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CHEM / MBIO 2770   Elements of Biochemistry I   Final Examination
Robert Schulz Theatre   Seats 1 – 112
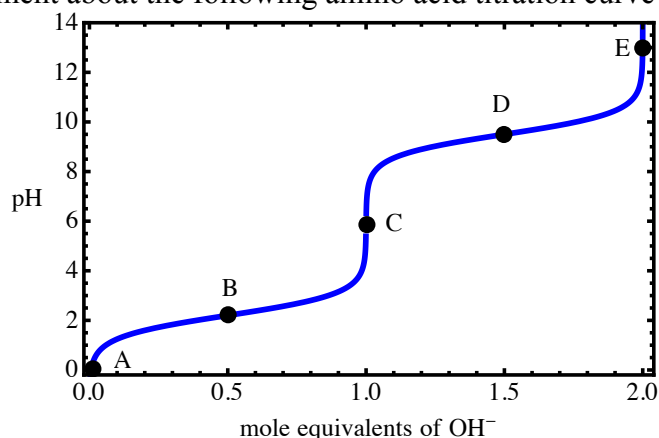Examiners: Dr. J. O'Neil and Dr. E. Nichols

Instructions

- *Please mark the Answer Sheet using PENCIL ONLY.*
- *Please protect your Answer Sheet from the view of other students.*
- *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.   All chemical and biochemical change involves rearrangements of _____
        A) protons.
        B) carbon atoms.
        C) electrons.
        D) nitrogen atoms.
        E) catabolism.

2.   Identify the correct statement about hydrogen bonding.
        A) NH is a good H-bond acceptor.
        B) It is a covalent attraction between polarized molecules containing O–H, N–H, or F–H.
        C) It is strongest when at a 90 degree angle.
        D) C=O is a good H-bond acceptor.
        E) A H-bond is about 28 nm in length.

3.   The dissolution of sodium chloride is driven primarily by _____
        A) the sodium-potassium ATPase.
        B) an entropy increase.
        C) solution enthalpy changes.
        D) the hydrophobic effect.
        E) hydrogen bonding.

4.   Three amino acids of the standard 20 contain hydroxyl side-chains. They are:
        A) Methionine, Cysteine, Proline.
        B) Tryptophan, Tyrosine Threonine.
        C) Alanine, Aspartic acid, Asparagine.
        D) Threonine, Serine, Tyrosine.
        E) Asparagine, Proline Glutamine.

5.   In ion exchange chromatography amino acids are eluted from a sulphonic acid resin
        because _____

        A) differences in the charges of the amino acids cause them to travel at different speeds in the electric field.
        B) differences in the sizes of the amino acids cause them to elute at different times.
        C) differences in the pI's of the amino acids cause them to elute at different pH's.
        D) differences in the chirality of the amino acids cause them to interact differently with the chromatography resin and elute at different times.
        E) differences in the hydrogen bonding of the amino acid side chains causes them to elute at different R_f values.

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6.   Which statement about the following amino acid titration curve is correct?

A)   Point "A" is the good buffering region.

B)   The pK_a of the compound is about 5.8.
C)   At point "E" the molecule is likely a Zwitterion.
D)   At point "B" the compound exists mainly in the weak acid form.
E)   The compound being titrated is anionic at point "E".

7.   Which amino acid is most likely being titrated in the titration curve shown above?
A)   Alanine.
B)   Aspartic acid.
C)   Glutamic acid.
D)   Histidine.
E)   Lysine.

8.   Identify the **INCORRECT** statement:
A)   The concept of "*induced fit*" involves a change in the conformation of an
       enzyme to obtain the proper orientation of the active-site amino acids.
B)   The α-helix is one possible conformation of a polypeptide.
C)   Leucine and isoleucine are isomers because they can be interconverted by a
       conformational change.
D)   Unfolding or denaturation of a protein usually leads to a loss of biological
       activity.
E)   Peptides can adopt many conformations because of rotation about single
       covalent bonds.

9.   Aspartate and glutamate residues tend to disrupt an alpha-helix when several occur next to one
       another in a protein because _____
A)   both Glu and Asp are highly hydrophilic.
B)   of steric hindrance between the bulky Asp and Glu R-groups.
C)   of the formation of disulfide bonds between Asp and Glu R-groups.
D)   of charge repulsion between their R-groups at cellular pH values.
E)   neither R-group can form a H-bond.

