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.*
- *Please read each question CAREFULLY.*

LECTURE SECTION (Questions 1 to 45)

1. Which equation defines a system at equilibrium?
   A) $\Delta G > 0$
   B) $\Delta G^\circ = \Delta G$
   C) $\Delta G = 0$
   D) $\Delta G = \Delta H - T\Delta S$
   E) $\Delta G = RT \ln$ ([products]/[reactants])

2. 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 explainable in terms of solute enthalpy.
   D) Primarily involve the effect of polar solutes on the entropy of aqueous systems.
   E) Are the driving force in the formation of micelles of amphipathic compounds in water.

3. The Second Law of Thermodynamics states:
   A) Systems tend to proceed from disordered states to ordered states.
   B) The free energy of the universe is constantly decreasing.
   C) The enthalpy of biological reactions is never positive.
   D) All naturally occurring processes proceed toward disorder.
   E) The free energy of the universe is constantly increasing.

4. The percentage of Glycine molecules having an uncharged carboxyl group at pH 1.8 is close to? (pK_a values for Glycine are 2.35 and 9.78.)
   A) 22% B) 28% C) 39% D) 50% E) 78%

5. 25 mL of 0.4 M NaOH is added to 75 mL of 0.2 M formic acid, containing no formate anion. (The pK_a of formic acid is 3.75). The resulting mixture has a pH close to:
   A) 2 B) 3 C) 4 D) 5 E) 6

6. Which of the following amino acids has **no** chiral carbon?
   A) Lysine
   B) Threonine
   C) Cysteine
   D) Glycine
   E) Aspartic acid

7. Which of the following do ***NOT*** describe the chemical properties of the 20 common amino acids?
   A) The α -carbon is bonded to a hydroxyl group.
   B) The α-carbon is bonded to a hydrogen.
   C) The α-carbon is bonded to a carboxylic acid.
   D) The α-carbon configuration is *L* in all but glycine.
   E) The α-carbon is bonded to variable side-chain group.

8. The zwitterion form of aspartic acid (Asp) would have the symbol:
   A) Asp^{+}
   B) Asp^{o}
   C) Asp^{-}
   D) Asp^{-2}
   E) None of the above.

9. Tertiary structure is defined as:
   A) The sequence of amino acids.
   B) Hydrogen bonding interactions between adjacent amino acid residues in helical or pleated segments.
   C) The folding of a single polypeptide chain in three-dimensional space.
   D) The way in which separate folded monomeric protein subunits associate to form oligomeric proteins.
   E) All are true.

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

11. Hemoglobin is an example of a(n):
   A) Enzyme.
   B) Regulatory protein.
   C) Transport protein.
   D) Storage protein.
   E) Structural protein.

12. Amino acid side chains capable of forming hydrogen bonds are usually located on the protein _____ and form hydrogen bonds primarily with the _____.
   A) Surface, water solvent.
   B) Interior, water solvent.
   C) Surface, other amino acid side chains.
   D) Interior, other amino acid side chains.
   E) All are true.

13. The hyperbolic Michaelis-Menten equation can be transformed into a straight line equation, y = mx + b, by the Lineweaver-Burk double reciprocal plot. What is the Y-intercept of the double reciprocal plot?
   A) K_m/V_{max}
   B) $1/V_{max}$
   C) $1/K_m$
   D) $1/V_o$
   E) 1/[S]

14. All of the following are properties of a coenzyme EXCEPT:
   A) They are usually actively involved in the catalytic reaction of the enzyme.
   B) They can be organic molecules or metals.
   C) They can serve as intermediate carriers of functional groups.
   D) They are proteins.
   E) They may contain vitamins as part of their structure.

15. When every enzyme molecule in the reaction mixture has its substrate-binding site occupied by substrate, it is considered _____, and the velocity is _____.
    A) Complementary; at the maximum.
    B) Inhibited; at half the maximum.
    C) Saturated; at half the maximum.
    D) Saturated; at the maximum.
    E) Inhibited; at the maximum.

