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CHEM / MBIO 2770   Elements of Biochemistry I   Final Examination
210 – 224 University Centre   Seats 130 – 249
Examiners: Dr. J. O'Neil and Dr. E. Nichols

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.*
- *Please protect your Answer Sheet from the view of other students.*
- *Scratch Paper is available at the back of the examination.*

LECTURE SECTION (Questions 1 to 45)

1.   An organized network of reactions that decompose complex biomolecules and release free energy is best described by the word:
        A) metabolism
        B) condensation
        C) catabolism
        D) cannibalism
        E) anabolism

2.   Identify the **INCORRECT** statement about free energy changes ΔG.
        A) The free energy of a reaction can be determined from measurements of reactant and product concentrations when the reaction has reached equilibrium.
        B) The free energy of a redox reaction can be determined from the difference in standard reduction potentials for the two contributing half-reactions.
        C) The free energy of a reaction can be decomposed into enthalpy and entropy components.
        D) Free energy is always released in spontaneous reactions.
        E) The free energy of a reaction determines the reaction rate.

3.   What functional groups are present in the molecule shown below?
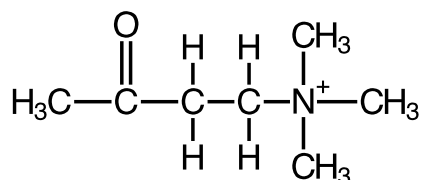
        A) amino and aldehyde.
        B) ether and alcohol.
        C) ketone and choline.
        D) amino and carboxylic acid.
        E) hydroxyl and ketone

4.   300 mL of 0.05M NaOH were added to 100 mL of 0.1M aspartate solution having pH = pKa of the alpha-carboxyl group. What is the new pH? pKa values for aspartate are 1.88, 3.65 (R-group) and 9.60.
        A) 1.88
        B) 2.76
        C) 3.65
   D) 6.62
        E) 9.60

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5. _____ is unique among the amino acids because its side-chain is covalently bonded to its α-amino group:
   A) Methionine.
   B) Tryptophan.
   C) Alanine.
   D) Threonine.
   E) Proline.

6. It is possible to form a disulphide bond between the amino acid Cys and _____.
   A) NADH.
   B) Gly.
   C) ATP.
   D) Lipoic acid.
   E) Ribose.

7. The **net** charge on the dipeptide glutamyllysine at pH 7 is _____.
   A) +2.
   B) +1.
   C) 0.
   D) -1.
   E) -2.

8. The pH of milk is about 6.6. What is the hydroxide ion concentration?
   A) $1.0 \times 10^{-6.6}$ M
   B) 2.51×10^{-7} M
   C) 3.98×10^{6} M
   D) 3.98×10^{-8} M
   E) 2.51×10^{7} M

9. All of the following are considered "*weak*" interactions in proteins, ***except***:
   A) amide bonds.
   B) hydrogen bonds.
   C) induced dipole interactions.
   D) electrostatic interactions.
   E) van der Waals forces.

10. The regular, repeating conformation of the polypeptide backbone is called _____.
    A) primary structure.
    B) secondary structure.
    C) tertiary structure.
    D) quaternary structure.
    E) double helix.

11. Which of the following statements about proteins is **FALSE**?
    A) Strong acid can unfold a protein and break the bonds between the amino acids.
    B) Non-polar amino acid side-chains are arranged on the inside of the protein where they avoid contact with water.
    C) Membrane proteins may traverse a lipid bilayer membrane or interact with only the surface of the membrane.
    D) Glycosidic bonds link the amino acids.
    E) Most proteins are encoded by DNA genomes.

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12.   In proteins, β-sheet structure is stabilized primarily by _____
     A) electrostatic interactions between the side-chains.
     B) hydrogen bonding between the side-chains.
     C) disulphide bonds between adjacent Cys residues.
     D) hydrogen bonds between backbone amide groups of parallel or anti-parallel chains.
     E) hydrophobic interactions between the α-H of the polypeptide backbone.