10.   Identify the correct description of hydrogen bonding in an α-helix:
A) $C=O_i \cdots H-N_{i+5}$

B) $C=O_i \cdots H-N_{i+4}$

C) $C=O_i \cdots H-N_{i+3}$

D) $C=O_i \cdots H-N_{i+2}$

E) $C=O_i \cdots H-N_{i+1}$

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11. Phenylisothiocyanate, proteolytic enzymes, and careful control of pH are important in

    _____
    A) lipid analysis.
    B) amino acid analysis.
    C) protein sequencing.
    D) preventing genetic mutations.
    E) protein purification.

12. In gel sieving chromatography, _____i_____ proteins don't enter the porous beads and
    so run _____ii_____ through the column whereas _____iii_____ proteins enter and
    exit the beads and elute more _____iv_____
    A) i = small; ii = quickly; iii = big; iv = slowly.
    B) i = big; ii = quickly; iii = small; iv = slowly.
    C) i = big; ii = slowly; iii = small; iv = quickly.
    D) i = small; ii = slowly; iii = big; iv = quickly.
    E) i = big; ii = small; iii = quickly; iv = slowly.

13. For any enzyme that follows simple Michaelis-Menten kinetics, when the initial Velocity of the
    reaction is 80% of V_{max} what is the substrate concentration?
    A) $[S] = K_m$
    B) $[S] = \frac{1}{2}K_m$
    C) $[S] \ll K_m$
    D) $[S] = 0.8K_m$
    E) $[S] = 4K_m$

14. Regarding the following mechanism, which statement is **INCORRECT**?
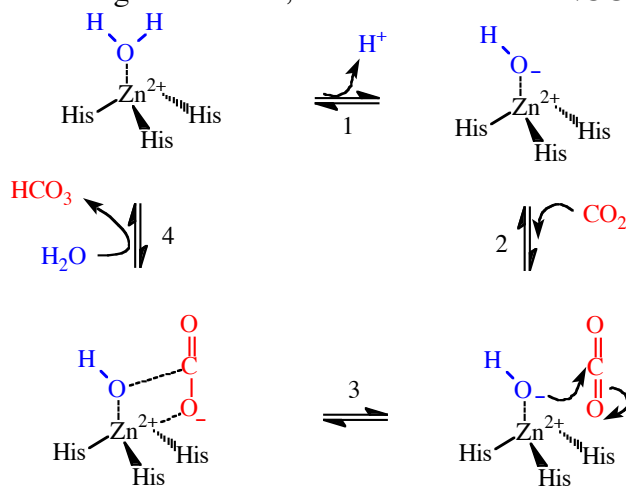

    A) It shows carbon dioxide and water reacting to form bicarbonate.
    B) The His residues belong to the enzyme carbonic anhydrase.
    C) Zinc helps lower the energy of the transition state.
    D) Zinc helps bind and orient the substrate molecules.
    E) Binding of the substrates helps increase their entropy.

15. When every enzyme molecule in a reaction mixture has its substrate-binding site occupied
    by substrate it is considered _____i_____, its initial velocity is _____ii_____, and
    its reaction is _____iii_____.
    A) i = complementary; ii = ½ V_{max}; iii = 1st order.
    B) i = saturated; ii = V_{max}; iii = zero-order.
    C) i = inhibited; ii = ½ V_{max}; iii = 1st order.
    D) i = saturated; ii = ½ V_{max}; iii = zero order.
    E) i = complementary; ii = V_{max}; iii = 2nd order.

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16. An enzyme follows Michaelis-Menten kinetics and has an initial reaction velocity of 19 micromoles / min at a substrate concentration 100 times the K_M. When the substrate concentration is 32 micromolar, the initial reaction velocity is 9.4 micromoles / min. What is the initial velocity of reaction when the substrate concentration is 16 micromolar?

    A) 0.59 micromoles / min.
    B) 4.7 micromoles / min.
    C) 6.22 micromoles / min.
   D) 9.4 micromoles / min.
    E) 16 micromoles / min.

