THE UNIVERSITY OF MANITOBA

DATE: December 13, 2004 — Final EXAMINATION
PAPER NO: 188/189 — PAGE NO: 1 of 11
DEPARTMENT & COURSE NO: 2.277/60.277 — TIME: 2 Hours
EXAMINATION: Elements of Biochemistry I — Examiner: Drs. D. Burton/ A. Scoot

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INSTRUCTIONS

1. **You must mark the answer sheet with pencil (not pen).**
2. **Put your name and enter your student number on the answer sheet.**
3. **The examination consists of multiple choice questions. Choose the answer that you think is correct and record your choice on the answer sheet. There in only ONE CORRECT answer.**
4. **This exam will count for 60% of your final mark.**
5. **HINT: In all calculations be sure you are using correct and compatible units.**
6. **There is a blank page at the end of the exam for rough work.**

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1. The percentage of glycine molecules having a charged carboxyl group at pH 3.0 is close to? (pK_a values for glycine are 2.35 and 9.78.)

   A) 18% B) 22% C) 45% D) 55% E) 82%

2. 25 mL of 0.4 M NaOH is added to 55 mL of 0.2 M lactic acid. (The pK_a of lactic acid is 4.1). The resulting mixture has a pH close to:

   A) 2 B) 3 C) 4 D) 5 E) 6

3. The isoelectric point (pI) of glutamic acid (pK_avalues are: 2.2, 4.3 & 9.7) is:

   A) 3.25 B) 6.7 C) 7.0 D) 9.7 E) 10.5

4. At what pH will all molcules of glutamic acid in solution have a net charge of -1? pK_a values are given in question 3 above.

   A) 3.35 B) 6.7 C) 7.0 D) 9.7 E) 10.5

5. At what pH will the average net charge of glutamic acid molecules be -1.5?

   A) 3.35 B) 6.7 C) 7.0 D) 9.7 E) 10.5

6. Which of the following statements are *true?*

   1) A reaction may not occur at a detectable rate even though it has a large, negative $\Delta G^{0'}$.
   2) For an enzyme having Michaelis-Menten kinetics, K_m is the [S] at which $v = V_{max}$
   3) The smaller the K_m for a substrate, the more tightly it binds to the enzyme.
   4) Enzymes catalyze reactions by shifting the equilibrium in favour of the product.
   5) Lowering the temperature of a reaction will lower the reaction rate.

   A) 1, 2 & 3 B) 1, 3 & 5 C) 2 &5 D) all are true E) none are true

7. An enzyme has a K_m for its substrate S of 2 mM. At [S] = twice the K_m, the velocity of the reaction will be ? % of V_{max}

   A) 100% B) 50% C) 67% D) 25% E) 33%

8. For the same enzyme and substrate as in question 7, which of the following is the minimum substrate concentration necessary to produce a velocity of greater than 90% of V_{max}?

   A) 4 mM B) 7 mM C) 10 mM D) 20 mM E) 40 mM

9. Aspartate and glutamate residues tend to disrupt an alpha-helix when several occur next to one another in a protein because:

A) of electrostatic repulsion at cellular pH values between Asp and Glu R-groups
B) both Glu and Asp are highly hydrophilic
C) neither R-gp can H-bond
D) of steric hindrance between the bulky Asp and Glu R-groups
E) of the formation of disulfide bonds between Asp and Glu R-groups

10. In a 20 amino acid long alpha-helical segment of a polypeptide chain, approximately how many turns are there?

A) 2 B) 4 C) 6 D) 8 E) 10

11. Give the correct name for the molecule shown.

A) Beta-D-galactose B) Alpha-D-glucose
C) Beta-D-mannose D) Beta-D-glucose
E) Alpha-D-fructose

12. Lactose (milk sugar) contains which of the following?

A) Beta-D-fructose B) Alpha-D-mannose C) Both Alpha-D-fructose & Beta-D-galactose
D) Both Alpha-D-glucose & Beta-D-galactose E) Both Alpha-D-glucose & Beta-D-mannose

