

DATE: Dec. 8, 2003Final EXAMINATIONPAPER NO.: 158/159PAGE NO.: 1 of 13DEPARTMENT & COURSE NO.: 2.277/60.277Time: 2 HOURSEXAMINATION: Elem. of Biochemistry IEXAMINER: Drs. Burton/Scoot

INSTRUCTIONS

- You must mark the answer sheet with pencil (not pen).**
 - Put your name and enter your student number on the answer sheet.**
 - 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.**
 - This exam will count for 60% of your final mark.**
 - There is a blank page at the end of the exam for rough work.**
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- Hydrophobic interactions:
 - Primarily involve the effect of polar solutes on the entropy of aqueous systems.
 - Do not contribute to the structure of water-soluble proteins.
 - Refer to the ability of water to denature proteins.
 - Are the driving force in the formation of micelles of amphipathic compounds in water
 - Cause the formation of disulfide bonds between cysteine residues in proteins
- The pH of a sample of blood is 7.4. The pH of a sample of gastric juice is 1.4. The $[H^+]$ in the blood sample is:
 - 5.29 times lower than in gastric juice.
 - 6 times lower than in gastric juice.
 - 6,000 times lower than in gastric juice.
 - a million times lower than in gastric juice.
 - 6 times higher than in gastric juice.
- Histidine has pK_a values of 1.8, 6.0 (R-gp) and 9.2. The percentage of histidine R-gps carrying a positive charge at pH 5.4 is:
 - 25%
 - 40%
 - 65%
 - 80%
 - 95%
- A weak acid having a pK_a of 7.4 was used to prepare a 0.1 M buffer at pH = 8.0. To 100 mL of this buffer was added 30 mL of 0.1 M hydrochloric acid. The pH of the resulting solution is:
 - 7.58
 - 7.4
 - 7.22
 - 6.8
 - 6.53
- In a highly basic solution, pH = 12, the dominant form of glycine is:
 - $NH_2 - CH_2 - COOH$
 - $^+NH_3 - CH_2 - COOH$
 - $NH_2 - CH_2 - COO^-$
 - $^+NH_3 - CH_2 - COO^-$
 - $NH_2 - CH_3^+ - COO^-$
- In an α -helix, the R groups on the amino acid residues:
 - Are found on the outside of the helix.
 - Generate the hydrogen bonds that form the helix.
 - Stack within the interior of the helix.
 - Cause only right-handed helices to form.
 - Alternate between the outside and the inside of the helix.

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7. Which of the following statements about proteins are true?
- 1) Primary structure determines tertiary structure
 - 2) In water-soluble proteins, hydrophobic (nonpolar) amino acid residues are generally buried and not exposed to water.
 - 3) Proteins that contain α -helical regions never contain β -sheets.
 - 4) Proline cannot readily fit into an α -helix.
 - 5) Hydrogen bonds are not important in the structure of proteins.
- A) 1, 2 & 3 B) 1, 2 & 4 C) 2, 3 & 4 D) 2, 3 & 5 E) 3, 4 & 5
8. Glutamate and aspartate residues tend to disrupt α -helical structure at cellular pH values when several occur close to one another in a polypeptide chain because:
- A) Of steric hindrance between their bulky R-groups
 - B) Neither R-group can form H-bonds
 - C) Of mutual electrostatic attraction between the R-groups
 - D) Of mutual electrostatic repulsion between the R-groups
 - E) Both Glu and Asp are highly hydrophobic
9. Which of the following statements are *false*?
- 1) A reaction may not occur at a detectable rate even though it has a large equilibrium constant.
 - 2) At the end of an enzyme-catalyzed reaction, the functional enzyme becomes available to catalyze the reaction again.
 - 3) Substrate binds to an enzyme's active site.
 - 4) For $S \rightleftharpoons P$, a catalyst shifts the reaction equilibrium to the right.
 - 5) Lowering the temperature of a reaction will increase the reaction rate.
- A) 1 & 2 B) 1 & 3 C) 2 & 4 D) 3 & 4 E) 4 & 5
10. Which of the following statements about a plot of V vs. [S] for an enzyme that follows Michaelis-Menten kinetics are *false*?
- 1) K_m is the [S] at which $V = V_{max}$
 - 2) The shape of the curve is a hyperbola.
 - 3) The slope of the curve is equal to the rate of reaction
 - 4) At relatively low [S] the reaction is essentially first order.
 - 5) At very high [S], the velocity is essentially independent of [S]
- A) 1 & 2 B) 1 & 3 C) 2 & 3 D) 3 & 4 E) 3 & 5
11. For enzymes in which the slowest (rate-limiting) step is the reaction
- $$ES \rightarrow E + P$$
- K_m becomes equivalent to:
- A) the [S] where $V = V_{max}$
 - B) $1/2 V_{max}$
 - C) ΔG° for the overall reaction
 - D) the dissociation constant, K_d , for the ES complex.
 - E) the maximal velocity.