17. Which statement correctly describes a pentose?

    A) A peptide containing 5 amino acids.
    B) A polysaccharide containing 5 sugars.
    C) A sugar containing 5 carbons.
    D) A fatty acid with 5 carbons in the hydrocarbon chain.
    E) An amino acid with 5 carbons in the side-chain.

18. Identify the correct statement about the following structures:
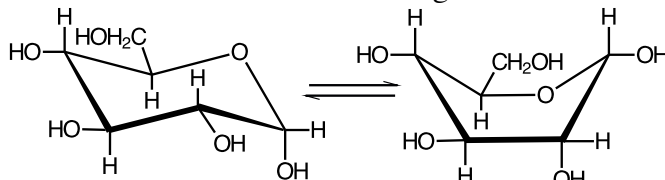
    A) α-D-glucose is shown in 2 puckered configurations.
    B) Chair and boat conformations of α-D-glucose are in equilibrium.
    C) A ketone and an alcohol are in equilibrium with a ketal.
    D) An aldehyde and an acid are in equilibrium with a hemiacetal.
    E) β-D-glucose is shown in equilibrium with β-D-fructose.

19. Which statement best describes the following structure?
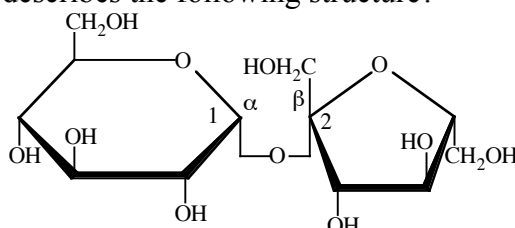
    A) It is a non-reducing disaccharide composed of a 2 pentoses.
    B) It is a reducing disaccharide composed of a 2 hexoses.
    C) It is a non-reducing disaccharide composed of glucose and levulose.
    D) It is a reducing disaccharide composed of 2 glucose units.
    E) It is a non-reducing disaccharide composed of glucose and fructose.

20. Identify the following molecule:
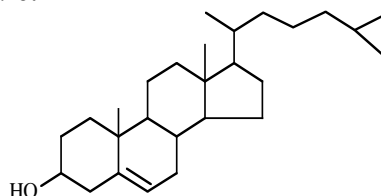
    A) Cholesterol
    B) Dolichol
    C) Glycerol
    D) Mannitol
    E) Sorbitol
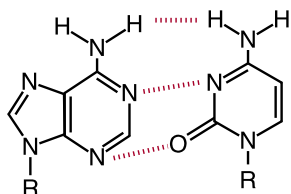
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21.   Olive oil is a liquid at room temperature because it is rich in _____
        A) unsaturated fatty acids.
        B) trans-fatty acids.
        C) saturated fatty acids.
        D) cholesterol.
        E) lipases.

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

23.   Which statement about fatty acids is **FALSE**?
        A) Except for some marine organisms most have an even number of carbon
            atoms.
        B) None have conjugated double bonds.
        C) Double bonds are always in the *cis* configuration.
        D) The carboxyl pK_a is 9.5-10.0.
        E) Their melting points increase with chain length.

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

25.   Identify the **INCORRECT** statement about the Fluid-Mosaic model of membranes.
        A) Lipid bilayers are 5 - 8 nm thick.
        B) Lipids diffuse laterally in the membrane whereas transbilayer movement is
            rare.
        C) Membranes undergo a phase transition in which the lipid hydrocarbon chains
            become rigid at high temperatures.
        D) Membrane fluidity depends on the amount of cholesterol in the membrane.
        E) Some proteins are free to move in the membrane whereas others are anchored
            to the cytoskeleton.

26.   The second messengers NO and CO cross membranes freely because _____
        A) transport proteins are available to facilitate their passage.
        B) they are small and uncharged.
        C) they contain oxygen.
        D) membranes have polar interiors.
        E) membrane proteins contain large pores and they are small molecules.

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27.   Which base pair is illustrated below?

   A) A:T
   B) G:C
   C) A:U
   D) A:I
   E) None of the above.

28.   Identify the RNA sequence that is complementary to the following DNA sequence.
                              (5') CTAAGCTTGAC (3')

   A) (3') GUCAAGCUUAG (3').
   B) (5') GATTCGAACTG (3').
   C) (5') GAUUCGAACUG (3').
   D) (3') GAUUCGAACUG (5').
   E) (3') GATTCGAACTG (5').