13. Which statements about the molecule shown in question 11 are **incorrect**?

A) In aqueous solution, **all** of the molecules are in the cyclic hemiacetal form.
B) Carbon 4 is the anomeric carbon which can be oxidized by Cu^{2+}
C) It is a non-reducing sugar
D) It is a ketohexose
E) All the above are incorrect

14. Which of the following correctly describe the structural relationship between alpha-D-Glucose and alpha-D-Mannose?

1) Enantiomers 2) epimers 3) mirror images 4) diastereoisomers 5) anomers

A) 1 & 2 B) 2 & 3 C) 3 & 5 D) 2 & 4 E) 2, 4 & 5

15. Which **two** of the following statements about cellulose, starch and glycogen are **false**?

1) They are homopolymers of glucose
2) Amylose & cellulose are unbranched, amylopectin contains many alpha (1:6) branches.
3) Both starch and cellulose are intracellular energy stores.
4) All three serve as structural elements in cell walls.
5) Two of the three contain alpha (1: 4) linkages.

A) 1 & 2 B) 2 & 3 C) 3 & 4 D) 4 & 5 E) 1 & 5

16. Following treatment of harvested ears of wheat under conditions causing partial hydrolysis of polysaccharides which of the following disaccharides could be isolated from the reaction mix?

1. Maltose 2. Isomaltose 3. Cellobiose 4. Chitobiose 5. Sucrose

A) 1 B) 1 and 2 C) 1, 2 and 3 D) 1, 2 and 4 E) 1, 2 & 5

17. Which of the following apply to double-stranded DNA?

1) The proportion of bases that are purines must be the same in both strands
2) The planes of the bases lie perpendicular to the long axis of the DNA molecule
3) The 2' hydroxyl groups of ribose participate in hydrogen bonding
4) The two strands are antiparallel
5) The adenine content of one strand must be equivalent to the cytosine content in the complementary strand

A) 1&5 B) 2 &4 C) 3 & 5 D) 1, 3 & 4 E) 2, 4 & 5

18. Double-stranded DNA was isolated from two different species. In species 1, guanine was found to make up 25% of the bases and, in species 2, adenine made up 33% of the bases. Which of the statements is true about the melting temperatures (T_m) of the two DNA samples?

A) The T_m values will be identical B) DNA from species 1 will have the higher T_m
C) DNA from species 2 will have the higher T_m
D) The question cannot be answered without knowing the percentages of all bases in each DNA
E) $T_m$values cannot be predicted but must be measured experimentally

19. The polymer (5') CAGTTCAAGT (3') could form a double-stranded structure with:

A) (5') ACUUGAACUG (3')
B) (5') GTCAAGTTCA (3')
C) (5') CACUTTCGCCC (3')
D) (5') GCTTGATCAC (3')
E) (5') ACTTGAACTG (3')

20. Which of the following lipids is **not** derived from isoprenoid precursors?

A) geraniol
B) vitmin K
C) squalene
D) phosphatidylethanolamine
E) testosterone

21. Saponification (alkaline hydrolysis) of phosphatidylcholine (lecithin) would produce which of the following molecules?

1. Inorganic phosphate 2. Glycerol 3. Fatty acid(s) 4. Ethanolamine 5. Sphingosine

A) 1 & 5 only B) 2 and 3 only C) 4 and 5 only D) 2, 3, 4 and 5 E) 1, 2 & 3

22. Which of the following are true of phospholipid bilayers?

1) Many phospholipids spontaneously form bilayers in aqueous environments
2) Formation of bilayers from phospholipid molecules individually dispersed in aqueous environments is accompanied by an increase in the overall entropy of the system
3) Phospholipid molecules in bilayers can move laterally and can also move from one side of the bilayer to the other.
4) Polar molecules can easily cross a phospholipid bilayer
5) All of the above are true

A) 5 B) 1 & 2 only C) 1, 2 & 3 only D) 2 & 3 only E) 1 only

23. Which statements about membrane proteins are true?

1. Integral membrane proteins interact with fatty acid "tails" of bilayers
2. Peripheral membrane proteins behave like typical soluble proteins when released from the bilayer.
3. Peripheral membrane proteins are released from the membrane by treatment with aqueous salt solutions.
4. Peripheral membrane proteins can be released from membranes only by detergent treatment
5. Integral membrane proteins have one or more sequences of hydrophobic amino acids.