16. The following data were obtained in a study of an enzyme known to follow Michaelis-Menten kinetics:

V_0 (μmol/min)	Substrate added (M)
19.7	0.100
41.6	0.200
63.5	0.400
72.9	0.800
77.0	0.850
79.6	0.900

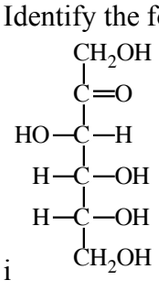
The K_m for this enzyme is approximately:
    A) 1 mM.
    B) 10 mM.
    C) 15.3 mM
    D) 50 mM.
    E) 200 mM.

17. All of the following disaccharides are reducing sugars ***EXCEPT***:
    A) Isomaltose.
    B) Lactose.
    C) Maltose.
    D) Sucrose.
    E) Cellobiose.

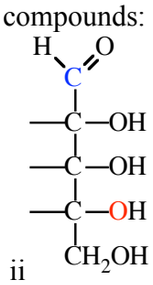
18. Which of the following monosaccharides are **NOT** ketoses?
    1) Ribose 2) Galactose 3) Fructose 4) Dihydroxyacetone 5) Glyceraldehyde

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

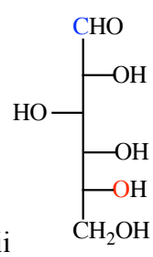
19. Identify the following compounds:



i



ii



iii

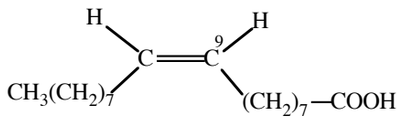
    A) i = D-Galactose ii = Lactose iii = D-Ribose
    B) i = D-Fructose ii = D-Ribose iii = D-Glucose
    C) i = D-Mannose ii = D-Glycerol iii = Vitamin C
    D) i = L-Fructose ii = L-Mannitol iii = D-Mannose
    E) i = D-Fructose ii = D-Mannose iii = D-Glucose

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

21. Fatty acids are all EXCEPT:
    A) Polymers of lipids.
    B) Either saturated or unsaturated.
    C) Mostly found with an even number of carbons.
    D) Amphipathic.
    E) All are true.

22. Steroid hormones include all of the following EXCEPT:
    A) Aldosterone.
    B) Cortisol.
    C) Estradiol.
    D) cAMP.
    E) Testosterone.

23. Name the following compound:



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

24. Which vitamin is essential to vision?
    A) A_1
    B) B_1
    C) B_{12}
    D) C
    E) D_3

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

26. Lipids that spontaneously form micelles, monolayers and bilayers have what property?
    A) Waxy.
    B) Polar.
    C) Amphipathic.
    D) Bipolar.
    E) Polyisoprenoid.

27. Flippases are enzymes that flip:
    A) Fatty acids from one position on glycerol to another position.
    B) Glucose from α- to β-glucose.
    C) Amino acids from one position to another in a protein.
    D) Cholesterol from one organelle to another.
    E) Phospholipids across to the other side of a membrane.

28. 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 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) Integral membrane proteins traverse the bilayer as either α-helices or β-sheets.

29. The hyperchromic shift that occurs when dsDNA is _____ is a(n) _____ in ultraviolet light absorption.
    A) Isomerized; increase.
    B) Methylated; decrease.
    C) Mutated; decrease.
    D) Denatured; increase.
    E) Melted; decrease.

30. In a double-stranded nucleic acid, guanine typically base-pairs with:
    A) Adenosine.
    B) Uracil.
    C) Inosine.
    D) Thymine.
    E) Cytosine.

31. DNA and RNA are polymers of _____ joined by _____ bonds.
    A) Nucleotides; amide.
    B) Nucleotides; phosphodiester.
    C) Deoxy-Ribose; glycosidic.
    D) Nucleosides; Hydrogen.
    E) Amino acids; phosphodiester.

32. The higher the _____content of a DNA, the _____ the melting temperature.
    A) G:A; higher.
    B) G:C; lower.
    C) G:C; higher.
    D) A:T; higher.
    E) A:G; lower.