29.   Below are 5 DNA sequences. Each can form a double helix with its complementary
       sequence. Identify the double helix with the highest melting point.
   A) (5') ATGCGGGCCCAGGG (3').
   B) (5') ATGCGGTCCCAGGG (3').
   C) (5') ATGCGTTCCCAGGG (3').
   D) (5') ATGCGGGACCAGGG (3').
   E) (5') ATGCGGGCCCATTG (3').

30.   Which of the following phenomena do **NOT** lead to mutations in DNA?
   A) Spontaneous deamination of cytosine.
   B) Ultra-violet light.
   C) Temperatures below $25^{\circ}C$.
   D) Nitrogenous base tautomerization.
   E) X-rays.

31.   The reaction $6CO_2 + 6H_2O \rightarrow (CH_2O)_6 + 6O_2$ has a large ____i____ ΔH and a large
       _____ii_____ ΔS.
   A) i = negative ii = positive.
   B) i = positive ii = negative.
   C) i = Free energy ii = Entropy.
   D) i = positive ii = positive.
   E) i = negative ii = negative.

32.   What do CTP, coenzyme A, 1,3-bisphosphoglycerate, and phosphoenolpyruvate have in
       common?
   A) They are resonance stabilized.
   B) They store enough free energy to power the phosphorylation of ADP.
   C) They are high-energy phosphate carriers.
   D) They contain a nitrogenous base.
   E) They are strong bases.

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33.   Regarding the following equation, which statement is **INCORRECT**?

$$\Delta G'^{o} = -RT \ln(K'_{eq})$$

   A) The equation illustrates that free energy changes and equilibrium constants are different ways of expressing the same thing.
   B) The prime (') indicates measurements at pH 1.
   C) The o indicates standard conditions of 1 molarity in reactants, 55 M water, and $25^{o}C$.
   D) R is the gas constant.
   E) T represents the absolute temperature in Kelvin.

34.   Which statement about ATP is **INCORRECT**?
   A) ATP is thermodynamically unstable but kinetically stable.
   B) ATP is considered the cell's *"energy currency"*.
   C) One reason for ATP's high energy storage capacity is that there are fewer resonance forms of ADP + P_i than of ATP.
   D) Hydrolysis of the terminal phosphate releases about 30 kJoules/mol of free energy under standard conditions.
   E) The synthesis of ATP is a highly endergonic reaction.

35.   When glucose-6-phosphate and fructose-6-phosphate are mixed with the enzyme phosphohexose isomerase under standard conditions, the final equilibrium concentration of glucose-6-phosphate is 1.33 M and the final concentration of fructose-6-phosphate is 0.66 M. What is the free energy change for the conversion of glucose-6-phosphate → fructose-6-phosphate?   R = 8.315 J/mol-K; T = 298 K.
   A) − 1.7 kJ/mol.
   B) +74 kJ/mol.
   C) − 74 kJ/mol.
   D) 0.5 kJ/mol.
   E) +1.7 kJ/mol.

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

   ½ O_2 + 2H^+ + 2e^{-1} → H_2O + 0.82 V

   NAD^+ + 2H^+ + 2e^{-1} → $NADH + H^+$ − 0.32 V

   Which of the following correctly indicate the flow of electrons that will occur when the two half reactions are coupled?
   A) From O_2 to NADH.
   B) From O_2 to NAD^+.
   C) From NAD^+ to NADH.
   D) From NAD^+ to O_2.
   E) From NADH to O_2.

37.   In DNA replication the function of DNA binding proteins is _____
   A) to keep the DNA strands separated.
   B) to use ATP to dissociate the DNA strands.
   C) to relieve topological stress due to strand separation.
   D) to synthesize DNA.
   E) to seal the breaks in DNA.

