerase, or other protein on the DNA.

31. **(1 point)** After binding by *E. coli* RNA polymerase, the correct order of events for transcription initiation is:
A) closed complex formation, open complex formation, promoter clearance, start of RNA synthesis.
B) closed complex formation, open complex formation, start of RNA synthesis, promoter clearance.
C) open complex formation, closed complex formation, start of RNA synthesis, promoter clearance.
D) start of RNA synthesis, closed complex formation, open complex formation, promoter clearance.
E) start of RNA synthesis, open complex formation, closed complex formation, promoter clearance.

32. **(1 point)** Protein structural motifs often have general functions in common. Which one of the following motifs is not involved in direct protein-DNA interactions?
A) *b*-barrel
B) Helix-turn-helix
C) Homeodomain
D) Leucine zipper
E) Zinc finger

33. **(1 point)** The binding of CRP (cAMP receptor protein of *E. coli*) to DNA in the *lac* operon:
A) assists RNA polymerase binding to the *lac* promoter.
B) is inhibited by a high level of cAMP.
C) occurs in the *lac* repressor region.
D) occurs only when glucose is present in the growth medium.
E) prevents the repressor from binding to the *lac* operator.

34. **(1 point)** Transcription of the lactose operon in *E. coli* is stimulated by:
A) a mutation in the repressor gene that strengthens the affinity of the repressor for the operator.
B) a mutation in the repressor gene that weakens the affinity of the repressor for the operator.
C) a mutation in the repressor gene that weakens the affinity of the repressor for the inducer.
D) binding of the repressor to the operator.
E) the presence of glucose in the growth medium.

35. **(1 point)** Gene silencing by RNA interference acts by _____ of the target gene.
A) inhibiting transcription
B) inhibiting translation
C) inhibiting splicing
D) degradation of the mRNA
E) inhibiting polyadenylyation

Short Answer Questions:

36. **(4 points)** Describe qualitatively how the t_m for a double-stranded DNA depends upon its nucleotide composition.

37. **(5 points)** All known DNA polymerases catalyze synthesis only in the 5′ → 3′ direction. Nevertheless, during semiconservative DNA replication in the cell, they are able to catalyze the synthesis of both daughter chains, which would appear to require synthesis in the 3′ → 5′ direction. Explain the process that occurs in the cell that allows for synthesis of both daughter chains by DNA polymerase.

38. **(5 points)** Name four general types of posttranscriptional processing reactions that are observed in RNA. Briefly (one sentence or less) point out an example of each type. In your example, identify the type of RNA molecule involved (tRNA, mRNA, rRNA, etc.), the type of "processing" involved, and whether the example is characteristic of eukaryotes or prokaryotes, or both. Do not describe specific genes, sequences, complicated structures, or enzymes.

39. **(5 points)** Describe and contrast positive regulation and negative regulation of gene expression.

Part III (30 points)

Multiple Choice Questions

40. **(2 points)** Phosphofructokinase is allosterically _____ by high concentrations of _____.

I. activated; ATP
II. inhibited; ATP
III. inhibited; fructose-2,6-bisphosphate
IV. activated; fructose -2,6-bisphosphate

A) I, III B) II, III C) II, IV D) I, IV

41. **(2 points)** Glucose is converted to _____ in skeletal muscle under anaerobic conditions.

A) lactate B) acetyaldehyde C) fructose D) glycogen

42. **(2 points)** Individuals with galactosemia

A) cannot catabolize galactose via glycolysis.
B) lack the enzyme hexokinase which is required for phosphorylation of galactose.
C) lack the enzyme galactokinase which is required for interconversion between glucose-1-phosphate and galactose-1-phosphate.
D) cannot synthesize galactose from glucose.

43. **(2 points)** Which of the following best describes the control exhibited by phosphofructokinase (PFK)?
A) It is allosterically inhibited by ATP and citrate. B) It is allosterically activated by F2,6P.
C) It is allosterically activated by ATP and citrate. D) Both A and B are correct.

44. **(2 points)** Which of the following enzymes directly converts phosphorylase *b* into the more active form, phosphorylase *a*?
A) cAMP-dependent protein kinase B) phosphorylase kinase
C) protein kinase A D) adenylate cyclase

45. **(2 points)** If cAMP levels are high
I. Glycogenolysis will occur in muscle cells but not liver cells.
II. Glucose released from muscle glycogen will enter glycolysis.
III. Glucose released from liver glycogen will exit liver cells via the GLUT4 transporter.
IV. Glucose will enter liver cells resulting in glycogen synthesis.
A) I, II, IV
B) I, II
C) II, III, IV
D) II only

46. **(2 points)** Which of the following best describes the role of fructose-2,6-bisphosphate (FBP) in liver cells?
A) It is an intermediate in glycolysis.
B) It is an intermediate in gluconeogenesis.
C) It is an intermediate in both glycolysis and gluconeogenesis.
D) FBP is a potent allosteric activator of phosphofructokinase and an inhibitor of fructose bisphosphatase.

47. **(2 points)** Which of the following will NOT activate glycogen phosphorylase in the liver?
A) Epinephrine B) glucagon C) eating a high carbohydrate meal D) cAMP

48. **(2 points)** In eukaryotes, the citric acid cycle occurs in the _____ and therefore requires that reactants of the citric acid cycle be transported from the _____.
A) cytosol; mitochondrial matrix
B) mitochondrial matrix; cytosol
C) endoplasmic reticulum; mitochondrial matrix
D) inner mitochondrial membrane; mitochondrial matrix

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49. **(2 points)** The electrons formed from the aerobic oxidation of glucose are
I. ultimately transferred to O_2 after several other transfer reactions.
II. transferred to the coenzymes NAD^+ and FAD.
III. directly transferred to O_2 during the citric acid cycle.
IV. transferred to succinate and arachidonic acid.
A) I only B) II only C) I, II D) II, III, IV

50. **(2 points)** Based on the information in the chapter, which of the following is TRUE regarding Complex III?
I. A large portion of Complex III dissociates from the membrane bound portion of the complex.
II. Complex III contains three identical cytochrome redox centers.
III. The Q cycle allows stepwise reoxidation of the two electrons from $CoQH_2$.
IV. A change in conformation of iron sulfur protein (ISP) ensures that the Reiske center is reduced preferentially by $CoQ^{\cdot-}$.
A) I only B) I, II C) III only D) III, IV

51. **(2 points)** The rate of oxidative phosphorylation
I. is regula ted by the availability of ADP and P_i.
II. is reduced when the ratio of [NADH]/[NAD^+] is high.
III. increases with a higher concentration of reduced cytochrome *c*
IV. is regulated by activity of the ADP-ATP translocator.
A) I, II, IV B) I, III, IV C) II, III D) I, III, IV

Short Answer Questions:

52. What pathological conditions can arise from a large increase in blood levels of ketone bodies in diabetics? (6 points)