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Paper # 531/532	Elements of Biochemistry I	Final Examination
CHEM / MBIO 2770		Examiners: Dr. J. O'Neil and
210 – 224 Univ. Centre	Seats 1 – 115	Dr. A. Scoot

Instructions

- *Please mark the Answer Sheet using PENCIL ONLY.*
- *Enter your NAME and STUDENT NUMBER on the Answer Sheet.*
- *The exam consists of 60 multiple choice questions. Enter your answers on the Answer Sheet.*
- *There is only 1 correct answer for each question.*
- *Please read each question CAREFULLY.*
- *Scratch Paper is available at the back of the examination.*

LECTURE SECTION (Questions 1 to 45)

1. Which of the following statements are **false**?
    1. Lowering the temperature of a reaction will lower the reaction rate.
    2. Nonpolar ends of lipids form hydrophilic interactions with water.
    3. Arginine contains 3 ionizable groups.
    4. Enzymes catalyze reactions by shifting the equilibrium in favour of the product.
    5. A reaction may not occur at a detectable rate even though it has a large, negative $\Delta G^{0'}$.
        A) 1 and 2.
        B) 2 and 4.
        C) 3, 4, and 5.
        D) 2, 3, and 4.
        E) 1 and 5.

2. What functional groups are present in the molecule shown below?

    $$H_3\overset{+}{N}-CH_2-CH_2-C\overset{\displaystyle OH}{\underset{\displaystyle O}{}}$$
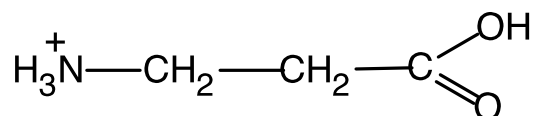
    A) Hydroxyl and aldehyde.
    B) Ether and aldehyde.
    C) Hydroxyl and carboxylic acid.
    D) Amino and carboxylic acid.
    E) Hydroxyl and ketone.

3. Identify the **correct** statement(s) about hydrogen bonding.
    1. It is a non-covalent attraction between polarized molecules containing O-H, N-H, or F-H.
    2. It is strongest when at a 90 degree angle.
    3. C=O is a good H-bond acceptor.
    4. NH is a good H-bond donor.
    5. A H-bond is about 28 nm in length.
        A) 1, 3, and 5.
        B) 2 and 4.
        C) 2 only.
        D) 1, 4 and 5.
        E) 1, 3 and 4.

4. The pH of lemon juice is 2.3 and the pH of watermelon juice is 5.5. The watermelon has a __
    A) 3.2 times higher $[H^+]$ than the lemon juice.
    B) 3.2 times lower $[H^+]$ than the lemon juice.
    C) 1585 times higher $[H^+]$ than the lemon juice.
    D) 1585 times lower $[H^+]$ than the lemon juice.
    E) 24.5 times lower $[H^+]$ than the lemon juice.

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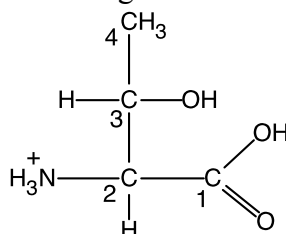210 – 224 Univ. Centre   Seats 1 – 115   Dr. A. Scoot

5.   The percentage of Glycine molecules having an uncharged carboxyl group at pH 2.85 is
        close to? (pK_a values for Glycine are 2.35 and 9.78.)
            A) 3%   B) 24%   C) 32%   D) 50%   E) 76%

6.   Identify the chiral carbons in the following amino acid:

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

7.   Which of the following best represents the backbone arrangement of two peptide bonds?

        A) C_α—C_α—C—N—C_α—C_α—C

        B) C_α—C—N—C_α—C—N

        C) C_α—N—C_α—C—C_α—N—C_α—C

        D) C_α—N—C—C—N—C_α

        E) C—N—C_α—C_α—C—N

8.   Titration of asparagine by a strong acid, for example HCl, reveals two pKa's. The
        titration reaction occurring at pK_a = 2.1 is:

