THE UNIVERSITY OF MANITOBA

DATE: Dec. 17, 2001 — Final EXAMINATION

PAPER NO.: 432/433 — PAGE NO.: 1 of 12

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 is only **ONE CORRECT** answer.
4. This exam will count for 60% of your final mark.
5. There is a blank page at the end of the exam for rough work.

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1. Fifty mL of 0.2 M NaOH is added to 110 mL of 0.1 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

2. For any amino acid with a non-polar R-group, at any pH above the pI of the amino acid, the predominant form in solution will:

   A) be neutral without any charge B) have no net charge C) have a net positive charge
   D) have a net negative charge E) have equal numbers of positive and negative charges

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

   1) A reaction may not occur at a detectable rate even though it has a large, negative $\Delta G'^{o}$.
   2) For an enzyme having Michaelis-Menten kinetics, K_M is the [S] at which $v = V_{max}$
   3) The larger 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 B) 2,3 & 4 C) 2,4 &5 D) 3,4 & 5 E) 1,3 & 5

USE THE FOLLOWING DATA TO ANSWER QUESTIONS 4 and 5.

An enzyme which follows Michaelis-Menten kinetics has a K_M for its substrate of 1 x 10^{-5} M and, at a substrate concentration of 0.01 M, catalyzes the formation of product at v = 20 micromoles/min.

4. The reaction velocity (v) at a substrate concentration of 1 x 10^{-5} M is ? micromoles/min.

   A) 1.8 B) 2.5 C) 5.0 D) 10 E) 15

5. The reaction velocity (v) at a substrate concentration of 1 x 10^{-6} M is ? micromoles/min.

   A) 1.8 B) 2.5 C) 5.0 D) 10 E) 15

6. Threonine and leucine residues tend to disrupt an alpha-helix when several occur next to one another in a protein because:

   A) of electrostatic repulsion between Thr and Leu R-groups
   B) both Thr and Leu are highly hydrophobic C) neither R-gp can H-bond
   D) of steric hindrance between the bulky Thr and Leu R-groups
   E) of the formation of covalent bonds between Thr and Leu R-groups

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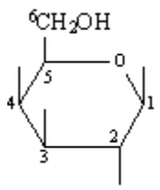
For questions 7 to 9 please refer to the molecule shown here.



7. Give the correct name for the molecule.

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

8. Which of the following disaccharides contains this molecule as a component?

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

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

9. Which statement is **incorrect** about this molecule?

A) In aqueous solution, it is in equilibrium with its anomer as well as its straight chain form.
B) Carbon 1 is the anomeric carbon and it can be oxidized by Cu^{2+}
C) It is a cyclic hemiacetal
D) In the process of mutarotation it is converted to alpha-D-glucose
E) It is an aldohexose.

10. 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 (1:6) branches.
C) Both starch and glycogen are intracellular energy stores.
D) Both serve as structural elements in cell walls.
E) Both contain alpha (1: 4) linkages.

11. 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. Sucrose

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

12. Which of the following applies 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 parallel 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 thymine content in the complementary strand

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

13. 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.

14. 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')

15. 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.

16. Which of the following lipids is derived from isoprenoid precursors?

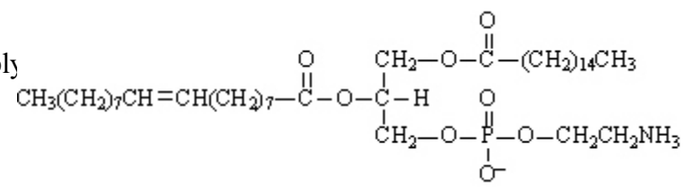
A) Palmitate B) Cholesterol C) Arachidonate
D) Phosphatidyl serine E) Sphingosine

17. Saponification (alkaline hydrolysis) of tristearoylglycerol (tristearin) would produce which of the following molecules?

1. Cholesterol 2. Glycerol 3. Stearate 4. Ethanolamine 5. Palmitate

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

18. Which of the following apply



1. It is phophatidylethanolamine
2. It is a derivative of phosphatidic acid
3. It is a component of cell membranes
4. It is not an amphipathic molecule

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

19. What is the principle reason why glycerophospholipids form bilayers?

A) Their hydrophobic tails attract one another
B) Their polar head groups attract one another.
C) Entropy is maximized when their hydrophobic tails are buried in the interior of the bilayer
D) Entropy is minimized when their polar heads interact with water at the surface of the bilayer.

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E) Their phosphate groups can form cross-links

20. Which of the following correctly describe peripheral membrane proteins?

1. They penetrate deeply into the lipid bilayer.
2. They can be released from membranes only by detergent treatment.
3. They are usually denatured when released from membranes.
4. They are generally noncovalently bound to membrane lipids.
5. They contain several membrane-spanning alpha-helical segments

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

21. 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 aqueous salt solutions.
D) They behave like typical soluble proteins when released from the bilayer.