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12. A metabolic pathway proceeds according to the scheme, $R \rightleftharpoons S \rightleftharpoons T \rightleftharpoons U \rightleftharpoons V \rightleftharpoons W$. 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) 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, causing feedback inhibition.
 - D) The last product, W, is likely to be an allosteric inhibitor of X, causing 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 are *not* aldoses?
- 1) ribose 2) galactose 3) fructose 4) dihydroxyacetone 5) erythrose
- A) 1 & 2 B) 1, 2 & 3 C) 3 & 4 D) 3, 4 & 5 E) 2 & 4
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.

USE THE FOLLOWING DATA TO ANSWER QUESTIONS 15 & 16

Freshly prepared solutions of α and β -D-galactose, with identical concentrations, show optical rotations of $+150.7^\circ$ and $+52.8^\circ$ respectively. After standing for a prolonged period, both solutions exhibit the same optical rotation, $+80.2^\circ$.

15. α and β -D-galactose are ?
- A) disaccharides B) anomers C) mirror images D) ketoses E) hemiketals
16. The percentage of β -D-galactose in the solution with optical rotation $+80.2$ is ?
- A) 28% B) 46% C) 66% D) 72% E) 91%
17. Chitin is a polymer of ?
- A) N-acetyl- α -D-glucosamine B) N-acetyl- α -D-mannosamine C) α -D-glucose
D) isomaltose E) cellobiose

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18. Which of the following statements about amylopectin and glycogen are *false*?
- 1) Both are homopolymers of glucose.
 - 2) Glycogen is branched; amylopectin is not.
 - 3) Both serve primarily as intracellular energy reserves
 - 4) Both serve primarily as structural elements in cell walls
 - 5) Amylopectin forms a deep blue complex with iodine, glycogen does not.
- A) 1, 2 & 3 B) 1 & 3 C) 2, 3 & 5 D) 1 & 5 E) 2, 4 & 5
19. Which of the following statements about the structure of double stranded DNA are *true*?
- 1) The purine content (fraction of bases that are purines) must be the same in both strands.
 - 2) Purine and pyrimidine bases lie outside the sugar phosphate backbone.
 - 3) Purine and pyrimidine bases are stacked inside the sugar phosphate backbone
 - 4) The number of A-T base pairs equals the number of G-C base pairs.
 - 5) The number of purine residues equals the number of pyrimidine residues.
- A) 1 & 3 B) 2 & 5 C) 3 & 4 D) 1 & 5 E) 3 & 5
20. When double-stranded DNA is heated at neutral pH, which changes do *not* occur?
- 1) The absorption of ultraviolet (260 nm) light increases.
 - 2) The phosphodiester bonds between nucleotide units are hydrolyzed.
 - 3) The hydrogen bonds between A and T break.
 - 4) The viscosity of the solution increases.
 - 5) The helical structure unwinds.
- A) 2 & 4 B) 1 & 3 C) 1 & 4 D) 2 & 5 E) 3 & 4
21. The polynucleotide (5') GTGATCAAGC (3') could form a double-stranded structure with:
- | | |
|-------------------------|-------------------------|
| A) (5') CACTAGTTCG (3') | B) (5') CACUAGUUCG (3') |
| C) (5') CACUTTCGCC (3') | D) (5') GCTTGATCAC (3') |
| E) (5') GCCTAGTTUG (3') | |
22. The molar percentage of guanine in a double-stranded DNA from a species of marine crustacean was found to be 15%. The molar percentage of thymine is:
- A) 15% B) 30% C) 35% D) 42.5% E) 85%
23. A nucleoside (note spelling!) isolated from RNA was found by chemical analysis to contain 4 oxygen atoms and five nitrogen atoms. The nucleoside is:
- A) adenosine B) uridine C) guanosine D) cytidine E) thymidine