        A) —COOH + —NH$_2$ →   —COO$^-$ + —NH$_2^+$

        B) —COOH + OH$^-$ →   —COO$^-$ + H$_2$O

        C) —NH$_3^+$ + H$^+$ →   —NH$_2$ + H$_2$O

        D) —COO$^-$ + H$^+$ →   —COOH

        E) —NH$_2$ + H$^+$ →   —NH$^-$ + H$_2$O

9.   The quaternary structure of a protein means _____
            A) the association of 2 or more polypeptides forms a functional protein.
            B) the destruction or denaturation of the protein structure.
            C) the protein contains 4 subunits.
            D) the protein is rich in turn structures.
            E) the regular, repeating 3D structure of a protein.

10.   Which statement about mutations is **INCORRECT**?
            A) They lead to biodiversity and enable evolution.
            B) They have nothing to do with proteins but only affect nucleic acids.
            C) They are important in aging and cancer.
            D) Some amino acid changes have no effect on the functions of proteins.
            E) All are true.

11.   Ovalbumin is an example of a(n) _____
            A) storage protein.
            B) enzyme.
            C) regulatory protein.
            D) transport protein.

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     E)   structural protein.

12.   The unique composition of collagen is accommodated in a structure called a _____
     A) triple helix.
     B) double helix.
     C) β-pleated sheet.
     D) coiled coil.
     E) helix-turn-helix motif.

13.   Which of the following statements about a plot of V_0 *vs.* [S] for an enzyme that follows Michaelis-Menten kinetics is **false**?
     A) The y-axis is a rate term with units of moles per litre/time.
     B) As [S] increases, the initial velocity of the reaction, V_0, also increases.
     C) At very high [S], the velocity curve becomes a horizontal line that intersects the y-axis at K_m.
     D) The shape of the curve is a hyperbola.
     E) K_m is determined from the graph by taking the [S] at which $V_0 = 1/2\ V_{max}$.

14.   Regarding the equilibrium constant (K_{eq}) of a biochemical reaction:
     A) The free energy of a reaction is just a different way of expressing the equilibrium constant.
     B) It is the product of the concentrations of the products minus the product of the concentrations of the reactants.
     C) K_{eq} is lowered by an enzyme in order to speed up the reaction.
     D) K_{eq} for a reaction depends on the sum of the free energies of the substrates and products.
     E) $\Delta G^o = \dfrac{R}{T} \bullet \ln_e (K_{eq})$

15.   The role of the enzyme in an enzyme-catalyzed reaction is to _____
     A) ensure the product is more stable than the substrate.
     B) make the overall free energy change for the reaction more favourable.
     C) increase the equilibrium constant for the reaction.
     D) increase the rate of conversion of substrate to product.
     E) ensure all the substrate is converted to product.

16.   Hexokinase has a K_m value of 0.1 mM whereas glucokinase has a K_m value of 10.0 mM. This is consistent with _____
     A) glucokinase phosphorylation of most of the glucose at low glucose levels.
     B) glucokinase acting on glucose at low concentrations.
     C) glucokinase acting on glucose only at high glucose concentrations.
     D) hexokinase acting at about half-maximal velocity at glucose concentrations of 4-5 mM.
     E) hexokinase acting on glucose only at high levels of glucose.

17.   An enzyme has a K_m for its substrate of 7×10^{-4} M. In one experiment, the initial velocity of the reaction catalyzed by the enzyme was measured at a substrate concentration of 0.3 M and was found to be 3.8×10^{-6} moles per litre per second. What would the rate of reaction have been if the substrate concentration had been 3×10^{-5} M?
     A) 0.3 moles per litre per second.
     B) 3.8088×10^{-6} moles per litre per second.
     C) 2.01×10^{-6} moles per litre per second.
     D) 1.002 moles per litre per second.
     E) 1.56×10^{-7} moles per litre per second.

