Instructions

- *Please mark the Answer Sheet using PENCIL ONLY.*
- *Enter your NAME and STUDENT NUMBER on the Answer Sheet.*
- *The exam consists of multiple choice questions. Enter your answers on the Answer Sheet.*
- *There is only 1 correct answer for each question.*

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1. Hydrophobic interactions:

   A) refer to the ability of water to denature proteins.
   B) do not contribute to the structure of water-soluble proteins.
   C) are the driving force in the formation of micelles of amphipathic compounds in water.
   D) are explainable in terms of solute enthalpy.
   E) primarily involve the effect of polar solutes on the entropy of aqueous systems.

2. Which of the following statements are **false**?

   A. The side-chain of Val does not ionize.
   B. Nonpolar ends of lipids form hydrophilic interactions with water.
   C. A reaction may not occur at a detectable rate even though it has a large, negative $\Delta G^{0\prime}$.
   D. Enzymes catalyze reactions by shifting the equilibrium in favour of the product.
   E. Lowering the temperature of a reaction will lower the reaction rate.

   A) i and ii.
   B) ii and iv.
   C) iii, iv, and v.
   D) ii, iii, and iv.
   E) i and v.

3. A compound has a pK of 7.4. To 100 mL of a 1.0 M solution of this compound at pH 8.0 is added 30 mL of 1.0 M hydrochloric acid. The resulting solution is pH:

   A) 7.4
   B) 7.22
   C) 7.58
   D) 6.53
   E) 6.8

4. Lemon juice at pH 2.3 contains about ___ times as much H^+ as milk of magnesia at pH 10.5.

   A) 8.2
   B) 1.6×10^8
   C) 10^{-8}
   D) 12
   E) 100,000

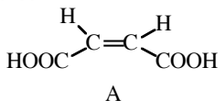
5. 75 mL of 0.1M HCl were added to 100 mL of 0.1M aspartate solution, pH=pI. What is the new pH? pKa values for aspartate are 1.88, 3.65 (R-group) and 9.60.

   A) 2.76
   B) 4.13
   C) 6.62
   D) 1.40
   E) 9.60

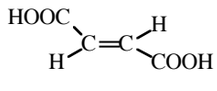
6. For any amino acid with a non-polar R-group, at any pH below the pI of the amino acid, the predominant form in solution will:
   A) have a net positive charge.
   B) have no net charge.
   C) have a net negative charge.
   D) have both positive and negative charges in equal concentration.
   E) be a Zwitterion.

7. Which of the following amino acids has **no** chiral carbon?
   A) glycine
   B) lysine
   C) threonine
   D) cysteine
   E) aspartic acid

8. Molecules A and B are:



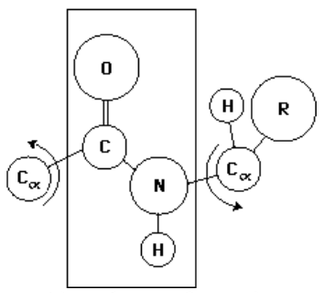
A



B

   A) Moronic acid and Fumaric acid
   B) Non-superimposible mirror images
   C) Sterioisomers but not enantiomers
   D) Dextrorotatory and levorotatory
   E) Epimers at C2

9. In the diagram below, the plane drawn behind the peptide bond indicates the:



   A) plane of rotation around the C_α—N bond.
   B) region of steric hindrance determined by the large C=O group.
   C) region of the peptide bond that contributes to a Ramachandran plot.
   D) theoretical space between –180 and +180 degrees that can be occupied by the ϕ and ψ angles in the peptide bond.
   E) absence of rotation around the C—N bond because of its partial double-bond character.

10. Which of the following best represents the backbone arrangement of two peptide bonds?
   A) C_α—N—C_α—C—C_α—N—C_α—C
   B) C_α—C—N—C_α—C—N
   C) C_α—N—C—C—N—C_α
   D) C—N—C_α—C_α—C—N
   E) C_α—C_α—C—N—C_α—C_α—C

11. Which of the following statements about proteins is **false**?
    A) Most proteins are denatured by high temperature.
    B) Non-polar amino acid side-chains are arranged on the outside of the protein where they interact with water.
    C) Most globular proteins are compact.
    D) Most proteins are encoded by DNA genomes.
    E) Carbohydrates are sometimes attached to proteins.