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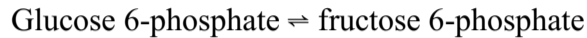
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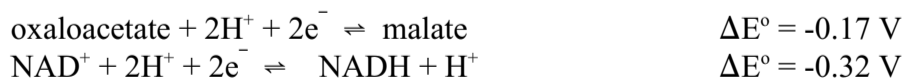
24. The common, trivial name for the fatty acid $\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$ is ?
 A) palmitic acid B) stearic acid C) palmitoleic acid D) oleic acid E) linoleic acid
25. The saturated fatty acid of the same chain length as the one in question 24 is:
 A) palmitic acid B) stearic acid C) palmitoleic acid D) oleic acid E) linoleic acid
26. Fats and oils contain mainly:
 A) phosphatidylcholine B) phosphatidylserine C) sphingomyelin
 D) triacylglycerols E) cholesterol
27. The major component of olive oil is trioleoylglycerol. Saponification (alkaline hydrolysis of this molecule) would yield ?
 1. Cholesterol 2. Glycerol 3. Oleate 4. Ethanolamine 5. Palmitate
 A) 1 B) 2 and 3 C) 4 and 5 D) 2, 3, 4 and 5 E) All of these
28. 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) May span the bilayer several times
 E) Are generally noncovalently bound to membrane lipids
29. 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 salt solutions.
 D) They behave like typical soluble proteins when released from the bilayer.
 E) They are found only on the cytoplasmic side of the membrane
30. The ΔG° values for the two reactions shown below are given.
 $\text{Oxaloacetate} + \text{acetyl-S-CoA} + \text{H}_2\text{O} \rightleftharpoons \text{citrate} + \text{CoASH} \quad \Delta G^\circ = -32.2 \text{ kJ/mol}$
 $\text{Oxaloacetate} + \text{acetate} \rightleftharpoons \text{citrate} \quad \Delta G^\circ = -1.9 \text{ kJ/mol}$
 What is the ΔG° for the hydrolysis of acetyl-S-CoA to acetate and CoASH?
 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

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31. 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? ($R = 8.315 \text{ J/mol} \cdot \text{K}$; $T = 298 \text{ K}$)



- A) ΔG° is incalculably large and negative. B) ΔG° is zero. C) ΔG° is -1.72 kJ/mol
 D) ΔG° is $+1.72 \text{ kJ/mol}$.
 E) ΔG° cannot be calculated without knowing the molar concentrations of reactant and product
32. For the reaction $A \rightleftharpoons B$, ΔG° 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 ΔG° 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
33. Phosphoglucomutase (PGM) catalyzes the reaction $\text{Glucose-6-P} \rightleftharpoons \text{Glucose-1-P}$. The ΔG° for this reaction is $+7.53 \text{ kJ/mole}$ at 25° C . ($R = 8.315 \text{ J/mol} \cdot \text{degree}$). The equilibrium constant for this reaction is:
- A) 1.76×10^{-16} B) 9.12×10^{-4} C) 4.77×10^{-2} D) 21.0 E) 1.1×10^3
34. Use the information in question 33 to solve this problem. The enzyme PGM is added to a solution (temperature 25° C) containing 0.1 M glucose-6-P but NO glucose-1-P. The reaction takes place rapidly and soon attains equilibrium. The equilibrium concentrations of glucose-6-P and glucose-1-P are closest to:
- A) $[\text{G-6-P}] = 0.095 \text{ M}$; $[\text{G-1-P}] = 0.0045 \text{ M}$ B) $[\text{G-6-P}] = 0.075 \text{ M}$; $[\text{G-1-P}] = 0.025 \text{ M}$
 C) $[\text{G-6-P}] = 0.055 \text{ M}$; $[\text{G-1-P}] = 0.045 \text{ M}$ D) $[\text{G-6-P}] = 0.020 \text{ M}$; $[\text{G-1-P}] = 0.080 \text{ M}$
 E) $[\text{G-6-P}] = 0.010 \text{ M}$; $[\text{G-1-P}] = 0.090 \text{ M}$
35. The standard reduction potentials (ΔG°) for the following half reactions are given.



If you mixed oxaloacetate, malate, NAD^+ , and NADH 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, NADH would be unchanged because it is a cofactor, not a substrate
 C) Both malate and oxaloacetate would be oxidized; both NAD^+ and NADH would be reduced.
 D) Oxaloacetate would be reduced, NADH would be oxidized.
 E) No reaction would occur, because all reactants and products are already in the standard state

