THE UNIVERSITY OF MANITOBA

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DEPARTMENT & COURSE NO.: 2.277/60.277 — Time: 2 HOURS

EXAMINATION: Elements of Biochemistry I — EXAMINER: Drs. D.Burton and A. Scoot

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GENERAL 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 what you think is the best, correct answer and record your choice on the answer sheet. There is only **ONE CORRECT** answer.
4. This exam will count for 60% of your final mark.

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2. Hydrophobic interactions:

A) primarily involve the effect of polar solutes on the entropy of aqueous systems.
B) do not contribute to the structure of water-soluble proteins.
C) refer to the ability of water to denature proteins.
D) are the driving force in the formation of micelles of amphipathic compounds in water

2. The pH of a sample of blood is 7.4. The pH of a sample of gastric juice is 1.4. The blood sample has:

A) 5.29 times lower $[H^+]$ than the gastric juice.
B) 6 times lower $[H^+]$ than the gastric juice.
C) 6,000 times lower $[H^+]$ than the gastric juice.
D) a million times lower $[H^+]$ than the gastric juice.
E) 0.189 times the $[H^+]$ as the gastric juice.

3. Phosphoric acid is tribasic, with pK_a values of 2.14, 6.86 and 12.4. The ionic form that predominates at pH 3.2 is:

A) $H_3PO_4^-$
B) $H_2PO_4^-$
C) HPO_4^{2-}
D) PO_4^{3-}

4. A compound has a pK_a of 7.4. To 100 mL of a 1.0 M solution of this compound at pH 8.0 is added 30 mL of 1.0 M hydrochloric acid. The resulting solution is pH:

A) 7.58
B) 7.4
C) 7.22
D) 6.8
E) 6.53

5. One hundred mL of 0.1 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

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E) 6

6. In a highly acidic solution, pH = 1, the dominant form of glycine is:

A) NH_2 - CH_2 - COOH
B) NH_3^+ - CH_2 - COOH
C) NH_2 - CH_2 - COO^-
D) NH_3^+ - CH_2 - COO^-
E) NH_2 - CH_3^+ - COO^-

7. In an α-helix, the R groups on the amino acid residues:

A) are found on the outside of the helix spiral.
B) generate the hydrogen bonds that form the helix.
C) stack within the interior of the helix.
D) cause only right-handed helices to form.
E) alternate between the outside and the inside of the helix.

8. Which of the following statements about proteins is true?

A) Proteins are generally very loosely structured.
B) In water-soluble proteins, hydrophobic (nonpolar) amino acid residues are generally buried and not exposed to water.
C) Proteins that contain α-helical regions never contain β sheets.
D) "Corners" between α-helical regions in globular proteins invariably contain a glycine residue, which, because of its unique properties, cannot fit into the helix.
E) Hydrogen bonds are not important in the structure of proteins.

9. Which of the following statements is *false*?

A) A reaction may not occur at a detectable rate even though it has a favourable equilibrium.
B) At the end of an enzyme-catalyzed reaction, the functional enzyme becomes available to catalyze the reaction again.
C) Substrate binds to an enzyme's active site.
D) For S → P, a catalyst shifts the reaction equilibrium to the right.
E) Lowering the temperature of a reaction will lower the reaction rate.

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

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

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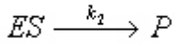
11. For enzymes in which the slowest (rate-limiting) step is the reaction



K_m becomes equivalent to:

A) the [S] where V = V_{max}
B) ½ V_{max}
C) $\Delta G'^0$ for the overall reaction
D) the dissociation constant, K_d, for the ES complex.
E) the maximal velocity.

12. A metabolic pathway proceeds according to the scheme, R → S → T → U → V → W. An allosteric enzyme, X, catalyzes the first reaction in the pathway. Which of the following is most likely correct for this pathway?

A) The last reaction will be catalyzed by a second allosteric enzyme.
B) Either metabolite U or V is likely to be an allosteric activator, increasing the activity of X.
C) The first product S, is probably the primary allosteric inhibitor of X, leading to feedback inhibition.
D) The last product, W, is likely to be an allosteric inhibitor of X, leading to feedback inhibition.
E) The last product, W, is likely to be an allosteric activator, increasing the activity of X.