12. All of the following are considered "weak" interactions in proteins, ***except:***
    A) hydrogen bonds.
    B) hydrophobic interactions.
    C) ionic bonds.
    D) van der Waals forces.
    E) peptide bonds.

13. Which of the following statements about silk fibroin are **false**?
    A) It is predominantly composed of antiparallel β-pleated sheets.
    B) It is a strong material, held together by disulphide bonds.
    C) It has a high content of Gly and Ala.
    D) The β-sheets are held together by interactions between the side-chains.
    E) The Gly side-chains tend to be on one side of the sheet.

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

15. An enzyme-catalyzed reaction was carried out with the substrate concentration initially 10 times greater than the K_m for that substrate. After 15 minutes, 2% of the substrate had been converted to product, and the amount of product formed in the reaction mixture was 45 μmol. If, in a separate experiment, one-third as much enzyme and twice as much substrate had been combined, how long would it take for the same amount (45 μmol) of product to be formed?

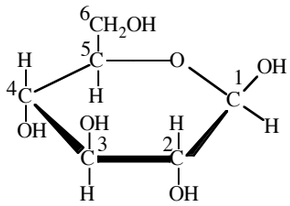
    A) 45 min
    B) 90 min
    C) 27 min
    D) 15 min
    E) 5 min

16. Which of the following definitions correctly identifies the common name of the compound?
    A) Maltose = Glc (β1→4) Glc
    B) Lactose = Gal (β1→4) Fru
    C) Sucrose = Fru (α1→β2) Fru
    D) Cellulose = $(Glc\ \alpha1\rightarrow4\ Glc)_n$
    E) Iso-maltose = Glc (α1→6) Glc

17. Which statement is **incorrect**?

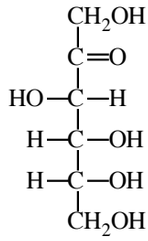
A) β-*D*-Glc can put all bulky substituents in the equatorial position so it is a very stable and abundant molecule.
B) Mutarotation is the interconversion of α- and β-glucose and can be measured by the rotation of polarized light.
C) Reduction of glyceraldehyde yields glycerol.
D) Vitamin C is a sugar acid lactone.
E) Maltose, (O-α-*D*-glucopyranosyl-(1→4) β-*D*-glucopyranose) is a non-reducing disaccharide.

18. In the following compound carbon ____ (i) is the anomeric C, and carbons _____ (ii) are asymmetric.



A) i = 6 and ii = 2, 3, 4, and 5
B) i = 2 and ii = 3, 4, 5, and 6
C) i = 1 and ii = 1, 2, 3, 4, and 5
D) i = 5 and ii = 6
E) i = 1 and ii = 1, 2, 3, 4, 5, and 6

19. Name the following compound:

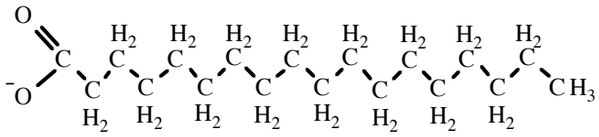


A) Glyceraldehyde
B) D-Ribose
C) D-Fructose
D) L-Glucose
E) Vitamin C

20. Which of the following monosaccharides are **not** aldoses?
1) ribose 2) galactose 3) fructose 4) dihydroxyacetone 5) erythrose

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

21. Name the following compound:



A) Oleic acid or 18:1 (Δ^9)
B) ATP
C) Acetic acid
D) Sphingomyelin
E) Stearic acid

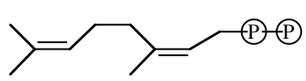
22. Saponification (alkaline hydrolysis) of triacylglycerols would produce which of the following molecules?

1. Inorganic phosphate 2. Glycerol 3. Fatty acid(s) 4. Ethanolamine 5. Sphingosine

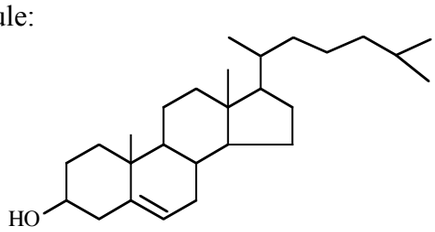
A) 2, 3, 4 and 5
B) 1 & 5 only
C) 4 and 5 only
D) 2 and 3.
E) 1, 2 & 3

23. In which process is the hydrophobic effect **not** important?
A) The folding of proteins.
B) The ionization of Glutamic acid.
C) The formation of detergent micelles.
D) The folding of the DNA double helix.
E) The formation of lipid bilayers.