A) 1 & 5 only B) 1, 2, 4 & 5 C) 2 & 3 only D) 1, 2, 3 & 5 E) 2, 3, 4 & 5

24. Which of the following statements are correct about the chloride-bicarbonate exchanger of the erythrocyte membrane?

1. Its mechanism of transport is best classified as facilitated diffusion.
2. As part of its function it pumps Na^+ ions out of the cell and K^+ ions in.
3. It is an example of an active transport system.
4. Transport in this system is coupled directly to ATP hydrolysis.
5. Its role is to increase the CO_2 - carrying capacity of the blood.

A) 1 B) 1 and 5 C) 1, 2 and 5 D) 2, 3 and 4 E) All of these

25. Given that the standard free energy change, $\Delta G^{o'}$, for the hydrolysis of ATP to ADP and P_i is -30.5 kJ/mol, calculate the equilibrium constant for the reaction. R = 8.3 J/mol.K and T = 25 ^oC. The value of the equilibrium constant is ?

A) 2.14×10^{12} B) 2.26×10^{5} C) 4.43×10^{-6} D) 1.16 E) 1.40

26. The $\Delta G^{o'}$ for the overall reaction catalyzed by the enzyme phosphofructokinase is -14.2 kJ/mol, and the $\Delta G^{o'}$ for hydrolysis of ATP to ADP and P_i is -30.5 kJ/mol. Calculate the $\Delta G^{o'}$ for the hydrolysis of fructose-1,6-bisphosphate to fructose-6-phosphate & P_i. The value is ?

A) -44.7 kJ/mol B) -16.3 kJ/mol C) +44.7 kJ/mol D) +16.3 kJ/mol E) +14.2 kJ/mol

27. The $\Delta G^{0'}$ for hydrolysis of glucose-6-phosphate to glucose & P_i is -14 kJ/mol. In muscle tissue the concentrations of glucose-6-P, glucose, and P_i are 1×10^{-3} M, 2×10^{-4} M and 5×10^{-2} M respectively. What is the value of ΔG_{rxn} (i.e. the free energy change under cellular conditions. R = 8.3 J/mol.K and T = 37^0C.

A) -26 kJ/mol B) + 26 kJ/mol C) +40 kJ/mol D) -40 kJ/mol E) -36 kJ/mol

28. For the reaction A B, $\Delta G^{0'}$ is -60 kJ/mol. The reaction is started with 10 mmol of A; no B is initially present. After 8 hours, analysis reveals the presence in the reaction of 7 mmol A and 3 mmol B. These results ?

A) indicate equilibrium has been reached
B) indicate formation of B is thermodynamically unfavourable
C) are impossible, since $\Delta G'^0$is -60 kJ/mol, so there must have been an error in analysis
D) indicate formation of B is slow and equilibrium has not yet been reached
E) indicate an enzyme has shifted the equilibrium toward A

29. The standard reduction potentials ($E^{0'}$) for the following half reactions are given.

Oxaloacetate/malate	$E^{0'}$ = -0.18 V
NAD^+/NADH + H^+	$E^{0'}$ = -0.32 V

If you mixed oxaloacetate, malate, NAD^+ and NADH + H^+ together, all at 1 M concentrations and in the presence of malate dehydrogenase, which of the following would happen initially?

A) Malate would be oxidized, NAD^+ would be reduced.
B) Malate would be oxidized would be oxidized, NADH + H^+would be unchanged
C) Oxaloacetate and malate would be oxidized; NAD^+ and NADH + H^+would be reduced.
D) Oxaloacetate would be reduced, NADH + H^+ would be oxidized.
E) No reaction would occur, because all reactants and products are already at their standard concentrations.

30. The standard reduction potentials ($E^{0'}$) for the following half reactions are given.

acetaldehyde/ethanol	-0.20 V
NAD^+/NADH + H^+	-0.32V

Calculate the equilibrium constant for the reaction in which ethanol is formed via alcoholic fermentation in yeast. R = 8.3 J/mol.K, T = 25^0C, $\mathcal{F}$ (Faraday constant) = 96.4 kJ/volt.mol The value is ?