13. Which of the following monosaccharides is *not* an aldose?

A) ribose
B) glucose
C) fructose
D) glyceraldehyde
E) erythrose

14. When two carbohydrates are epimers:

A) they rotate plane-polarized light in the same direction.
B) they differ in length by one carbon.
C) one is an aldose, the other a ketose.
D) one is a pyranose, the other a furanose.
E) they differ only in the configuration around one carbon atom.

15. Which of the following is *not* a reducing sugar?

A) ribose
B) glucose
C) fructose
D) glyceraldehyde
E) sucrose

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16. Which of the following statements about starch and glycogen is *false*?

A) Both are homopolymers of glucose.
B) Amylose is unbranched; amylopectin and glycogen contain many ($\alpha 1 \rightarrow 6$) branches.
C) Both starch and glycogen are intracellular energy reserves
D) Both serve primarily as structural elements in cell walls.

17. In the Watson-Crick structure of DNA:

A) the purine content (fraction of bases that are purines) must be the same in both strands.
B) purine and pyrimidine bases lie outside the sugar phosphate backbone.
C) 2′-hydroxyl groups in ribose sometimes participate in hydrogen bonding.
D) the number of A-T base pairs equals the number of G-C base pairs.
E) the number of purine residues equals the number of pyrimidine residues.

18. When double-stranded DNA is heated at neutral pH, which change does *not* occur?

A) The absorption of ultraviolet (260 nm) light increases.
B) The covalent bond between the base and the pentose breaks.
C) The hydrogen bonds between A and T break.
D) The viscosity of the solution decreases.
E) The helical structure unwinds.

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

A) (5') CACTAGTTCG (3')
B) (5') CACUAGUUCG (3')
C) (5') CACUTTCGCCC (3')
D) (5') GCTTGATCAC (3')
E) (5') GCCTAGTTUG (3')

20. In living cells, nucleotides serve as:

A) precursors for nucleic acid synthesis.
B) enzyme cofactors.
C) intracellular signals.
D) carriers of metabolic energy.
E) all of the above.

21. Which of the following statements about membrane lipids is true?

A) Lecithin (phosphatidylcholine) is a sphingolipid.
B) Glycerophospholipids contain fatty acids linked to glycerol through amide bonds.
C) Some sphingolipids include oligosaccharides in their structure.
D) Glycerophospholipids are found only in the membranes of plant cells.

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22. A lipid derived from isoprenoid precursors is:

A) palmitate
B) cholesterol
C) arachidonate
D) phosphatidyl serine
E) sphingosine

23. The fluidity of the lipid side chains in the interior of a bilayer is generally increased by:

A) a decrease in temperature
B) an increase in fatty acyl chain length
C) an increase in the number of double bonds in fatty acids
D) the binding of water to the fatty acyl side chains

24. Peripheral membrane proteins:

A) penetrate deeply into the lipid bilayer
B) can be released from membranes only by detergent treatment
C) are usually denatured when released from membranes
D) are generally noncovalently bound to membrane lipids

25. Which of these statements is generally true of integral membrane proteins?

A) They are usually completely buried in the bilayer.
B) They have one or more sequences of hydrophobic amino acids.
C) They can be released from the membrane by treatment with concentrated salt solutions.
D) They behave like typical soluble proteins when released from the bilayer.

26. Which of these statements about facilitated diffusion across a membrane is true?

A) It can increase the size of a transmembrane concentration gradient of the diffusing solute.
B) It is impeded by the solubility of the transported solute in the nonpolar interior of the lipid bilayer.
C) A specific membrane protein lowers the activation energy for movement of the solute through the membrane.
D) It is responsible for the transport of gases such as O_2, N_2, and CH_4 across biological membranes.

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27. The $\Delta G'^{o}$ values for the two reactions shown below are given.

Oxaloacetate + acetyl - CoA + H_2O → citrate + CoASH $\Delta G'^{o}$ = -32.2 kJ/mol

Oxaloacetate + acetate → citrate $\Delta G'^{o}$ = -1.9 kJ/mol

What is the $\Delta G'^{o}$ for the hydrolysis of acetyl - CoA?
Acetyl-CoA + H_2O → acetate + CoASH + H^+

A) -32.2 kJ/mol
B) -30.3 kJ/mol
C) +61.9 kJ/mol
D) +34.1 kJ/mol
E) -34.1 kJ/mol

28. When a mixture of glucose 6-phosphate and fructose 6-phosphate is incubated with the enzyme phosphohexose isomerase (which catalyzes the interconversion of these two compounds) until equilibrium is reached, the final mixture contains twice as much glucose 6-phosphate as fructose 6-phosphate. Which one of the following statements is most nearly correct, when applied to the reaction below?