38.   What process in DNA synthesis follows the step shown below?
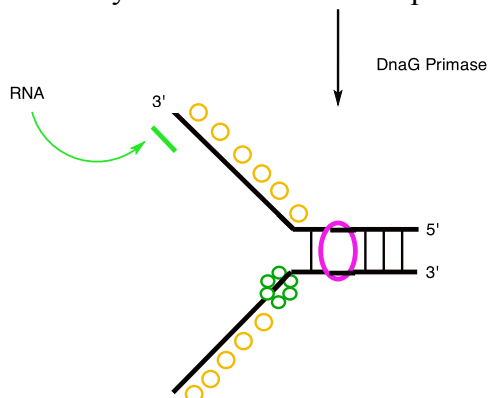
A) 8 DnaA-ATP proteins bind to the Origin of replication.
B) DNA ligase seals the nick between Okazaki fragments.
C) The leading strand is made in short 5' to 3' Okazaki fragments.
D) *DNA Polymerase-III* adds nucleotides to the RNA continuously.
E) *DNA Polymerase-I* removes the RNA paired to the template using its
     5'→3' exonuclease activity.

39.   DNA photolyases use visible light and Flavine Adenine Dinucleotide to repair
     _____
A) cross-linked thymine dimers.
B) uracil that results from deamination of cytosine.
C) guanine tautomers.
D) N^6-methylated adenines.
E) DNA base-pair mismatches.

40.   Identify the **INCORRECT** statement about RNA:
A) Some RNA molecules are catalysts.
B) In some organisms RNA functions as a genetic information storage molecule.
C) RNA's are degraded by a 3',5'–exoribonuclease.
D) RNA serves to transfer genetic information from the nucleus to the cytoplasm
     in eukaryotic cells.
E) RNA contains deoxyribose.

41.   What is a Svedberg?
A) It is a measure of radioactivity.
B) It is the name of a modified nitrogenous base.
C) It is a measure of the rate at which a particle sediments in a centrifugal field.
D) It is a component of the ribosome.
E) None of the above are correct.

42.   The σ subunit of RNA polymerase is needed for _____
A) catalysis of mRNA synthesis.
B) transcription termination.
C) the removal of introns.
D) interaction with cAMP-bound Catabolite Activator Protein.
E) promoter binding and transcription regulation.

43.   In translation, which factor does **NOT** contribute to the binding of fMet-tRNA^{fMet} at the
     initiator Met site?
A) Binding of mRNA to the 30S ribosome by its Shine-Dalgarno site.
B) N_{10}-formylTHF and transfomylase.
C) fMet-tRNA^{fMet} is the only tRNA that binds to the ribosomal P-site.
D) GTP hydrolysis by EF-Tu.
E) The fMet-tRNA^{fMet} anticodon H-bonds to the AUG codon.

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44.   What step in translation follows the formation of the complex shown in the diagram
         below?
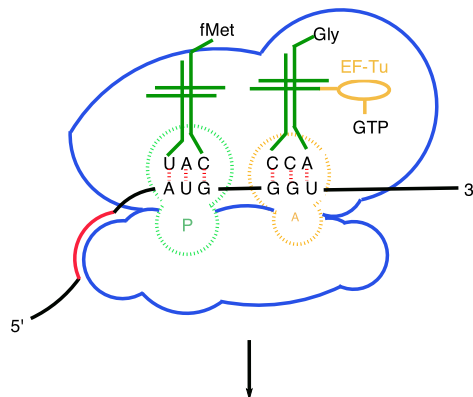
A) GTP is hydrolysed to GDP and P_i and EF-Tu-GDP departs.
B) The 50S ribosome binds and IF-1and IF-3 are released.
C) The A-site carboxyl attacks the P-site amino forming a new peptide bond.
D)   mRNA binds the 30S ribosome at the Shine-Dalgarno site.
E) Using the energy of hydrolysis of GTP the ribosome translocates 3 Base Pairs
       toward the 3' end of the mRNA.