24. Identify the **incorrect** statement:
A) A lysolipid is a lipid from which one of the fatty acid chains has been removed.
B) Diacylglycerol and inositol-1,4,5,trisphosphate are intracellular Second Messengers that regulate enzyme activity.
C) Sphingolipids are derived from the amino acid Serine.
D) Blood group antigens are fatty acids.
E) The structure of geranylphosphate is:



25. Identify the following molecule:



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

26. A lipid derived from isoprenoid precursors is:

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

27. Identify the **correct** statement:

A) Aquaporins use the energy of ATP to transport 2 Na^+ into a cell and 3 K^+ out of a cell.
B) The fluid mosaic model of a membrane assumes that lipids travel rapidly around the bilayer but 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 freely, equalizing their concentrations on both sides of the membranes.
E) Integral membrane proteins, such as Cytochrome C, traverse the bilayer as either α-helices or β-sheets.

28. Identify the **incorrect** definition:

A) Tautomers are rapidly interconverting isomers that exist in equilibrium.
B) DNA replication is the process by which an identical copy of a double-stranded DNA is made using existing DNA as a template.
C) Polycistronic RNA encodes 2 or more polypeptides.
D) A resonance structure is an average of 2 or more structures that differ only in the locations of their electrons.
E) A nucleic acid palindrome is any double helical DNA structure that exhibits self-complementarity between the strands.

29. Which of the following apply to double-stranded DNA?

1) The proportion of bases that are purines must be the same in both strands.
2) The planes of the bases lie perpendicular to the long axis of the DNA molecule.
3) The 2' hydroxyl groups of ribose participate in hydrogen bonding.
4) The two strands are antiparallel.
5) The adenine content of one strand must be equivalent to the cytosine content in the complementary strand.

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

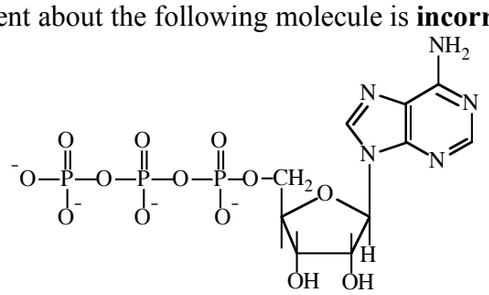
30. The polymer (5') ATTCGCAGTAA (3') could form a double-stranded structure with:

A) (5') TAAGCGTCATT (3')
B) (5') TTACTGCGAAT (3')
C) (5') TCATTGCGAAT (3')
D) (5') TCGTCGGCCAA (3')
E) (5') ATTCGCAGTAA (3')

31. Which of the following phenomena do **not** lead to mutations in DNA sequence:
    A) Ultra-violet light.
    B) H_2O_2.
    C) X-rays.
    D) Spontaneous deamination of cytosine.
    E) High concentrations of salt.

32. Which statement about RNA is **incorrect**:
    A) RNA is the catalytic component of the ribosome.
    B) Transfer RNA carries genetic information from the cytoplasm into the nucleus.
    C) Ribosomal RNA is the most abundant class of RNA.
    D) Messenger RNA forms a single-stranded, right-handed helix stabilized by base stacking.
    E) Transfer RNA forms self-complementary "clover-leaf" structures.

33. Which statement about the following molecule is **incorrect**?



    A) It contains a high-energy phosphoanhydride bond.
    B) The 1' Carbon of ribose adenylated.
    C) It is commonly referred to as the cell's "energy currency".
    D) The nucleotide base is hydrophobic.
    E) The 3' Carbon of ribose is phosphorylated.

34. For the reaction S $\rightleftharpoons$ P, $\Delta G^{0'}$ is -70 kJ/mol. The reaction is started with 10 mmol of S; no P is initially present. After 8 hours, analysis reveals the presence in the reaction of 8 mmol S and 2 mmol P. These results ?