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18. In the following compound carbon _____ (i) is the anomeric C, and carbons _____ (ii) are asymmetric.
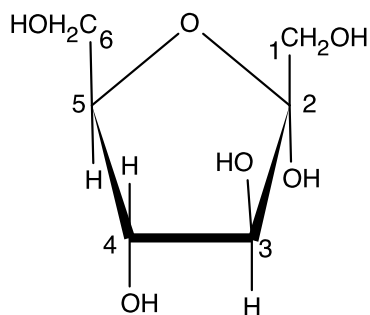
    A) i = 5 and ii = 2, 3, and 4.
    B) i = 2 and ii = 3, 4, and 5.
    C) i = 6 and ii = 1
    D) i = 2 and ii = 1, 2, 3, 4, and 5
    E) i = 1 and ii = 1, 2, 3, 4, 5, and 6

19. Which of the following monosaccharides are aldoses?
    1) Ribose   2) Galactose   3) Fructose   4) Dihydroxyacetone   5) Glyceraldehyde
    A) 2 & 4
    B) 3, 4 & 5
    C) 1, 2, & 5
    D) 3 & 4
    E) 1 & 2

20. Identify the following compounds:
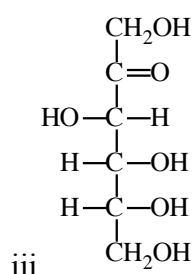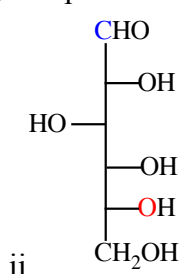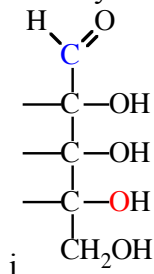
    A) i = D-Galactose   ii = Lactose   iii = D-Ribose
    B) i = D-Ribose   ii = D-Glucose   iii = D-Fructose
    C) i = D-Mannose   ii = D-Glycerol   iii = Vitamin C
    D) i = L-Fructose   ii = L-Mannitol   iii = D-Mannose
    E) i = D-Fructose   ii = D-Mannose   iii = D-Glucose

21. Which of the following is resposible for Lactose Intolerance?
    A) Gal ($\beta1 \rightarrow 4$) Glc
    B) Glc ($\alpha1 \rightarrow \beta2$) Fru
    C) (Glc $\alpha1 \rightarrow 4$ Gal)$_n$
    D) Glc ($\alpha1 \rightarrow 4$) Glc
    E) Glc ($\beta1 \rightarrow 4$) Glc

22. Saponification (alkaline hydrolysis) of triacylglycerols produces which of the following molecules?
    1. Fatty acid(s)   2. Glycerol   3. Inorganic phosphate   4. Ethanolamine   5. Sphingosine

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

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E) 2 and 3.

23.   From the following list identify the molecule which is **NOT** a steroid hormone.
           A) Aldosterone.
           B) Cortisol.
           C) Estradiol.
           D) Vitamin C.
           E) Testosterone.

24.   Identify the following molecule:

$$CH_2 \text{——} CH \text{——} CH_2$$

with phosphate group $O=P\text{—}O^-$ bearing X, and ester groups $C=O$ with R_2 and $C=O$ with R_1.

           A) Cholesterol
           B) Dolichol
           C) Ubiquinone
           D) Phospholipid
           E) Testosterone

25.   Which vitamin is an antioxidant?
           A) B_1 B) B_{12} C) C   D) D_3 E) K

26.   Diets aimed at reducing coronary heart disease should be _____
           A) low in trans-fatty acids and high in saturated fatty acids.
           B) high in trans-fatty acids and high in saturated fatty acids.
           C) low in trans-fatty acids and low in saturated fatty acids.
           D) high in trans-fatty acids and low in saturated fatty acids.
           E) low in trans-fatty acids and low in unsaturated fatty acids.