45.   The _____i_____ is where the initiator tRNA binds and the _____ii_____ is
         where each succeeding tRNA binds before its AA is added to the peptide chain.
            A) i = amino-acyl site; ii = peptidyl-site.
            B) i = amino-acyl site; ii = emptying-site.
            C) i = peptidyl site; ii = amino-acyl site.
            D) i = emptying site; ii = peptidyl-site.
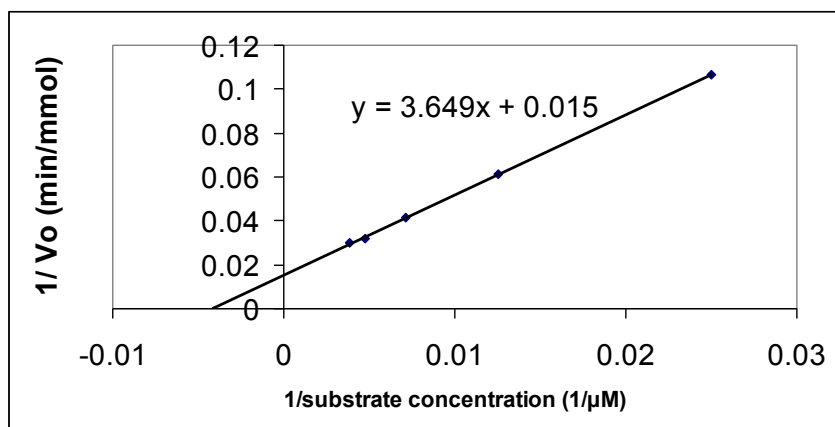   E) i = amino-acyl site; ii = mRNA binding site.

THE LABORATORY SECTION BEGINS ON THE FOLLOWING PAGE.

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LABORATORY SECTION (Questions 46 to 60)

46.   You added 0.1 mL of solution X to 35 mL of water. What is the fold dilution of solution X?

A) 35
B) 350
C) 3.5
D) 351
E) 35.1

47.   You mixed 200 µL of an 800 µg/mL solution of salmon sperm DNA with 19.80 mL of SSC buffer. What is the new concentration of the salmon sperm DNA?

A) 40 µg/mL
B) 8 mg/mL
C) 8 µg/mL
D) 4 mg/mL
E) 0.8 µg/mL

48.   You have 100 mL of 50 mM HEPES buffer pH 7.1. You added 0.1 mL of 5 M NaOH to your buffer and then you measured the pH. What is the new pH? (Hint: only one of the answers can possibly be correct.)

A) 7.0   B) 7.1   C) 6.9   D) 6.8   E) 7.3

49.   In a beaker you have 50 mL of a 25 mM phosphate buffer pH 6.90 and you added 10 drops of 0.8 M NaOH to the solution and then re-measured the pH. You found that the new pH was 7.63. Which of the following changes to the preceding experimental protocol would result in a greater net change of pH?

A) A volume of the phosphate buffer less than 50 mL.
B) A phosphate buffer concentration greater than 25 mM.
C) Fewer than 10 drops of the 0.8 M NaOH.
D) A concentration of NaOH less than 0.8 M.
E) All of the above.

50.   You have to make a buffer with a pH of 7.0. Which of the following buffers is most suitable for preparing this buffer?

A) TRIS which has a pKa of 8.3.
B) Citric acid which has a pKa of 5.4.
C) Acetic acid which has a pKa of 4.8.
D) CAPS which has a pKa of 10.4.
E) HEPES which has a pKa 7.5

51.   The Beer-Lambert Law can be written as $A = Elc$. If you double the path length, how much does the absorbance change for a light-absorbing compound in solution? Assume that you have not changed the concentration of the compound or the wavelength at which you are measuring absorbance?

A) Absorbance is unchanged because the concentration is the same.
B) Absorbance will double.
C) Absorbance will be halved.
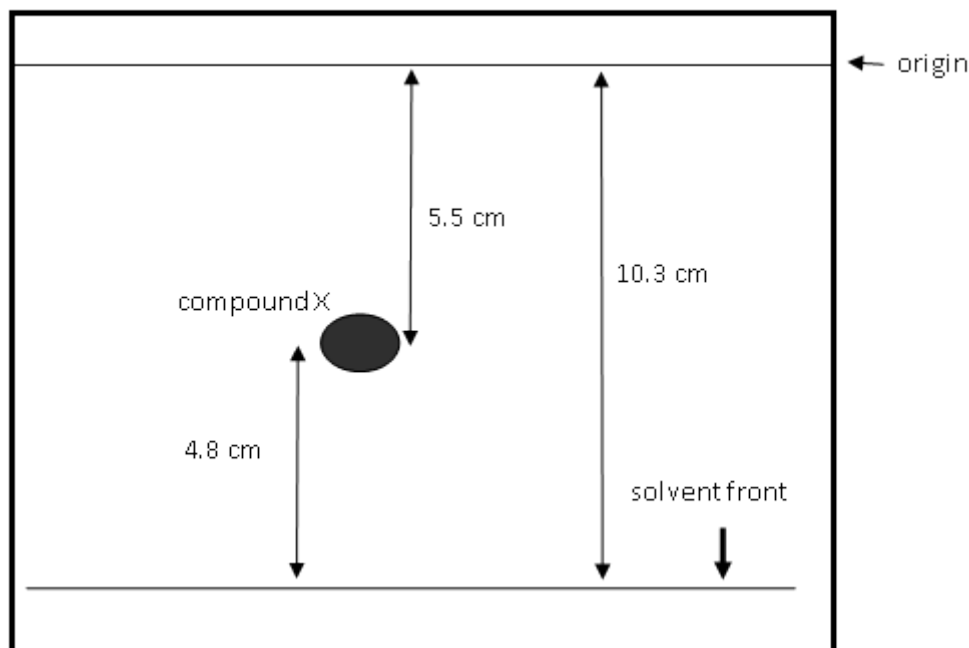D) It depends upon the compound under investigation.
E) None of the above.