13.   In Sodium Dodecyl Sulphate Polyacrylamide Gel Electrophoresis, _____i_____ proteins enter the gel with difficulty and thus electrophorese _____ii_____ whereas _____iii_____ proteins enter the gel easily and electrophorese _____iv_____.
     A) i = small; ii = quickly; iii = big; iv = slowly.
     B) i = big; ii = slowly; iii = small; iv = quickly.
     C) i = small; ii = slowly; iii = big; iv = quickly.
     D) i = big; ii = quickly; iii = small; iv = slowly.
     E) i = big; ii = small; iii = quickly; iv = slowly.

14.   An enzyme following Michaelis-Menten kinetics catalyzes a reaction with an initial velocity of 50 micromoles/litre-seconds when the substrate concentration is 5 micromolar and 80 micromoles/litre-seconds when the substrate concentration is 10 micromolar. The V_{max} and K_m of this enzyme are:
     A) 50 micromoles/litre-seconds; 5 micromolar
     B) 80 micromoles/litre-seconds; 10 micromolar.
     C) 200 micromoles/litre-seconds; 15 micromolar
     D) 100 micromoles/litre-seconds; 12.5 micromolar
     E) 10 micromoles/litre-seconds; 1 micromolar

15.   Identify the **CORRECT** definition of oxidoreductase enzymes:
     A) They catalyze transfer of e^{-1} as H or H^{-}.
     B) They catalyze group transfers.
     C) They catalyze bond breakage through addition of water.
     D) They catalyze addition to or formation of double bonds.
     E) They catalyze group transfer yielding isomers.

16.   Regarding the following mechanism, which statement is **INCORRECT**?
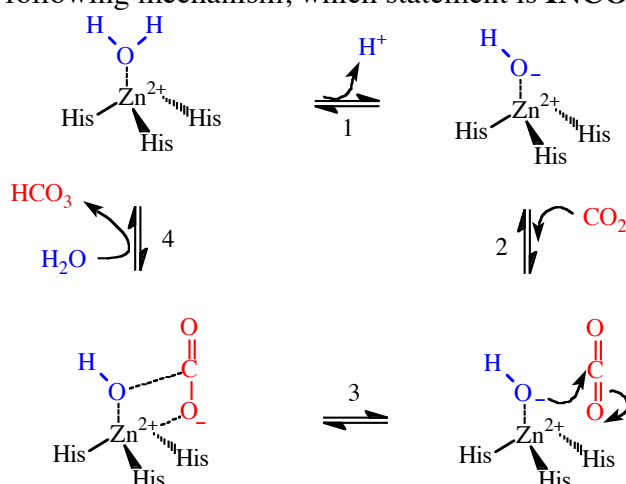
     A) It shows carbon dioxide and water reacting to form bicarbonate.
     B) Binding of the substrates helps decrease their entropy.
     C) The His residues belong to the enzyme chymotrypsin.
     D) Zinc helps lower the energy of the transition state.
     E) Zinc helps bind and orient the substrate molecules.

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17.   The role of the enzyme in an enzyme-catalyzed reaction is to _____
       A) absorb the excess free energy of the reaction.
       B) increase the rate of conversion of substrate to product.
       C) increase the equilibrium constant for the reaction.
       D) raise the transition-state free energy of the reaction.
       E) ensure all the substrate is converted to product.

18.   Addition of an inhibitor to an enzyme-catalyzed reaction causes an apparent increase in
       the K_m of the enzyme. This is consistent with _____
       A) an increase in apparent affinity of the enzyme for the substrate and
           competitive inhibition.
       B) an increase in apparent affinity of the enzyme for the substrate and non-
           competitive inhibition.
       C) a decrease in apparent affinity of the enzyme for the substrate and non-
           competitive inhibition.
       D) a decrease in apparent affinity of the enzyme for the substrate and competitive
           inhibition.
       E)   a decrease in apparent affinity of the enzyme for the substrate and no
           inhibition.

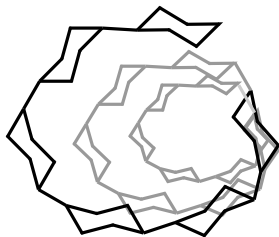19.   Identify the chiral carbons in the following sugar.
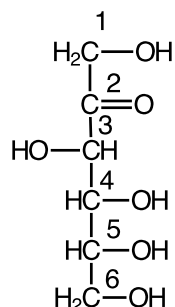
       A) 2.
       B) 1, 2, 6.
       C) 3, 4, 5.
       D) 1, 6.
       E) 4, 5.