    A) indicate formation of P is slow and equilibrium has not yet been reached.
    B) indicate equilibrium has been reached.
    C) indicate an enzyme has shifted the equilibrium toward S.
    D) are impossible, since $\Delta G^{0'}$ is -70 kJ/mol, so there must have been an error in the analysis.
    E) indicate formation of P is thermodynamically unfavourable.

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

Oxaloacetate/malate	$E^{0'} = -0.18$ V
$NAD^+/NADH + H^+$	$E^{0'} = -0.32$ V

If you mixed oxaloacetate, malate, NAD^+ and $NADH + H^+$ 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) No reaction would occur, because all reactants and products are already at their standard concentrations.
    C) Oxaloacetate would be reduced, $NADH + H^+$ would be oxidized.
    D) Oxaloacetate and malate would be oxidized; NAD^+ and $NADH + H^+$would be reduced.
    E) Malate would be oxidized, $NADH + H^+$would be unchanged.

36. Phosphoglucomutase (PGM) catalyzes the reaction Glucose-6-P $\rightleftharpoons$ Glucose-1-P. The $\Delta G^{0'}$ for this reaction is +7.53 kJ/mole at 298 K. (R = 8.3 J/mol*degree). The equilibrium constant for this reaction is:

A) 9.12×10^{-4}
B) 1.76×10^{-16}
C) 21.0
D) 4.8×10^{-2}
E) 0

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

acetaldehyde/ethanol	-0.20 V
$NAD^+/NADH + H^+$	-0.32V

Calculate the equilibrium constant for the reaction in which ethanol is formed via alcoholic fermentation in yeast. R = 8.3 J/mol.K, T = 298 K, $\mathcal{F}$ (Faraday constant) = 96.4 kJ/volt*mol The value is ?

A) 108
B) 1.15×10^4
C) 8.7×10^{-5}
D) 9.26×10^{-3}
E) 1.12

38. The conversion of one mole of glucose to two moles of lactate by the glycolytic pathway results in the net formation of:

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

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 $\Delta G^{0'}$) is catalyzed by:

A) phosphoglycerate kinase
B) hexokinase
C) glyceraldehyde-3-phosphate dehydrogenase
D) phosphofructokinase
E) triose phosphate isomerase

40. Reactions of glycolysis and the TCA cycle are regulated by compounds that signal the energy status of the cell: Identify the **correct** statement.

A) Pyruvate dehydrogenase is activated by NADH.
B) Phosphofructokinase is inhibited by ATP.
C) α-ketoglutarate dehydrogenase is activated by Succinyl-CoA.
D) Pyruvate kinse is activated by acetyl-CoA.
E) Citrate synthase is inhibited by ADP.

41. Which of the following statements about the conversion of isocitrate to oxaloacetate during the TCA cycle, is **incorrect**?

A) One molecule of water is consumed at the reaction step catalyzed by fumarase.
B) Two molecules of CO_2 are produced
C) A total of three pairs of electrons are transferred to coenzymes.
D) One GDP is phosphorylated by direct chemical coupling (substrate level phosphorylation).
E) One carbon-carbon bond is oxidized by FAD at the reaction step catalyzed by succinate dehydrogenase.

42. Which of the following steps of the TCA cycle is/are linked to the reduction of FAD?
1) succinate → fumarate 2) citrate → isocitrate 3) malate → oxaloacetate
4) fumarate → malate 5) succinyl-S-CoA → succinate

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

43. Which of the following co-enzymes contains a nucleotide base also found in DNA and RNA?

1. Thiamine Pyrophosphate
2. Coenzyme A
3. Lipoate
4. FAD
5. NAD

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

44. Identify the **incorrect** statement regarding chemiosmotic coupling:

A. The matrix of the mitochondrion becomes filled with protons during electron transport.
B. 10 protons are pumped for each 2 electrons transferred from NADH to oxygen.
C. 6 protons are pumped for each 2 electrons transferred from succinate to oxygen.
D. The passage of 4 protons through the ATP Synthase releases enough free energy to make 1 ATP molecule from ADP and inorganic phosphate.
E. The free energy released in the oxidation of NADH is stored in an electrochemical proton gradient.