22. 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

23. Given that the standard free energy change, $\Delta G'^0$, for the overall reaction catalysed by pyruvate kinase is -31.4 kJ/mol and the $\Delta G'^0$ for the hydrolysis of ATP is -30.5 kJ/mol, what is the equilibrium constant for the hydrolysis of phosphoenol pyruvate? R = 8.3 J/mol.K and T = 298K

A) 1.3×10^{-11} B) 0.6 C) 1.4 D) 3.3×10^{5} E) 7.6×10^{10}

24. 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 = 8.3 J/mol.K and T = 298K

Glucose-6-phosphate ---->fructose-6-phosphate

A) $\Delta G'^0$ is incalculably large and negative. B) $\Delta G'^0$ is zero. C) $\Delta G'^0$ is -1.7 kJ/mol.
D) $\Delta G'^0$ is + 1.7 kJ/mol E) $\Delta G'^0$ is incalculably large and positive.

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25. 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

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

Fumarate/succinate	$E'^{o} = +0.031$ V
$FAD/FADH_2$	$E'^{o} = -0.219$ 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 be oxidized, FAD would be reduced.
B) Succinate would be oxidized, $FADH_2$ would be unchanged
C) Fumarate and succinate would be oxidized; FAD and $FADH_2$ would be reduced.
D) Fumarate would be reduced, $FADH_2$ would be oxidized.
E) No reaction would occur, because all reactants and products are already at their standard concentrations.

27. Given the information that follows what is the $\Delta G'^{0}$ for the oxidation of $NADH + H^+$ by oxygen in the electron transport chain?

E'^{o} ($NAD^+/NADH$) = -0.32 volt E'^{0} (O_2/H_2O) = +0.82 volt
Faraday Constant = 96.5 J/V • mol

A) -219 kJ/mol B) -109 kJ/mol C) -96 kJ/mol D) 96 kJ/mol E) +219 kJ/mol

28. 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

29. The conversion of one mole of fructose-1,6-bisphosphate to two moles of pyruvate by the glycolytic pathway results in 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) Two moles of NADH and two moles of ATP.
D) Two moles of NADH and four moles of ATP.
E) Two moles of NAD^+ and four moles of ATP.

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30. The final electron acceptor in the fermentation of glucose to ethanol is which of the following?

A) Pyruvate B) Acetate C) Acetaldehyde D) Ethanol E) NAD^+

31. Which of the following is not required for the reaction where pyruvate is converted to acetyl-CoA?

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

32. Complete oxidation of one mole of acetyl-CoA via the citric acid (TCA) cycle results in ?

1. Net production of one mole of citrate.
2. Net consumption of one mole of oxaloacetate.
3. Net production of 2 moles of CO_2
4. Net production of 7 moles of ATP.
5. Net production of one mole of succinate.

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

33. 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 $FADH_2$.

34. All of the oxidative steps of the citric acid cycle are linked to the reduction of NAD^+ *except* the reaction catalyzed by which of the following?

A) Succinate dehydrogenase B) alpha-ketoglutarate dehydrogenase complex
C) Malate dehydrogenase D) Isocitrate dehydrogenase E) There are no exceptions.

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

A) To anchor cytochrome c to the mitochondrial 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

36. The conversion of 1 mol of pyruvate to 3 mol of CO_2 via pyruvate dehydrogenase and the citric acid (TCA) cycle 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) 3; 1; 1 E) 2; 2; 2

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37. Which of the following statements about electron transport in eukaryotic cells is FALSE?

A) Energy released during electron transport is conserved as a proton gradient
B) The components of the electron transport chain are located in the mitochondrial matrix
C) Electron transport results in pumping of protons out of the mitochondrial matrix
D) Cytochrome c transfers electrons from complex III to complex IV of the electron transport chain
E) Oxidation of 1 mole NADH + H^+ via the electron transport chain consumes one oxygen atom

38. Which of the following enzymatic activities would you expect to be decreased by dietary deficiency of the B-vitamin nicotinamide (niacin)?

1) Succinate dehydrogenase. 2) Isocitrate dehydrogenase 3) Aconitase
4) Fumarase. 5) Malate dehydrogenase.

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

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.

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

A) Oxidation of NADH + H^+ 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.

41. How many of the ATP equivalents (high energy phosphate bonds) generated during the complete aerobic oxidation of one molecule of glucose are formed by substrate level phosphorylation?

A) 2 B) 4 C) 6 D) 30 E) 32

42. The number of oxygen **atoms** consumed during complete aerobic oxidation of one mole of pyruvate is:

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

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43. 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.

44. Which of the following statements apply to the reaction producing succinate in the TCA cycle?

1. Its products include both CO_2 and succinate
2. It is catalysed by isocitrate dehydrogenase.
3. Its substrate is alpha-ketoglutarate
4. It is coupled to the hydrolysis of ATP.
5. It involves substrate level phosphorylation

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

45. Which of the following statements about the conversion of alpha-ketoglutarate 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.
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.

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LAB SECTION (Questions 46 to 60)

For questions 46, 47 and 48 please refer to the following titration curve for 30 mL of 0.05 M unknown amino acid initially at a pH of 1.3 with 0.15 M NaOH.