20.   Identify the **CORRECT** statement about the following structures:
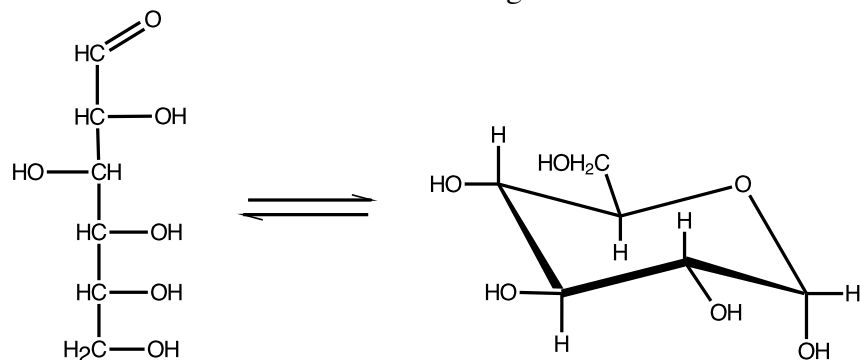

       A) α-D-glucose is shown in 2 puckered configurations.
       B) An aldehyde reacts with an alcohol to form a cyclic hemiacetal.
       C) Chair and boat conformations of α-D-glucose are in equilibrium.
       D) An aldehyde and an acid are in equilibrium with a hemiacetal.
       E) A ketone and and an alcohol are in equilibrium with a hemiketal.

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21.   Which statement best describes the following structure?

A) It represents the DNA double helix.
B) It represents a 6-residue per turn amylose (glucose) helix.
C) It represents a single-stranded RNA helix.
D) It represents an α-helix.
E) It represents a collagen fibril.

22.   The cell walls of bacteria contain a cross-linked network of short peptides and sugars called _____
A) peptidoglycan.
B) cellulose.
C) starch.
D) proteoglycan.
E) levan.

23.   Name the following compound:
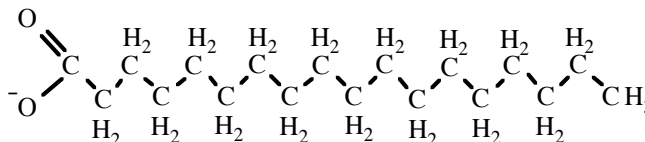
A) ATP
B) stearic acid
C) acetic acid
D) oleic acid or 18:1 (Δ^9)
E) sphingomyelin

24.   Which vitamin is derived from an orange pigment essential to vision?
A) A_1
B) B_1
C) C
D) D_3
E) E

25.   Sphingolipids are derived from _____
A) glycerol.
B) palmitate.
C) cholesterol.
D) tyrosine.
E) serine.

26.   Which statement about *trans*-fats is **INCORRECT**:
A) Like saturated fatty acids they are a risk factor for coronary artery disease.
B) They are found in high amounts in dairy products and meat.
C) They raise levels of "*bad*" LDL cholesterol.
D) When mixed with flour in baking products they produce a desirable texture.
E) Their production by partial hydrogenation raises the melting points of fats.

27.   Identify the **INCORRECT** statement regarding the Sodium-Potassium ATPase:
        A) It moves 2 K^+ into the cell and 3 Na^+ out of the cell.
        B) It uses the energy of ATP to move ions against their concentration gradients.
        C) It is the direct cause of the cell becoming negatively charged.
        D) It is an integral membrane protein that permits ions to flow through the membrane by passive diffusion.
        E) It maintains cells' transmembrane electrical potential of 50-70 mVolts.

28.   Identify the **CORRECT** statement:
        A) The fluid mosaic model of a membrane assumes that lipids travel rapidly around the bilayer but all proteins are fixed and unable to move.
        B) CH_4, O_2, N_2, and H_2O cross membranes with the help of active transporters.
        C) Lipid bilayers and cell membranes undergo a phase transition from a gel state to a liquid crystalline state as the temperature is elevated.
        D) Glucose permease is a 12 α-helical protein that uses the energy of ATP to pump glucose into the red blood cell.
        E) Integral membrane proteins are held to the surfaces of membranes by covalent bonds to carbohydrates.