45. Identify the correct statement about the following reaction:

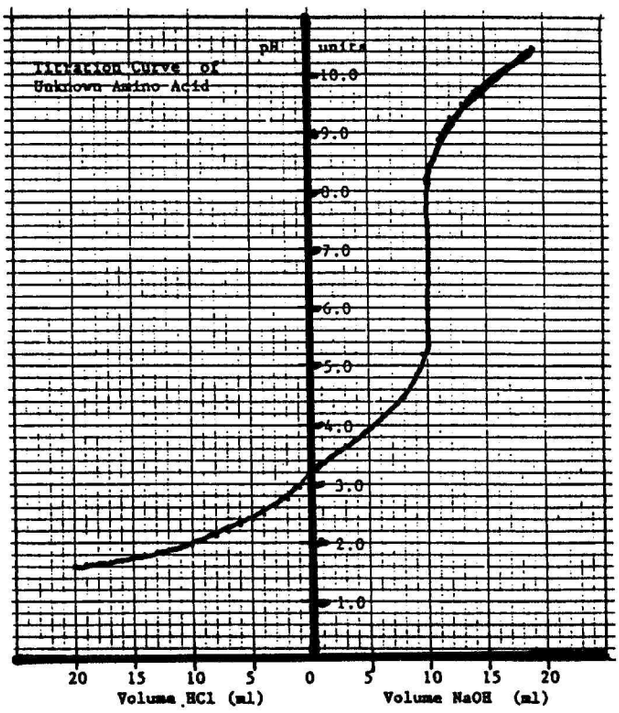
$$NADH + H^+ + 1/2O_2 \rightarrow H_2O + NAD^+$$

A. 4 electrons flow from oxygen to NADH.
B. NADH is reduced to NAD^+.
C. 2 electrons flow from NADH to oxygen.
D. Free energy considerations indicate the reaction will spontaneously go from left to right.
E. Electron flow from oxygen to NADH oxidizes the oxygen and reduces NADH.

LAB SECTION (Questions 46 to 60)

For questions 46 to 48 please refer to the following:

The titration curve for 30.0 mL of 0.05 M unknown amino acid with 0.15 M HCl and 0.15 M NaOH is shown below.



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

		pK_a (α- COOH)	pK_a (α- NH_3^+)	pK_a (R-gp)
A)	Arginine	2.2	9.0	12.5
B)	Aspartic acid	2.4	9.8	4.0
C)	Phenylalanine	1.8	9.1	--
D)	Serine	2.2	9.1	--
E)	Alanine	2.4	9.8	--

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

A) 1.4 B) 3.2 C) 4.0 D) 6.1
E) 7.0

48. To 100 mL of a 0.1 M solution at pH 9.8 of the same unknown amino acid from questions 46 and 47 was added 25 mL of 0.2 M HCl. What is the new pH of the solution?

A) 3.2 B) 4.0 C) 5.4 D) 6.1
E) 6.9

For questions 49, 50 and 51 please refer to the following:

An enzyme assay was done by measuring the concentrations of NAD^+ and NADH in the same sample using a spectrophotometer. Readings were taken for a 1 in 200 dilution of the original sample at two wavelengths, 260 nm and 340 nm, using a 1.2 cm sample holder. The following absorbencies were obtained:

0.495 at 260 nm and 0.155 at 340 nm.

The molar extinction coefficients for these two compounds at these two wavelengths are shown below:

	E , M^{-1} cm^{-1}	
	260 nm	340 nm
NAD^+	18,000	0
NADH	15,000	6300

49. What was the molar concentration of the reduced form of the electron carrier in the original sample?

A) 4.10×10^{-3}M B) 1.16×10^{-3}M C) 5.50×10^{-5}M
D) 2.75×10^{-5}M E) 2.05×10^{-5}M

50. What was the molar concentration of the oxidised form of the electron carrier in the original sample?

A) 4.58×10^{-3}M B) 1.16×10^{-3}M C) 2.29×10^{-5}M
D) 0.58×10^{-5}M E) 0.00M

51. Which of the following enzymes could be assayed using this technique?

1. Glyceraldehyde-3-phosphate dehydrogenase
2. Lactate dehydrogenase
3. Pyruvate dehydrogenase
4. Isocitrate dehydrogenase
5. Succinate dehydrogenase