46. Which of the five amino acids listed below is the unknown amino acid?

		pK_a(α-COOH)	pK_a(α-NH_3^+)	pK_a(R-gp)
A)	Alanine	2.3	9.8	—
B)	Glutamic acid	2.3	9.8	4.3
C)	Histidine	1.8	9.2	6.0
D)	Lysine	2.2	9.0	10.5
E)	Proline	2.0	10.6	—

47. What is the pI for this unknown amino acid?

A) 3.3 B) 5.5 C) 6.0 D) 7.0 E) 9.8

48. To 30 mL of a 0.10 M solution at pH 9.8 of the same unknown amino acid from questions 46 and 47 was added 10 mL of 0.30 M HCl. What is the new pH of the solution?

A) 2.3 B) 4.3 C) 7.0 D) 8.8 E) 10.8

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49. In order to confirm the identity of the unknown amino acid it was subjected to paper chromatography together with the five amino acids listed in question 46 using ethanol: ammonia: water (8:1:1) as the solvent after which it was necessary to visualise the spots in order to measure the Rf. This was achieved by which of the following?

A) Staining with biuret reagent to produce purple spots
B) Adding phenol red to give a colour change
C) Changing the pH to a highly alkaline pH to bring about a colour change
D) Adding phenolphthalein and changing the pH to give a colour change
E) None of the above

50. Which of the following would result in a 1 in 50 dilution of an original solution Y?

1. A 5 mL aliquot of Y was diluted with 20 mL of buffer. This was further diluted by taking a 2 mL aliquot and adding 18 mL buffer.
2. A 0.1 mL aliquot of Y was diluted by adding 4.9 mL of buffer.
3. A 1.0 mL aliquot of Y was diluted with 9.0 mL of buffer. This was further diluted by taking a 5.0 mL aliquot and adding 20 mL buffer.
4. A 5.0 mL aliquot of Y was diluted with 5.0 mL of buffer. This was further diluted by taking a 2.0 mL aliquot and adding 48 mL buffer.

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

51. Which of the following statements describe Bial's test?

1. It is used to detect pentoses
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) 1, 3 and 5 D) 1 and 5
E) None of the above

52. Which of the following statements describe the Molisch test?

1. It is used to detect ketoses
2. The result with sucrose is positive
3. A furfural intermediate is formed
4. It requires orcinol and ferric ions
5. Red condensation products are formed

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

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53. 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 biuret 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

For questions 54 to 56 please refer to the following:

An investigation into the kinetics of alkaline phosphatase yielded data from which the Lineweaver-Burk plot shown below was derived.

The total assay volume was 5 mL and the assay time 10 min. A 1.0 mL volume of enzyme solution was added to each assay tube. The concentration of the enzyme solution was 5×10^{-7}M.

54. What are the values for K_m and V_{max} for this enzyme under these conditions?

A) K_m = 30 M V_{max} = 40 mmoles/min
B) K_m = 40 mmoles/min V_{mzx} = 30 M
C) K_m = 0.033 M V_{max} = 0.050 mmoles/min
D) K_m = 0.033 M V_{max} = 0.025 mmoles/min
E) Cannot be determined

55. If the assay time was reduced to 5 min how would this affect the values of K_m and V_{max}?

A) K_m halved V_{max} halved
B) K_m unchanged V_{max} halved
C) K_m unchanged V_{max} unchanged
D) K_m halved V_{max} unchanged
E) K_m doubled V_{max} halved

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56. If the enzyme concentration used in the assay was deoubled how would this affect the values of K_m and V_{max}?

A)	K_m	doubled	V_{max}	doubled
B)	K_m	unchanged	V_{max}	doubled
C)	K_m	unchanged	V_{max}	unchanged
D)	K_m	doubled	V_{max}	unchanged
E)	K_m	halved	V_{max}	doubled

57. When DNA was isolated from salmon sperm nuclei sodium dodecyl sulphate and sodium citrate both performed which of the following roles?

A) Disruption of the salmon sperm nuclei
B) Freeing the DNA from nucleoproteins
C) Inhibition of DNase present in the nuclei
D) Precipitation of protein
E) Precipitation of the DNA to form sticky fibres.

58. Which of the following statements describe the role of iso-pentyl alcohol: ethyl acetate in the isolation of DNA from salmon sperm nuclei?

1. It disrupts the nuclei
2. It frees the DNA from nucleoproteins
3. It precipitates the protein
4. It precipitates the DNA as sticky fibres
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

59. When DNA was isolated from Salmon sperm one of the steps separated the DNA from RNA. Which of the following statements relate to this step?

1. It is achieved because DNA is double-stranded whereas RNA is single-stranded.
2. It is achieved using ethanol
3. It requires the presence of citrate ions
4. DNA is precipitated by ethanol whereas RNA remains in solution
5. DNA is denatured by SDS and forms sticky fibres whereas RNA forms a flocculent precipitate.

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

60. When doubled-stranded DNA is subjected to the action of DNase, which of the following does not occur?

A) Phosphodiester linkages are broken
B) The viscosity of the solution decreases
C) The molecule is broken down to give single nucleotides
D) The helical structure is destroyed
E) The covalent bond between the base and the pentose remains intact.