27.   O, A, and B Blood Group Antigens are glycosphingolipids that _____
           A) differ in their complex carbohydrate head groups.
           B) differ in their ceramide group.
           C) differ in their fatty acid chain.
           D) differ in their sphingosine moiety.
           E) differ in their Serine group.

28.   In simple diffusion, the transported species moves across the membrane in the
           _____ favored direction _____
           A) kinetically; using a transport protein.
           B) thermodynamically; without a specific transport system/molecule.
           C) kinetically; without a specific transport system/molecule.
           D) thermodynamically; using a transport protein.
           E) none of the above.

29.   Identify the **correct** statement:
           A) Integral membrane proteins are held to the surfaces of membranes by covalent
              bonds to carbohydrates.
           B) The fluid mosaic model of a membrane assumes that lipids travel rapidly
              around the bilayer but all proteins are fixed and unable to move.
           C) Glucose permease is a 12 α-helical protein that uses the energy of ATP to
              pump glucose into the red blood cell.
           D) CH_4, O_2, N_2, and H_2O cross membranes with the help of active transporters.
           E) Aquaporins facilitate the transport water across membranes.

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30.   Identify the **correct** statement about cAMP and cGMP.
        A) They are important carriers of free energy for anabolism.
        B) They function as cellular "second messengers".
        C) They store the cell's genetic information.
        D) They add flexibility to membranes.
        E) They are pentoses.

31.   All are true for the DNA double helix ***EXCEPT***:
        A) The two strands are parallel.
        B) The two strands are held together by interchain hydrogen bonds.
        C) The two strands have complementary base pairing.
        D) Information is accessed through transcription of the information into RNA.
        E) In each of the strands, consecutive nitrogenous bases stack one on top of another.

32.   RNA is a _____ polymer made of _____ joined by _____ bonds.
        A) protein; amino acids; peptide.
        B) deoxy-ribose; sugars; glycosidic.
        C) nucleosides; ribose bases; amide.
        D) lipid; fatty acids; ester.
        E) nucleic acid; nucleotides; phosphodiester.

33.   The polymer (5') GTCTAGGCTAAC (3') could form a double-stranded structure with:
        A) (5') GTCTAGGCTAAC (3').
        B) (5') CAGATCCGATTG (3').
        C) (5') GTTTGCCTATAC (3').
        D) (3') CAGATCCGATTG (5').
        E) (3') GTCTAGGCTAAC (5').

34.   Which of the following sequences will form a hairpin loop structure?
        A) (5') ATTTAGCAATCATTTA(3').
        B) (5') ATTTAGCAATCGCCCG (3').
        C) (5') ATTTAGCAATCTAAAT(3').
        D) (5') GCCCGGCAATCTAAAT (3').
        E) (5') GCCCGGCAATCUCCCU (3').

35.   For the reaction $S \rightleftharpoons P$, $\Delta G^{0'}$ is -50 kJ/mol. A reaction is started with 20 mmol of S and no P is initially present. After 8 hours, analysis reveals the presence in the reaction of 15 mmol S and 5 mmol P. These results _____
        A) indicate formation of P is thermodynamically unfavourable.
        B) indicate equilibrium has been reached.
        C) indicate an enzyme has shifted the equilibrium toward S.
        D) indicate formation of P is slow and equilibrium has not yet been reached.
        E) are impossible, since $\Delta G^{'0}$ is -50 kJ/mol, so there must have been an error in analysis.

36.   Identify the **correct** statement about the following reactions:

$$2Fe^{3+} + 2e^{-} \rightarrow 2Fe^{2+}$$

$$NADH + H^{+} \rightarrow NAD^{+} + 2H^{+} + 2e^{-}$$

        A) Fe^{2+} is reduced to Fe^{3+} and NAD^{+} is oxidized to NADH.
        B) The electrons in the first reaction are reduced and in the second reaction are oxidized.
        C) NAD^{+} is reduced by 2 protons to NADH plus 1 free proton.
        D) NADH is oxidized to NAD^{+}.