29.   Which base pair is illustrated below?
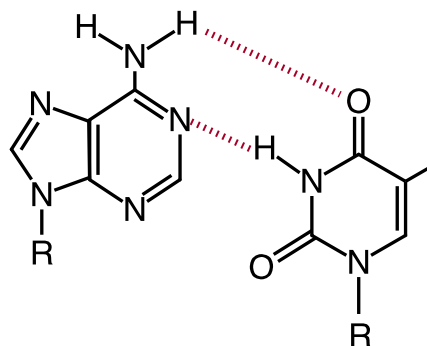
        A) A:T
        B) G:C
        C) A:C
        D) G:I
        E) None of the above.

30.   Identify the DNA sequence that is complementary to the following DNA sequence.
                            (5') AGTTCCGATCT (3')
        A) (5') TCAAGGCTAGA (3').
        B) (5') AGATCGGAACT (3').
        C) (5') AGTTCCGATCT (3').
        D) (5') AGAUCGGAACU (3').
        E) (5') UCAAGGCUAGA (3').

31.   Which of the following apply to RNA?
          I. It can exist as single stranded or double stranded.
         II. No organisms store genetic information in the form of RNA.
        III. Hydrogen bonding between ribose hydroxyls determines the conformation of
              RNA.
        IV. Base stacking can cause adoption of a right-handed helix.
         V. About 25% of the bases in RNA are thymine.

        A. III, IV, & V
        B. V
        C. I & IV
        D. II
        E. All are true.

32.   Which statement about the following molecule is **INCORRECT**?
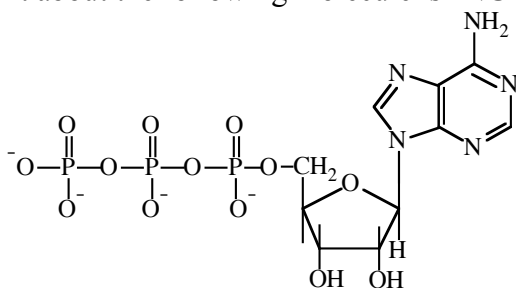
        A) The 5' carbon of ribose is phosphorylated.
        B) The nitrogenous base is hydrophobic.
        C) The 1' carbon of ribose adenylated.
        D) The ribose sugar is rigid and inflexible.
        E) It is commonly referred to as the cell's "*energy currency*".

33.   Under anaerobic conditions, some yeast generate ethanol from pyruvate to:
        A) lower the pH of wine.
        B) prevent poisoning from excess pyruvate build up.
        C) generate additional ATP.
        D) prevent uncontrolled cell growth.
        E) regenerate NAD^+ for further catabolism of glucose by glycolysis.

34.   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 ATP.
        B) Four moles of ATP.
        C) Two moles of NADH and two moles of ATP.
        D) Two moles of NADH and one mole of ATP.
        E) Two moles of NAD^+ and two moles of ATP.

35.   The unity and diversity of life are wondrous! Nearly every living cell oxidizes glucose by
        glycolysis. Most of the differences between cells _____
        A) lie in the regulation of the pathway.
        B) are found in the preparatory phase.
        C) are found in the payoff phase.
        D) lie in the amount of free energy captured by the cell as ATP.
        E) depend on the anaerobic *vs*. aerobic natures of the cells.

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36. _____ is a _____ electron carrier that donates and receives electrons in oxidation-reduction reactions.
    A) Ubiquinone; hydrophilic.
    B) NADH; soluble.
    C) Coenzyme Q; covalently-attached.
    D) Glucose; hydrophilic.
    E) FADH; soluble.