A) 8.7×10^{-5} B) 1.12 C) 108 D) 1.15×10^4 E) 9.26×10^{-3}

31. Inorganic fluoride inhibits enolase. In an anaerobic system that is metabolizing glucose as a substrate, which of the following compounds would you expect to increase in concentration immediately following the addition of fluoride?

A) Glucose B) Phosphoenolpyruvate C) Citrate D) 2-phosphoglycerate E) Pyruvate

32. The conversion of one mole of glyceraldehyde-3-P to one mole of pyruvate by the glycolytic pathway results in the net formation of which of the following?

A) One mole of NAD^+ and two moles of ATP.
B) One mole of NADH and one mole of ATP.
C) One mole of NADH and two moles of ATP.
D) Two moles of NADH and four moles of ATP.
E) Two moles of NAD^+ and two moles of ATP.

33. The conversion of one mole of glucose to two moles of lactate by the glycolytic pathway results in the net formation of:
A) Two moles of NADH and two moles of ATP.
B) Two moles of ATP.
C) Two moles of NADH and one mole of ATP.
D) Four moles of ATP.
E) Two moles of NAD^+ and two moles of ATP.

34. Which of the following statements are true of the reaction catalyzed by the glycolytic enzyme glyceraldehyde-3-P dehydrogenase?

1) The reaction produces NADH + H^+ and ATP
2) The reaction produces NADH + H^+ and an acid anhydride bond in the product
3) The reaction consumes NAD^+ and inorganic phosphate (P_i)
4) Glyceraldehyde-3-P is oxidized in the reaction
5) One of the products of the reaction contains a phosphate ester bond

A) 1 & 2 only B) 2 & 3 only C) 3 & 4 only D) 1, 3, 4 & 5 E) 2, 3, 4 & 5

35. Which of the following statements are true of the reaction in which pyruvate is converted to acetyl-S-CoA?

1) Pyruvate is both oxidized and decarboxylated
2) Pyruvate is both reduced and decarboxylated
3) The overall net reaction results in the oxidation of NADH + H^+
4) The reaction involves four different coenzymes
5) The overall net reaction generates a thioester bond & NADH + H^+

A) 1, 2 & 3 only B) 2, 3 & 4 only C) 1, 4 & 5 D)1, 3, 4 & 5 E) 2, 3, 4 & 5

36. Under aerobic conditions, the glycolytic intermediate 3-phosphoglycerate (3-PGA) is ultimately metabolized to 3 mol of CO_2 via acetyl-S-CoA and the citric acid (TCA) cycle. The conversion of 1 mol of 3-PGA to 3 mol of CO_2 via this process also yields ____ mol of NADH + H^+, _____mol of $FADH_2$, and _____ mol of ATP (or GTP).

A) 3; 2; 0 B) 4; 2; 1 C) 4; 1; 1 D) 4; 1; 2 E) 2; 2; 2

37. In mammals, each of the following is accomplished by the citric acid (TCA) cycle *except one*. Which is it?

A) Metabolism of acetyl-CoA to carbon dioxide and reduced electron carriers.
B) Oxidation of acetyl-CoA produced from glycolysis.
C) Formation of alpha-ketoglutarate.
D) Net synthesis of oxaloacetate from acetyl-CoA.
E) Generation of NADH and $FADH_2$.

38. Which of the following statements about the enzyme succinate dehydrogenase (SDH) are true?

1) Like the other TCA cycle enzymes, SDH is found in the mitochondrial matrix
2) Unlike the other TCA cycle enzymes, SDH is located in the mitochondrial inner membrane
3) Unlike the three other dehydrogenases functioning in the TCA cycle, SDH requires FAD as its coenzyme
4) Like the three other dehydrogenases functioning in the TCA cycle, SDH requires NAD^+ as its coenzyme
5) SDH is a component of Complex II of the electron transport chain.

A) 1 & 3 only B) 2 & 4 only C) 3 & 5 only D) 1, 4, & 5 E) 2, 3, and 5

39. Which of the following statements about the conversion of isocitrate to oxaloacetate during the TCA cycle, is **incorrect**?