(R = 8.315 J/mol • K; T = 298 K)
Glucose 6-phosphate → fructose 6-phosphate

A) $\Delta G'^{o}$ is incalculably large and negative.
B) $\Delta G'^{o}$ is zero.
C) $\Delta G'^{o}$ is -1.72 kJ/mol.
D) $\Delta G'^{o}$ is +1.72 kJ/mol.
E) $\Delta G'^{o}$ is incalculably large and positive

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

Fumarate + $2H^+ + 2e^-$ → succinate E'^{o} = +0.031 V
FAD + $2H^+ + 2e^-$ → $FADH_2$ E'^{o} = -0.219 V

If you mixed succinate, fumarate, FAD, and $FADH_2$ together, all at 1 M concentrations and in the presence of succinate dehydrogenase, which of the following would happen initially?

A) Succinate would become oxidized, FAD would become reduced.
B) Succinate would become oxidized, $FADH_2$ would be unchanged because it is a cofactor, not a substrate.
C) Both fumarate and succinate would become oxidized; both FAD and $FADH_2$ would become reduced.
D) Fumarate would become reduced, $FADH_2$ would become oxidized.
E) No reaction would occur, because all reactants and products are already at their standard concentrations.

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30. The structure of NAD^+ does not include:

A) an adenine nucleotide
B) a flavin nucleotide
C) a pyrophosphate bond
D) two ribose residues
E) nicotinamide.

31. The steps of glycolysis between glyceraldehyde 3-phosphate and 3-phosphoglycerate involve all of the following except:

A) ATP synthesis
B) utilization of P_i
C) oxidation of NADH to NAD^+
D) the formation of 1,3-bisphosphoglycerate
E) catalysis by phosphoglycerate kinase

32. As you write this exam, you are (presumably) consuming oxygen. What single reaction accounts for most of your oxygen consumption?

A) Oxidation of NADH by complex I of the electron transport chain.
B) Reduction of O_2 to water by cytochrome oxidase (complex IV) of the electron transport chain.
C) Oxidation of isocitrate by isocitrate dehydrogenase.
D) Reduction of FAD during the reaction catalyzed by succinate dehydrogenase.
E) Oxidation of pyruvate to acetyl-S-CoA by the pyruvate dehydrogenase complex.

33. The first reaction in glycolysis that results in the formation of an energy-rich compound (i.e., a compound whose hydrolysis has a highly negative $\Delta G'^{o}$) is catalyzed by:

A) hexokinase
B) phosphofructokinase
C) glyceraldehyde 3-phosphate dehydrogenase
D) phosphoglycerate kinase
E) triose phosphate isomerase

34. The conversion of 1 mol of fructose 1,6-bisphosphate to 2 mol of pyruvate by the glycolytic pathway results in a net formation of:

A) 1 mol of NAD^+ and 2 mol of ATP
B) 1 mol of NADH and 1 mol of ATP
C) 2 mol of NADH and 2 mol of ATP
D) 2 mol of NADH and 4 mol of ATP
E) 2 mol of NAD^+ and 4 mol of ATP

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35. The anaerobic conversion of 1 mol of glucose to 2 mol of lactate by the glycolytic fermentation is accompanied by a net gain of:

A) 1 mol of ATP.
B) 2 mol of ATP.
C) 1 mol of NADH.
D) 2 mol of NADH.
E) 2 mol of ATP & 2 mol of NADH

36. Which of the following is not required for the oxidative decarboxylation of pyruvate to form acetyl-CoA?

A) NAD^+
B) Lipoic acid.
C) ATP
D) CoA-SH
E) FAD

37. The conversion of 1 mol of pyruvate to 3 mol of CO_2 via pyruvate dehydrogenase and the citric acid cycle also yields _____ mol of NADH, _____ mol of $FADH_2$, and _____ mol of ATP (or GTP).

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

38. Which of the following enzymatic activities would you expect to be decreased by thiamine deficiency?

A) Succinate dehydrogenase.
B) Isocitrate dehydrogenase
C) α-ketoglutarate dehydrogenase complex
D) Fumarase.
E) Malate dehydrogenase.