33. Likely the most ancient of the metabolic pathways in which energy is released from glucose and captured in the form of ATP under anaerobic conditions is called:
    A) Photooxidation.
    B) Oxidative phosphorylation.
    C) Citric acid cycle.
    D) Glycolysis.
    E) Fermentation.

34. In the second half of the glycolytic pathway, _____ new ATP molecules are produced and with the offset of ____ ATPs consumed in phase 1, the net yield is _____ ATPs per glucose.
    A) Four; four; zero
    B) Four; two; two
    C) Two; two; four
    D) Two; one; one
    E) Four; one; three

35. In alcohol fermentation from glucose, the reduction of pyruvate is catalyzed by:
    A) Glyceraldehyde-3-phosphate dehydrogenase and pyruvate kinase.
    B) Alcohol dehydrogenase and hexokinase.
    C) Pyruvate decarboxylase and alcohol dehydrogenase.
    D) Lactate dehydrogenase and glyceraldehyde-3-phosphate dehydrogenase.
    E) Enolase and pyruvate dehydrogenase.

36. Phosphofructokinase is an allosteric enzyme and key control point in glycolysis. It catalyzes the reaction Fructose-6-P $\rightleftharpoons$ Fructose1,6-bisP. The $\Delta G'^{0}$ for this reaction is -14.2 kJ/mole. What is the equilibrium constant for this reaction at 298 K? (R = 8.3 J/mol*degree).
    A) 0.99
    B) 311
    C) 1.8×10^{-6}
    D) 3.21×10^{-3}
    E) 5.5×10^{5}

37. The standard reduction potentials (E'^{o}) 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) 1.12
    D) 9.26×10^{-3}
    E) 8.7×10^{-5}

38. In eukaryotic cells, glycolysis occurs in the _____, and the TCA cycle reactions take place in _____.
    A) Plasma membrane; mitochondria.
    B) Cytoplasm; cytoplasm.
    C) Endoplasmic reticulum; ribosomes.
    D) Nucleus; plasma membrane.
    E) Cytoplasm; mitochondria.

39. α-Ketoglutarate dehydrogenase reaction is a multi-enzyme complex analogous to:
    A) Pyruvate kinase.
    B) Glyceraldehyde-3-phosphate dehydrogenase.
    C) Isocitrate dehydrogenase.
    D) Pyruvate dehydrogenase.
    E) Lactate dehydrogenase.

40. In the TCA cycle, carbon enters the cycle as _____ and exits as _____ with metabolic energy captured as _____, _____ and _____.
    A) Pyruvate; water; NADH; ATP; NADPH.
    B) Acetyl-CoA; CO_2; NADH; GTP; NADPH.
    C) Succinyl-CoA; CO_2; ATP; NADH; NADPH.
    D) Acetyl-CoA; CO_2; GTP; NADH; $FADH_2$.
    E) Succinate; water; NADH; $FADH_2$; ATP.

41. Which enzymes involve production of NADH in the TCA cycle?
    A) Glyceraldehyde-3-phosphate dehydrogenase, isocitrate dehydrogenase, succinate dehydrogenase.
    B) Citrate synthase, aconitase, succinyl-CoA synthetase.
    C) Succinate dehydrogenase, fumarase, malate dehydrogenase.
    D) Pyruvate dehydrogenase, pyruvate kinase, malate dehydrogenase.
    E) Isocitrate dehydrogenase, α-ketoglutarate dehydrogenase, malate dehydrogenase.

42. The reaction of malate oxidation to oxaloacetate is not thermodynamically favored under standard conditions. It occurs because:
    A) It involves substrate-level phosphorylation.
    B) It is coupled with a strong reduction.
    C) It is coupled with ATP hydrolysis.
    D) The previous reaction has a large negative ΔG.
    E) Oxaloacetate is used in the next reaction which has a large negative ΔG.

43. All of the following are properties of ubiquinone EXCEPT:
    A) It is hydrophobic.
    B) It can easily diffuse in the membrane.
    C) It shuttles from complex I and complex II to complex IV.
    D) It contains an isoprenoid tail.
    E) It can donate and accept two electrons.