A) A total of three pairs of electrons are transferred to coenzymes.
B) One GDP is phosphorylated by direct chemical coupling (substrate level phosphorylation).
C) One carbon-carbon bond is oxidized by FAD at the reaction step catalyzed by succinate dehydrogenase.
D) One molecule of water is consumed at the reaction step catalyzed by fumarase.
E) Two molecules of CO_2 are produced.

40. Complex I of the electron transport chain mediates the transfer of electrons from X to Y

A) X = succinate, Y= ubiquinone
B) X= ubiquinone, Y = cytochrome c
C) X = NADH + H^+, Y = ubiquinone
D) X = cytochrome c, Y = oxygen
E) X = $FADH_2$, Y= cytochrome c

41. Given the reduction potentials for the half-reactions:

$NAD^+/NADH + H^+$	-0.32 V
UQ/UQH_2	+ 0.04 V
$1/2O_2/H_2O$	+0.82 V

The $\Delta G^{0'}$ when 1 mol of NADH + H^+ is oxidized and 1 mol of H_2O is produced via the electron transport chain is (i)? The percentage of the energy released in this process that is produced when electrons from NADH + H^+ pass through complex I of the electron transport chain is (ii)? R = 8.3 J/mol.K, T = 25^0C, $\mathcal{F}$ (Faraday constant) = 96.4 kJ/volt.mol

A) (i) 220 kJ/mol (ii) 32%
B) (i) 160 kJ/mol (ii) 32 %
C) 160 kJ/mol (ii) 16%
D) (i) 110 kJ/mol (ii) 16%
E) (i) 96 kJ/mol (ii) 72%

42. One of the functions of ubiquinone during electron transport is which of the following?

A) To anchor cytochrome c to the mitochondrial inner membrane
B) To transport electrons from complex II to complex III.
C) To transport electrons between complex III and complex IV
D) To transfer electrons to H_2O
E) None of the above

43. Which of the following enzymatic activities would you expect to be decreased by dietary deficiency of the B-vitamin thiamine?

1) pyruvate dehydrogenase
2) Isocitrate dehydrogenase
3) aconitase
4) alpha-ketoglutarate dehydrogenase
5) Malate dehydrogenase.

A) 1 & 2
B) 2 &3
C) 1 & 4
D) 2 & 4
E) 2 & 5

44. Which of the following statements about electron transport in eukaryotic cells are **incorrect**?

1) energy released during electron transport is conserved as a proton gradient
2) the components of the electron transport chain are located in the mitochondrial matrix
3) electron transport results in pumping of protons out of the mitochondrial matrix
4) cytochrome c transfers electrons from complex III to complex IV of the electron transport chain
5) oxidation of 1 mole NADH + H^+ via the electron transport chain consumes one oxygen molecule

A) 1 & 2 B) 2 &3 C) 1 & 4 D) 2 & 4 E) 2 & 5

45. The number of oxygen **molecules** (O_2) consumed during complete aerobic oxidation of **one** mole of glyceraldehyde-3-P is:

A) 2 B) 3 C) 4 D) 5 E) 6

(HINT: in all calculations, be sure you are using the correct units, and that the units used in your calculations are comaptible).

LAB SECTION (Questions 46 to 60)

For questions 46 to 50 please refer to the following:

A 10 mL solution of 0.2M histidine at pH 0.8 was titrated with 0.1 M NaOH solution. During the titration the pH was monitored and the results were plotted on the graph shown. The key points in the titration are designated I to VII on the graph. For each of the questions below, identify the appropriate key point(s) in the titration.

46. At what point is the average net charge of histidine +1.5?

A) II B) III C) IV D) V E) VI

47. At what point or points is the pH equal to the pI?

A) III B) II, IV, and VI C) I D) V E) III and V

48. At what point is the R- group amino of half the molecules ionized?

A) III B) IV C) V D) VI E) VII

49. At what points does histidine have its maximum general buffering capacity?

A) I, III and V B) III, V and VII C) III and V D) I and VII E) II, IV and VI

50. At what point would histidine be unable to buffer hydroxyl ions (OH^-)?

A) I B) III C) V D) VI E) VII

Continued on next page…

For questions 51, 52 and 53 please refer to the following:

The chemical tests listed below are used to distinguish between different carbohydrates.