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

    Oxaloacetate $+ 2H^+ + 2e^- \rightarrow$ Malate $- 0.17$ V
    $NAD^+ + 2H^+ +2e- \rightarrow NADH + H^+$ $- 0.32$V

    Calculate the equilibrium constant for the coupled redox reaction that comprises the last step of the Krebs cycle. R = 8.3 J/mol*K, T = 298 K, $\mathcal{F}$ (Faraday constant) = 96.4 kJ/volt*mol
    The value is:
    A) 4.9×10^{11}.
    B) 1.2×10^5
    C) $- 4.4$.
    D) 1.01.
    E) 11.7

38. Which of the following correctly indicate the predicted flow of electrons under standard conditions that will occur when the two half reactions in the above question are coupled?
    A) From NAD^+ to NADH.
    B) From oxaloacetate to NADH.
    C) From malate to NAD^+.
    D) From oxaloacetate to NAD^+.
    E) From NADH to oxaloacetate.

39. Which set of enzymes are responsible for the synthesis of ATP by substrate-level phosphorylation?
    A) lactate dehydrogenase; succinyl CoA-synthetase; ATP synthase.
    B) hexokinase; glyceralsehyde-3-phosphate dehydrogenase; ATP synthase.
    C) Lactate dehydrogenase; succinyl CoA-synthetase; ATP synthase.
    D) phosphofructokinase; pyruvate dehydrogenase; succinyl CoA-synthetase;.
    E) phosphoglycerate kinase; pyruvate kinase; succinyl CoA-synthetase.

40. Identify the oxidized product resulting from the reaction catalyzed by the pyruvate dehydrogenase complex:
    A) $FADH_2$.
    B) NADH
    C) The carbon atom in carbon dioxide.
    D) The enzyme.
    E) The methyl carbon in pyruvate.

41. Which of the following compounds is **NOT** an indicator of a cell's high energy status?
    A) ATP.
    B) Succinyl-CoA.
    C) NADH.
    D) AMP.
    E) Citrate.

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42.   Two molecules of CO_2 are produced from one turn of the TCA cycle. At the beginning of the cycle one acetate contributes two carbon atoms and one oxygen atom to the cycle. Two oxygen atoms enter the cycle from two water molecules and another oxygen atom is contributed from _____.
       A) Malate dehydrogenase.
       B) Citrate.
       C) Inorganic phosphate.
       D) GTP.
       E) NAD^+.

43.   The mitochondrion is thought to be an ancient _____, gram negative, _____ bacterium that took up _____ residence in a primitive, eukaryotic, anaerobic host.
       A) Eukaryotic; anaerobic; parasitic.
       B) Amoebae; symbiotic; permanent.
       C) Prokaryotic, anaerobic, temporary.
       D) Vestigial; methanogenic; symbiotic.
       E) Prokaryotic; aerobic; symbiotic.

44.   Cytochrome c Oxidase is also known as _____
       A) Complex I of the ETC.
       B) Complex II of the ETC.
       C) Complex III of the ETC
       D) Complex IV of the ETC
       E) Cytochrome c.

45.   The following reaction is catalyzed by _____.

$$UQH_2 + 2Cyt\text{-}Fe^{3+} \rightleftharpoons UQ + 2Cyt\ c\text{-}Fe^{2+}$$

       A) Complex I of the ETC.
       B) Complex II of the ETC.
       C) Complex III of the ETC
       D) Complex IV of the ETC
       E) ATP Synthase.

LABORATORY SECTION (Questions 46 to 60)

46.   You determined that the initial rate for the hydrolysis of substrate ONPG by a β-galactosidase to be 0.040 AU/min. You realized after the assay that you had the cuvette in the cuvette holder in the wrong orientation. As a result, during the assay the path length was 0.30 cm rather than 1.00 cm. If the cuvette had been placed in the spectrophotometer correctly what would have been the new initial rate?
       A) The answer would have been the same because the enzyme and substrate concentration were unchanged.
       B) The initial rate would have been 0.133 AU/min.
       C) The initial rate would have been 0.080 AU/min.
       D) The initial rate would have been 0.012 AU/min.
       E) None of the above.

47.   Which of the following statements is **TRUE**?
       A) All enzyme inhibitors bind covalently to the enzyme.
       B) No enzyme inhibitors bind covalently to the enzyme.
       C) All enzyme inhibitor binding events are readily reversible.
       D) Enzyme inhibitors cannot be used to study how a substrate binds to an enzyme.
       E) Answers A) through D) are **FALSE**.