44. The final electron acceptor in the electron transport chain is:
    A) Molecular oxygen.
    B) H_2O.
    C) Cytochrome c.
    D) Ubiquinone.
    E) NAD^+.

45. Which of the following complex(es) translocate protons in the inner mitochondrial membrane?

    1. Complex I
    2. Complex II
    3. Complex III
    4. Complex IV
    5. F_oF_1-ATP Synthase

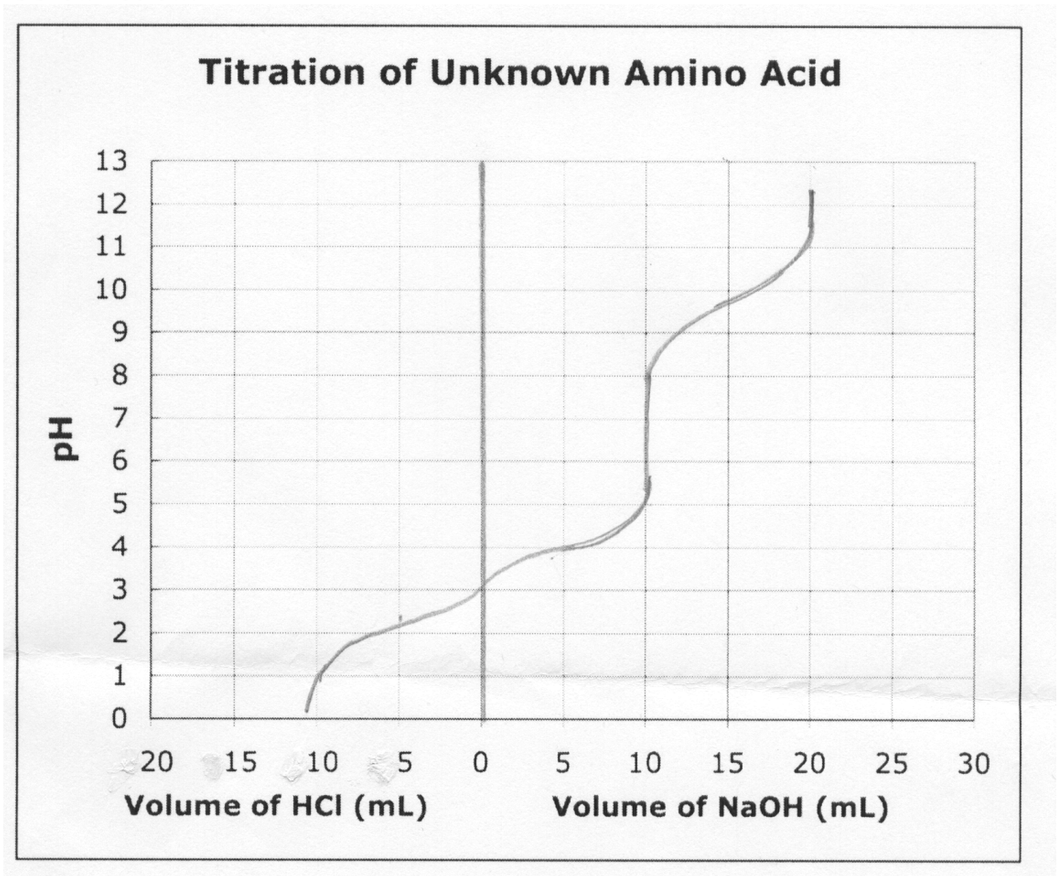
    A) 1, 3 & 4 only.
    B) 1 & 2 only.
    C) 1, 2 & 4 only.
    D) 1, 3, 4, & 5 only.
    E) All of the above.

THE LABORATORY SECTION BEGINS ON THE FOLLOWING PAGE.

LAB SECTION (Questions 46 to 60)

For questions 46 to 48 please refer to the following:

The titration curve for 15.0 mL of 0.1 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 50 mL of a 0.2 M solution at pH 9.8 of the same unknown amino acid above was added 50 mL of 0.1 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, and 50 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

For Questions 51, 52 and 53 please refer to the following:

The chemical tests listed below are used to distinguish between different carbohydrates.