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    E) The reactions cannot form a redox couple.

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

Pyruvate/lactate	-0.185 V
NAD^+/NADH + H^+	-0.32 V

Calculate the equilibrium constant for the reaction in which lactate is formed in a redox reaction with NADH.

R = 8.3 J/mol·K, T = 298 K, $\mathcal{F}$ (Faraday constant) = 96.4 kJ/volt·mol; The value is <u>?</u>

    A) 26.1
    B) 3.7×10^4
    C) 1.05×10^{-2}
    D) 192.8
    E) 1.01

38. The function of topoisomerases is _____
    A) to unwind double-helical DNA.
    B) to synthesize RNA primers.
    C) to relieve topological stress due to strand separation in DNA replication and transcription.
    D) to synthesize DNA.
    E) to cleave interior phosphodiester bonds.

39. DNA is replicated in the 5' to 3' direction with the result that _____
    A) the lagging strand is made in short 5' to 3' Okazaki fragments.
    B) the lagging strand is made continuously.
    C) the leading strand is made in short 5' to 3' Okazaki fragments.
    D) an RNA primer is required only for the strand that is synthesized in the 3' to 5' direction.
    E) RNA primers are synthesized for both strands by a topoisomerase.

40. Which definition is **incorrect**?
    A) <u>Gene</u>: A segment of DNA that encodes a functional biological product.
    B) <u>Genome</u>: The sum of all genes and intergenic DNA.
    C) <u>Endonucleases</u>: Enzymes that cleave interior phosphodiester bonds.
    D) <u>DNA polymerases</u>: Enzymes that synthesize DNA from an RNA template.
    E) <u>Helicases</u>: Proteins that use ATP to unwind DNA.

41. Identify the **correct** statement about DNA replication.
    A) DNA replication is intitated by the synthesis of DNA primers.
    B) DNA replication is the process by which mRNA is translated into protein.
    C) DNA replication is the process by which DNA is transcribed into RNA.
    D) DNA replication is the process by which proteins are post-translationally modified.
    E) DNA replication is the process by which an organism copies its DNA genome.

42. Identify the **correct** statement about RNA polymerase:
    A) It is a large RNA-protein complex.
    B) It consists of subunits $\alpha_2\beta_2$.
    C) The β-subunit is used for recognition of the promoter in the DNA.
    D) RNA polymerase requires a template but not a primer.
    E) Its mechanism involves attack of the 2'OH of the growing RNA on the terminal phosphate of the ribonucleoside diphosphate.

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43.   Identify the **<u>incorrect</u>** statement.
      A) Influenza virus is an RNA virus.
      B) The RNA-world hypothesis says that DNA preceeded RNA and proteins.
      C) HIV is an RNA retrovirus.
      D) Transcription is the process by which DNA is copied into RNA.
      E) The catalytic component of the ribosome consists of RNA.

44.   Identify the **<u>correct</u>** statement regarding transfer RNA.
      A) It carries amino acids by their side-chains.
      B) It is involved in the process of DNA replication.
      C) It can bind to the P-site and the A-site of ribosomes.
      D) It binds to messenger RNA by its codon arm.
      E) It carries an amino acid at both its 5' and 3' ends.

45.   The initiation codon AUG _____
      A) encodes Trp only.
      B) encodes a ribosome binding site.
      C) encodes Trp in prokaryotes and Met in eukaryotes.
      D) encodes a Stop signal.
      E) encodes Met in both prokaryotes and eukaryotes.

THE LABORATORY SECTION BEGINS ON THE FOLLOWING PAGE.

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LABORATORY SECTION (Questions 46 to 60)

46.   Which chemical was used in the laboratory this term to find the pK_a of the R-group carboxyl of an amino acid dissolved in water?
        A)   Hydochloric acid.
        B)   Sodium hydroxide.
        C)   Hydrochloric acid and sodium hydroxide.
        D)   Phenol red.
        E)   Ninhydrin.