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52. The absorbance of a 4.3×10^{-5} M solution of compound X is 0.094. Assuming a path length of 1 cm, what is the molar extinction coefficient for this compound?

     A) $2,186 \ M^{-1}cm^{-1}$.
     B) Cannot be answered as the wavelength for the measurement is required.
     C) $4.57 \times 10^{-4} M^{-1}cm^{-1}$.
     D) $44,510 \ M^{-1}cm^{-1}$.
     E) $21,860 \ M^{-1}cm^{-1}$.

53. Based upon the Lineweaver-Burke plot depicted below, what are the K_m and V_{max} for the enzyme?

     A) 243 µM and 66.7 µmol/min.
     B) 318 µM and 66.7 mmol/min.
     C) 343 mM and 78 mmol/min.
     D) 243 mM and 66.7 µmol/min.
     E) 243 µM and 66.7 mmol/min.

54. Based upon how you performed the alkaline phosphatase assays for Experiment 3, which of the following experimental errors would generate an absorbance value at 550 nm that was higher than it should have been if the assay had been done correctly?

     A) You added too little enzyme.
     B) You added too much stopping buffer.
     C) You added the stopping buffer later than you should have.
     D) You added the stopping buffer earlier than you should have.
     E) You added too little substrate.

55. Which carbohydrate test will distinguish between a pentose and a hexose?

     A) Benedict's Test.
     B) Student's t-test.
     C) Barfoed's Test.
     D) Bial's Test.
     E) Seliwanoff's Test.

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56. Based upon the chromatogram depicted below calculate the R_f value for compound X?

     A) 0.47   B) 1.15   C) 0.53   D) 0.87   E) 1.00

57. What was the purpose of the sodium dodecyl sulfate during the purification of DNA from salmon sperm nuclei?
    A) Split phosphodiester bonds.
    B) Break N-glycosyl linkages between deoxyribose and purines.
    C) Separation of DNA from deoxyribonucleic acid.
    D) Separation of DNA from nucleoproteins.
    E) None of the above.

58. You want to determine the iodine number for an unknown triglyceride. You determined that 0.15 grams of iodine were needed to saturate 0.48 grams of the unknown. What is the iodine number for this unknown?
    A) 0.31   B) 320   C) 3.2   D) 31   E) 310

59. Which of the following statements is correct?
    A) Single-stranded DNA is more viscous that double stranded DNA.
    B) The denaturation temperature of DNA is lower in distilled water compared to the melting temperature of the same DNA in standard saline solution.
    C) Saturated triglycerides have higher iodine numbers than unsaturated ones.
    D) Removal of divalent cations stimulates DNase activity.
    E) The stationary phase for paper chromatography is the non-polar solvent.

60. Which of the following statements is incorrect?
    A) Enzyme activity can be measured by decreases in absorbance values.
    B) Iodine number is a proxy for the degree of saturation of a triglyceride.
    C) DNA denaturation is the process of forming single-stranded DNA molecules.
    D) A lipid with a high iodine number is more likely to be a liquid at room temperature than a lipid with a low iodine number.
    E) An enzyme cannot catalyze chemical reactions at varying pH values.

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