39. Which of the following is *not* true of the citric acid cycle?

A) Although oxaloacetate is a substrate, there is no net consumption of it in the cycle.
B) GTP synthesis occurs via substrate level phosphorylation
C) Succinate dehydrogenase channels electrons directly into the electron transfer chain.
D) All enzymes of the cycle, except succinate dehydrogenase, are located in the mitochondrial matrix.
E) All enzymes of the cycle are located in the cytoplasm, except succinate dehydrogenase, which is bound to the inner mitochondrial membrane.

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40. Which of the following statements about the chemiosmotic theory is correct?

A) Electron transport in mitochondria is accompanied by pumping of protons into the matrix space of the mitrochondrion.
B) The effect of uncoupling reagents is a consequence of their ability to carry electrons through membranes.
C) It predicts that oxidative phosphorylation can occur even in the absence of an intact inner mitochondrial membrane.
D) The energy released when protons flow down their concentration gradient into the mitochondrial matrix is used by the membrane ATP synthase to generate ATP.
E) All of the above are correct.

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LAB SECTION (Questions 41 to 50)

For questions 41 and 42 please refer to the following:

The Michaelis-Menten plot shown below was drawn from data collected during an investigation into the kinetics of a reaction catalysed by alkaline phosphatase. The assay conditions were as follows; assay time 8 min., total assay volume 5 mL, 1.0 mL enzyme solution added to each assay tube, concentration of enzyme solution 5×10^{-7} M, assay pH 9.6.

41. From the graph determine V_{max} in μmoles product formed/min, for the reaction under the conditions cited?

A) 0.232 B) 0.465 C) 2.500
D) 3.720 E) Cannot be determined

42. Which of the following modifications of the experiment or the data would enable you to determine V_{max} more accurately?

1) Increase in the assay time.
2) Increase in the enzyme concentration.
3) Increase in the concentration range of the substrate.
4) Lineweaver-Burk modification of the data to give a double reciprocal plot.

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

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For questions 43 and 44 please refer to the following list of reagents.

1. Phenolphthalein monophosphate solution
2. Phenol red solution
3. Phenolphthalein solution
4. Glycine buffer, pH 10.8
5. Copper sulphate solution

43. Which of the following pairs refers to substrate and product listed in that order for the enzyme alkaline phosphatase?

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

44. Which of the reagents brings about colour development upon termination of the alkaline phosphatase assay?

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

45. What information can be determined from a Lineweaver-Burk plot of enzymatic data giving the following values 1/v is 0 (zero) when 1/[S] is -2.5×10^2M?

A) V_{max} is 1.25×10^2M/min
B) K_M is 0.004M
C) K_M is -4.0×10^{-3}M
D) K_M is -2.5×10^2M
E) Nothing can be determined.

46. The enzyme assay performed in the lab this term relied upon which of the following conditions?

1. Formation of a product whose absorbance could be determined.
2. Construction of a calibration curve.
3. Alkaline conditions.
4. The addition of a reagent to form a complex with the product to give a coloured compound.
5. Titration of the product with acid and base.

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

47. Three chemical tests, Benedict's, Bial's and Seliwanoff's, were performed in the order listed on the following carbohydrate solutions; fructose, glucose, xylose and sucrose. Each test led to a definite identification of one of the carbohydrates which could then be eliminated. Which one of the four carbohydrates remained after this process of elimination?

A) Fructose B) Glucose C) Xylose D) Sucrose E) Cannot be determined

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48. Which of the following statements describe Benedict's test?

1. It is used to distinguish between monosaccharides and disaccharides
2. The reagent contains copper acetate
3. The assay conditions are acidic
4. The copper ion is oxidised
5. A furfural intermediate is formed

A) All of the above B) 1, 2, 3 and 4 C) 2 and 3 and 4 D) 2 and 3
E) None of the above

49. Which of the following statements describe the role of sodium citrate in the isolation of DNA from salmon nuclei?

1. It disrupts the nuclei
2. It frees the DNA from nucleoproteins
3. It acts as a chelating agent
4. It inhibits DNase action by denaturing the enzyme
5. It causes the RNA to form a flocculent precipitate

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

50. Which of the following conditions would cause alteration in DNA structure during an isolation procedure?

1. pH greater than 10
2. pH less than 3
3. Addition of sodium dodecyl sulphate
4. Addition of iso-pentyl alcohol - ethyl acetate.
5. The presence of sodium citrate

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