48.   You have prepared four different HEPES buffers of identical concentration and volume. The only difference between them is their pH values that are 7.5, 7.4, 7.3, and 7.2 respectively. If you added 1 mL of 1.0 M HCl to each of them, which one would exhibit the largest net change in pH? The pKa of HEPES is 7.55.
      A) 7.5
      B) 7.4
      C) 7.3
      D) 7.2
      E) They are all buffers of equal concentration and volume and therefore their net change in pH will be identical.

49.   You want to determine K_M for the hydrolysis of substrate BA by trypsin. You set up a series of cuvettes with different concentrations of this substrate with a fixed concentration of enzyme and perform your assays. You notice that you could not accurately determine V_0 because your reaction progress curves deviated from linearity too quickly. You decide to set the reactions up again, what should you do differently?
      A) Add more enzyme to the same volumes of substrate.
      B) Add less enzyme to the same volumes of substrate.
      C) Use the same volumes of enzyme and substrate but monitor the change in absorbance for a longer period of time.
      D) Use the same volumes of enzyme, but lesser volumes of substrate.
      E) Use the same volumes of enzyme and substrate but lower the substrate concentration for each assay.

50.   The iodine value for a lipid sample was determined to be 47. Based upon your titration of unreacted iodine with thiosulfate you determined that the mass of iodine that was taken up by the lipid to be 0.35 grams. What was the mass of lipid that was used for this determination?
      A) 0.74 grams
      B) 0.35 grams
      C) 0.1 grams
      D) 0.14 grams
      E) The concentration and volume of thiosulfate used is required to answer this question.

51.   Based upon the Lineweaver-burke graph depicted below, the calculated values for K_M and V_{max} are:
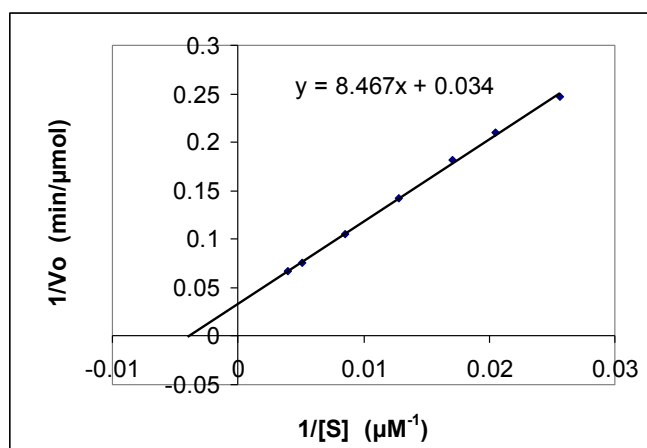
      A) 249 µM and 29.4 µmol/min
      B) 249 mM and 29.4 mmol/min
      C) 249 µM and 29.4 mmol/min
      D) 249 mM and 29.4 µmol/min
      E) 24.9 µM and 294 µmol/min

52.   Which of the following statements about paper chromatography that you used in
       Experiment 4 is **TRUE**?
       A)   The stationary phase is cellulose.
       B)   The mobile phase is water.
       C)   Polar solutes partition preferentially to the mobile phase.
       D)   Non-polar solutes partition preferentially to the mobile phase.
       E)   All of the above are false.

53.   The increased absorbance of UV light by denatured DNA compared to double stranded
       DNA is known as:
       A)   melting
       B)   the hypochromic effect
       C)   annealing
       D)   the hyperchromic effect
       E)   none of the above

54.   A titration curve for an unknown amino acid is depicted below.
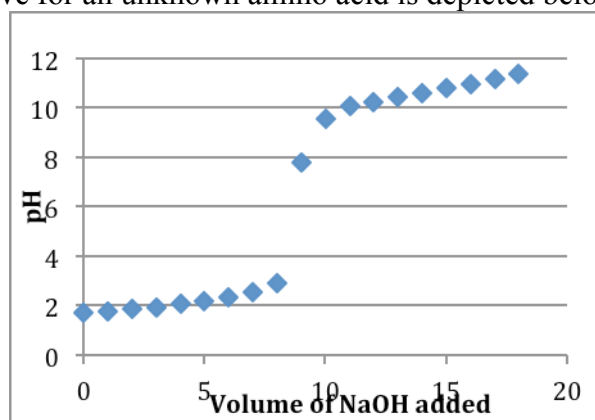
       Based upon the following table of pKa values, identify the unknown amino acid.