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36. 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
37. Fermentation, under anaerobic conditions, of 1 mole of glucose by yeast produces a NET yield of:
- A) 2 mol ethanol, 2 mol CO_2 , 2 mol ATP B) 2 mol ethanol, 2 mol CO_2 , 1 mol ATP
 C) 1 mol ethanol, 2 mol CO_2 , 2 mol ATP D) 2 mol ethanol, 0 mol CO_2 , 2 mol ATP
 E) 2 mol lactate, 0 mol CO_2 , 2 mol ATP
38. In the TCA cycle, malate is formed by the ? of fumarate:
- A) oxidation B) reduction C) decarboxylation D) hydration E) dehydration
39. 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 ΔG°) is catalyzed by:
- A) hexokinase B) phosphofructokinase
 C) glyceraldehyde-3-phosphate dehydrogenase D) phosphoglycerate kinase
 E) triose phosphate isomerase
40. 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
41. 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 GTP.
- A) 3; 2; 0 B) 4; 2; 1 C) 4; 1; 1 D) 3; 1; 1 E) 2; 2; 2
42. Which of the following enzymatic activities would you expect to be decreased by thiamine deficiency?
- 1) Succinate dehydrogenase.
 2) Pyruvate dehydrogenase
 3) α -ketoglutarate dehydrogenase
 4) Fumarase.
 5) Malate dehydrogenase.
- A) 1 & 2 B) 2 & 3 C) 3 & 4 D) 4 & 5 E) 1 & 3
43. How many of the net number of 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

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44. How many electrons are required for the reduction of 1 molecule of oxygen gas to water?
- A) 1 B) 2 C) 4 D) 6 E) 8
45. Approximately what percentage of the energy released during the mitochondrial oxidation of 1 mole of $\text{NADH} + \text{H}^+$ via electron transport is conserved as ATP? (E'° values for the NAD/NADH and $1/2\text{O}_2/\text{H}_2\text{O}$ half cells are -0.32 V and $+0.82\text{ V}$ respectively. The $\Delta G'^{\circ}$ for ATP hydrolysis is -30.5 kJ/mol and the Faraday constant = 96.5 kJ/V.mol)
- A) 35% B) 17.5% C) 40% D) 80% E) 70%

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LAB SECTION (Questions 46 to 60)

For questions 46, 47 and 48 please refer to the following curve resulting from the complete titration of 20 mL of 0.05 M aspartate initially at a pH of 2.2 with 0.10 NaOH. The pK_a values for aspartate are 2.2, 4.2 and 9.8.

46. What volume of NaOH was added to completely titrate the 20 mL of Aspartate i.e. to point Y on the graph?
- A) 5 mL B) 10 mL C) 25 mL D) 30 mL E) 50 mL
47. What volume of NaOH was added to reach the pI of the amino acid?
- A) 5 mL B) 10 mL C) 15 mL D) 20 mL E) 25 mL
48. What is the pH of the solution after the addition of the first 12.5 mL of 0.10 M NaOH?
- A) 3.2 B) 4.2 C) 4.7 D) 5.2 E) 9.8

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For questions 49 and 50 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.

49. From the graph determine V_{\max} in $\mu\text{moles product formed/min}$, for the reaction under the conditions cited.
- A) 0.232 B) 0.465 C) 2.500 D) 3.720 E) Cannot be determined
50. 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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51. Which of the following reagents brings about colour development upon termination of the alkaline phosphatase assay?
1. Phenolphthalein monophosphate solution
 2. Phenol red solution
 3. Copper sulphate solution
 4. Glycine buffer, pH 10.8
- A) 1 B) 2 C) 3 D) 2 and 4 E) 4
52. In your experience in the biochemistry labs which of the following statements about paper chromatography are false?
1. Separation of sample components is based upon their partition between two immiscible liquid phases.
 2. Water forms the stationary phase while a less polar solvent forms the moving phase.
 3. The less polar a component the less it moves.
 4. The more polar a component the more it moves.
 5. The R_f is calculated by taking the ratio of the distance moved by a sample component over distance moved by solvent.
- A) 1 and 2 B) 1, 2 and 5 C) 3 and 4 D) 2, 3 and 4 E) None of the above
53. Which of the following are required conditions for measuring protein by the Biuret method?
1. Alkaline conditions.
 2. The presence of Cu²⁺.
 3. Titration with acid and base.
 4. Establishment of a calibration curve.
 5. Formation of a complex whose absorbance can be determined.
- A) All of the above B) 1, 2, 3 and 4 C) 1, 2, 4 and 5 D) 4 and 5 E) 3
54. Using the Biuret method, the absorbance of a tube containing 0.2 mL of a 1 in 5 mL dilution of unknown protein solution was found to be 0.300. In the same size cuvette 1.5 mL of a standard bovine serum albumin solution containing 6 mg BSA/mL, gave an absorbance reading of 0.450. What is the protein concentration of the original protein solution?
- A) 1.2 mg/mL B) 6 mg/mL C) 30 mg/mL D) 100 mg/mL E) 150 mg/mL
55. Which of the following statements describe Barfoed'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, 3 and 4 D) 2 and 3 E) None of the above

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56. Which of the following statements describe Seliwanoff's test?
1. It is used to detect ketoses
 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
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. 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 depends upon 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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