47.   A 30 mL volume of 0.05 M arginine, initially at a pH of 1.2, was completely titrated with 0.1 M NaOH. What volume of the NaOH was required to do this? The pK_a values for arginine are 2.2, 9.0 and 12.5.
        A)   5 mL   B)   15 mL   C)   30 mL   D)   45 mL   E)   60 mL

48.   What is the pH of the solution in question 47 after the addition of 22.5 mL of the 0.1 M NaOH?
        A)   5.6   B)   9.0   C)   10.7   D)   12.5   E)   13.5 or greater

49.   What is the first reaction that occurs when the solution of arginine in question 47 is titrated with the NaOH?

        A) $\text{-COOH} + \text{OH}^- \rightarrow \text{-COO}^- + H_2O$

        B) $\text{-COOH} + \text{-NH}_2 \rightarrow \text{-COO}^- + \text{-NH}_3^+$

        C) $\text{-COO}^- + \text{-NH}_3^+ \rightarrow \text{-COOH} + \text{-NH}_2$

        D) $\text{-NH}_3^+ + \text{OH}^- \rightarrow \text{NH}_2 + H_2O$

        E) $\text{-NH}^+ + \text{OH}^- \rightarrow \text{-NH}^+ + H_2O$

For questions 50 and 51 refer to the following:

A glycine buffer is prepared by mixing 100 mL of 1.0 M glycine, pH 6.0, with 100 mL of 0.5 M NaOH and 300 mL of water. The pK_a values for glycine are 2.4 and 9.6.

50.   What is the pH of the buffer solution?
        A)   2.4   B)   6.0   C)   7.0   D)   9.6   E)   10.6

51.   What is the concentration of the buffer solution?
        A)   2.0 M   B)   1.0 M   C)   0.5 M   D)   0.2 M   E)   0.1 M

52.   In order to confirm the identity of an unknown amino acid it was subjected to paper chromatography together with five known amino acids. In order to measure the Rf it was necessary to visualise the spots. This was achieved by which of the following?
        A)   Adding Biuret reagent to produce purple spots.
        B)   Adding phenol red to give a colour change.
        C)   Adding ninhydrin to produce a purple pigment.
        D)   Adding aniline hydrogen phthalate to yield brown spots.
        E)   Adding ethanol:ammonia:water (8:1:1).

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53.   Which of the following are required for a colour change to occur with Biuret reagent?
1.   The presence of a disaccharide.
2.   The presence of Cu^{2+}.
3.   The presence of a peptide bond.
4.   The presence of alkaline phosphatase.
5.   The presence of acidic conditions.

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

54.   Using the Biuret method, the absorbance of a tube containing 0.2 mL of a 1 in 2 dilution of unknown protein solution was found to be 0.250. In the same size cuvette, 1.2 mL of a standard bovine serum albumin solution containing 5 mg BSA/mL, gave an absorbance reading of 0.375. What is the protein concentration of the original protein solution?

A) 4 mg/mL   B) 8 mg/mL   C) 16 mg/mL   D) 40 mg/mL   E) 150 mg/mL

For questions 55 and 56 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

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

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

56.   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

57.   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.   Acidic conditions.
4.   The presence of $CuSO_4$ to provide an oxidising agent.
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) 1, 2, 3, 4 and 5

58.   When DNA was isolated from salmon sperm nuclei sodium dodecyl sulphate performed which of the following roles?
1.   Disruption of the salmon sperm nuclei.
2.   Freeing of 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) 1, 2, 3, 4 and 5

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210 – 224 Univ. Centre   Seats 1 – 115   Dr. A. Scoot

59. Which of the following statements describe 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 to form sticky fibers.
    5. It precipitates RNA as a flocculent precipitate

    A) 1 and 2   B) 1, 2 and 3   C) 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 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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