1) Barfoed's test 2) Benedict's test 3) Bial's test 4) Seliwanoff's test

51. Which one of the test(s) could be used to distinguish between ribose and glucose?

A) 1 B) 4 C) 2 and 3 D) 3 E) 1 and 4

52. Which of the tests would be best to distinguish between glucose and maltose?

A) 1 B) 2 C) 3 D) 4 E) None

53. Which three of these tests when used in sequence would enable you to distinguish between the following five carbohydrate solutions; glucose, maltose, sucrose, ribose and fructose?

A) 1, 2 and 3 B) 2, 3 and 4 C) 1, 2 and 4 D) 1, 3 and 4 E) Not possible

54. Which of the following are required for a color change to occur with Biuret reagent?

1. Presence of a disaccharide.
2. Presence of Cu^{2+}.
3. Presence of a peptide bond.
4. Presence of sodium potassium tartrate.
5. Presence of alkaline phosphatase

A) 1 B) 3 C) 1, 2, and 4 D) 2, 3, 4 and 5 E) 2, 3 and 4

55. Which of the following statements about a plot of V_0 vs. [S] for an enzyme that follows Michaelis-Menten kinetics is *false*?

A) As [S] increases, the initial velocity of reaction V_0 also increases.
B) At very high [S], the velocity curve becomes a horizontal line that intersects the y-axis at K_m.
C) K_m is the [S] at which $V_0 = ½ V_{max}$.
D) The shape of the curve is a hyperbola.
E) The y-axis is a rate term with units describing product formed/min.

56. An enzyme-catalyzed reaction was carried out with the substrate concentration initially a thousand times greater than the K_m for that substrate. After 9 minutes, 1% of the substrate had been converted to product, and the amount of product formed in the reaction mixture was 12 μmol. If, in a separate experiment, one-third as much enzyme and twice as much substrate had been combined, how long would it take for the same amount (12 μmol) of product to be formed?

A) 1.5 min
B) 13.5 min
C) 27 min
D) 3 min
E) 6 min

Continued on the next page…

57. The double-reciprocal transformation of the Michaelis-Menten equation, also called the Lineweaver-Burk plot, is given by

$1/V_0 = K_m / (V_{max}[S]) + 1/V_{max}$.

To determine K_m from a double-reciprocal plot, you would:

A) multiply the reciprocal of the x-axis intercept by -1.
B) multiply the reciprocal of the y-axis intercept by -1.
C) take the reciprocal of the x-axis intercept.
D) take the reciprocal of the y-axis intercept.
E) take the x-axis intercept where $V_0 = 1/2\ V_{max}$.

58. When the DNA was isolated from salmon sperm nuclei sodium dodecyl sulphate (SDS) performed which of the following roles?

1. Disruption of the salmon sperm nuclei.
2. Freeing the DNA from nucleoproteins.
3. Inhibition of DNase present in the nuclei.
4. Precipitation of protein.
5. Precipitation of the DNA to form sticky fibres.

A) 1 and 2 B) 1, 2 and 3 C) 1, 2 and 4 D) 1, 2, 4 and 5 E) All of the above

59. Which of the following statements describes the role of ethyl acetate in the isolation of DNA from salmon sperm nuclei?

1. It disrupts the nuclei.
2. Together with SDS it frees the DNA from nucleoproteins.
3. Together with iso-pentyl-alcohol it precipitates the protein
4. It precipitates the DNA as sticky fibers.
5. It precipitates RNA as a flocculent precipitate.

A) 1 and 2 B) 3 C) 1, 2 and 3 D) 4 and 5 E) 3, 4 and 5

60. Which of the following statements about the T_m for DNA are true?

1. It is the temperature where half the DNA is single stranded and half is double stranded.
2. It is the temperature at the midpoint of DNA denaturation.
3. It is the midpoint of the transition temperature range for the DNA.
4. It is the melting temperature of DNA.
5. Its value is not related to the base composition of the DNA.

A) 4 B) 2 and 3 C) 1, 2 and 3 D) 1, 2, 3 and 4 E) 1, 2, 3, 4 and 5

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EXAMINATION: Elements of Biochemistry I

Working space