I) Barfoed's test II) Benedict's test III) Bial's test IV) Molisch's test V) Seliwanoff test

51. Which of the tests could be used to distinguish between ribose and glucose?
A) I B) II C) III
D) IV E) V

52. Which of the tests would be best to distinguish between glucose and maltose?
A) I B) II C) III
D) IV E) V

53. Which three of these tests when used in sequence would enable you to distinguish between the following five carbohydrate solutions: glucose, maltose, sucrose, ribose and fructose?
A) I, II and III B) II, III and V C) IV, III and I
D) I, III and V E) IV, III and V

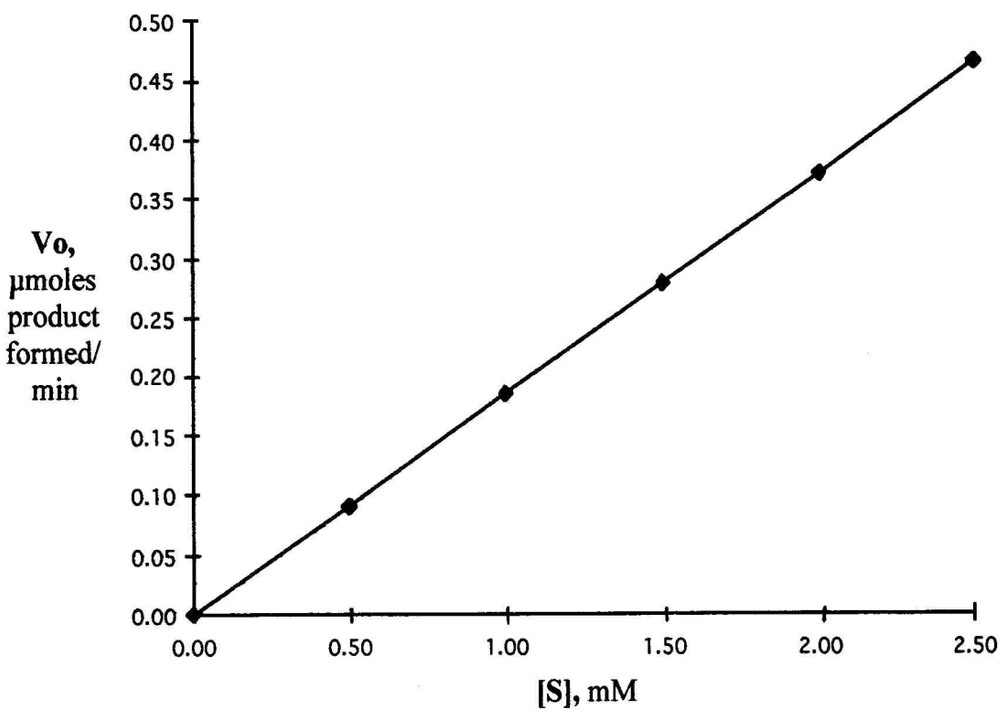
54. In your experience in the biochemistry labs which of the following statements about paper chromatography are true?

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 55 and 56 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.



55. From the graph above 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) Can not be determined from the graph

56. 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) 1 B) 2 C) 3 D) 4 E) All of the above

For questions 57 and 58 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

57. Which of the following pairs refers to substrate and product for the enzyme alkaline phosphatase?

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

58. 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

59. 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 -5.0×10^{2}M?

A) V_{max} is 5.0×10^{2}M/min
B) K_M is 0.002M
C) K_M is -2.0×10^{-3}M
D) K_M is -5.0×10^{2}M
E) Nothing can be determined.

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

1. It disrupts the nuclei
2. It frees the DNA from nucleoproteins
3. It acts as a chelating agent
4. It inhibits DNase action by denaturing the enzyme
5. It causes the RNA to form a flocculent precipitate

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

Scratch Paper

Scratch Paper

Scratch Paper