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

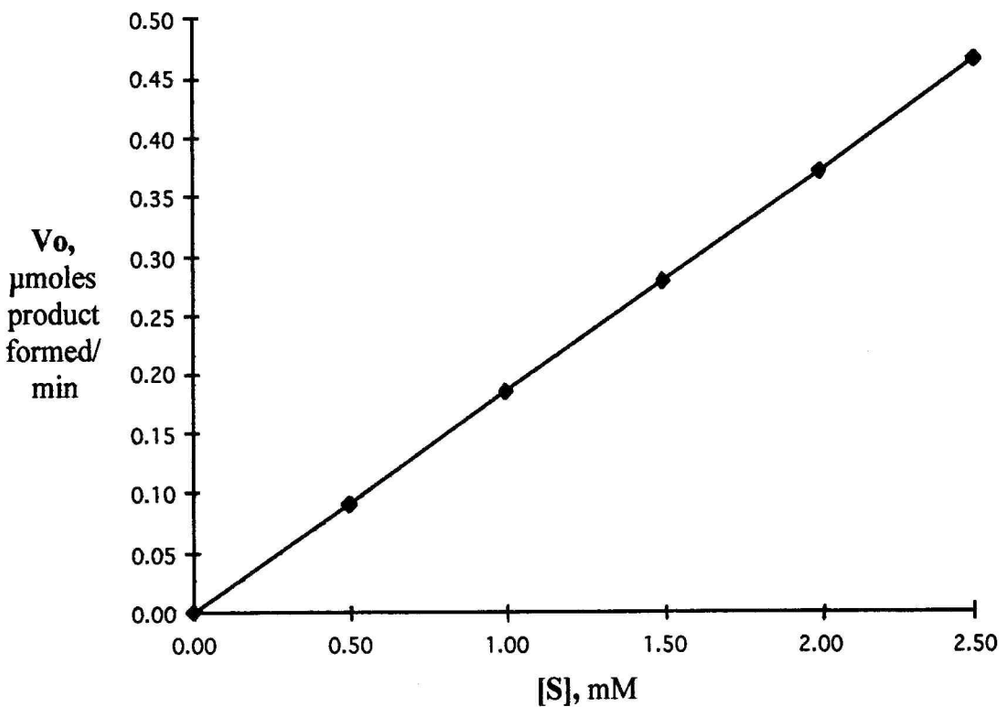
52. In your experience in the biochemistry labs which of the following statements about paper chromatography are true?

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 Rf 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) 1, 3 and 4 D) All of the above
E) None of the above

For questions 53 and 54 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 x 10^{-7}M, assay pH 9.6.



53. From the graph determine V_{max} in μmoles product formed/min, for the reaction under the conditions cited.

A) 0.232 B) 0.456 C) 2.500
D) 3.720 E) Cannot be determined

54. 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. Decrease 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

For questions 55 and 56 please 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 substrate and product listed in that order for the enzyme alkaline phosphatase?

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

56. Which of the reagents brings about color development upon termination of the alkaline phosphatase assay?

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

57. What information can be determined from a Lineweaver-Burk plot of enzymatic data giving the following values 1/v is 0(zero) when 1/[S] is -2.5×10^2M?

A) V_{max} is 1.25×10^2M/min
B) K_M is 0.004M
C) K_M is -4.0×10^{-3}M
D) K_M is -2.5×10^2M
E) Nothing can be determined.

58. The enzyme assay performed in the lab this term relied upon which of the following conditions?

1. Formation of a product whose absorbance could be determined.
2. Construction of a calibration curve.
3. Alkaline conditions.
4. The addition of a reagent to form a complex with the product to give a colored compound.
5. Titration of the product with acid and base.

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

59. Which of the following statements describes Benedict'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 and 3 and 4 D) 2 and 3
E) None of the above

60. Which of the following statements describe the role of sodium citrate in the isolation of DNA from salmon nuclei?

A) It disrupts the nuclei
B) It frees the DNA from nucleoproteins
C) It acts as a chelating agent
D) It inhibits DNase action by denaturing the enzyme
E) It causes the RNA to form a flocculent precipitate

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