Amino acid	**pKa Values**		
	carboxyl	amino	R-group
Histidine	1.9	9.2	6.0
Proline	2.1	10.6	-
Asparagine	2.0	8.8	-
Alanine	2.2	9.8	-
Glutamic acid	2.2	9.7	4.3

       A)   Histidine
       B)   Proline
       C)   Asparagine
       D)   Alanine
       E)   Glutamic acid

55.   The graph below depicts the absorption spectra for two related compounds that you studied in Experiment 2.
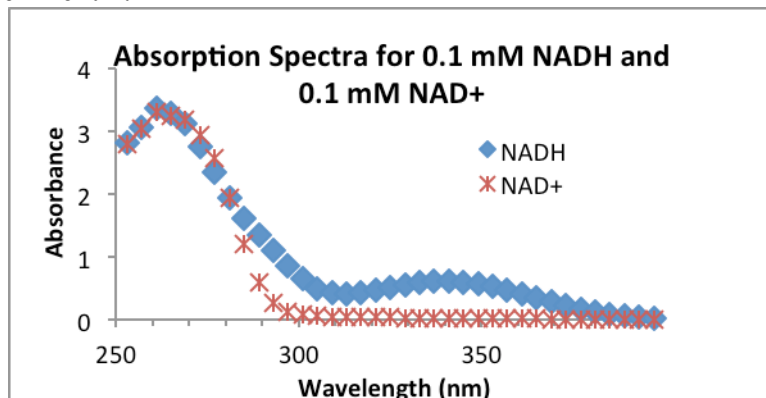
Based upon the graph, which of the following statements is **TRUE**?
    A)   The molar absorption coefficient of NADH at 350 nm is less than the molar absorption coefficient for NAD+ at the same wavelength.
    B)   The molar absorption coefficient of NADH at 350 nm is greater than the molar absorption coefficient for NAD+ at the same wavelength.
    C)   The molar absorption coefficient of NADH at 350 nm is greater than its molar absorption coefficient at 260 nm.
    D)   The molar absorption coefficient of NAD+ is 265 nm.
    E)   Both A) and D) are **TRUE**.

56.   For the determination of the iodine number of a lipid you used 0.05 M sodium thiosulfate. If the concentration of the sodium thiosulfate had been 0.03 M instead, which of the following statements is **TRUE**?
    A)   The iodine value would have been higher.
    B)   The iodine value would have been lower.
    C)   The volume of sodium thiosulfate used would have been greater.
    D)   The volume of sodium thiosulfate used would have been less.
    E)   Both A) and C) are true

57.   The absorbance at 260 nm for a sample of double-stranded DNA was 0.098, and the absorbance of the same sample of DNA when fully denatured was 0.133. During the melting of this sample of DNA the absorbance at 64°C was 0.120. What percentage of the DNA had been denatured at this temperature?
    A)   84
    B)   63
    C)   50
    D)   55
    E)   61

58.   Which of the chemical test(s) distinguish a reducing monosaccharide from a reducing disaccharide?
    A)   Benedict's Test
    B)   Bial's Test
    C)   Barfoed's Test
    D)   Barfoed's Test and Benedict's can distinguish them both.
    E)   Seliwanoff's Test

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59.   The catalytic rate for hydrolysis of BA by trypsin was found to be 5.1×10^{-6} M/second. If the total volume of enzyme and substrate in the cuvette was 2.0 mL, what is the catalytic rate in units of μmol/min?
   A)   The molar absorption coefficient for BA is required to answer this question.
   B) 3.06×10^{-7}
   C) 1.02×10^{-2}
   D)   0.306
   E)   0.612

60.   The absorbance value of a 4-nitroaniline solution was determined to be 0.228. If you made a 4-fold dilution of this sample in the same buffer and measured the absorbance of the diluted solution, what would be the new value?
   A)   The molar absorption coefficient of 4-nitroaniline is required to answer this question.
   B)   2.280
   C)   0.912
   D)   0.057
   E)   0.023

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Examiners: Dr. J. O'Neil and Dr. E. Nichols

Scratch Paper