Instructions

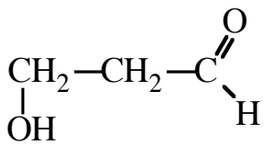
- *Please mark the Answer Sheet using PENCIL ONLY.*
- *Enter your NAME and STUDENT NUMBER on the Answer Sheet.*
- *The exam consists of multiple choice questions. Enter your answers on the Answer Sheet.*
- *There is only 1 correct answer for each question.*
- *Please read each question CAREFULLY.*

LECTURE SECTION (Questions 1 to 45)

1. If the enthalpy change ΔH for a reaction is +4.11 kJ/mol, the reaction is:
   A) at equilibrium.
   B) endergonic.
   C) endothermic.
   D) exergonic.
   E) exothermic.

2. Which of these statements about hydrogen bonds is ***NOT*** true?
   A) Hydrogen bonds help maintain the structures of proteins and nucleic acids.
   B) In liquid water, the average water molecule forms hydrogen bonds with three to four other water molecules.
   C) Individual hydrogen bonds are much weaker than covalent bonds.
   D) Hydrogen bonds are van der Waals attractions between polarized molecules containing O-H, N-H, or F-H.
   E) The strength of a hydrogen bond depends on the linearity of the three atoms involved in the bond.

3. What functional groups are present on this molecule?



   A) Ether and aldehyde.
   B) Hydroxyl and aldehyde.
   C) Hydroxyl and carboxylic acid.
   D) Amino and ester.
   E) Hydroxyl and ketone.

4. The dissolution of sodium chloride is driven primarily by:
   A) solution enthalpy.
   B) organized water cages.
   C) heat evolved by the reaction.
   D) entropy.
   E) the sodium-potassium ATPase.

5. The pH of a sample of blood is 7.4, while gastric juice is pH 1.4. The blood sample has:
   A) 0.189 times the $[H^+]$ as the gastric juice.
   B) 5.29 times lower $[H^+]$ than the gastric juice.
   C) 6 times lower $[H^+]$ than the gastric juice.
   D) 6,000 times lower $[H^+]$ than the gastric juice.
   E) a million times lower $[H^+]$ than the gastric juice.

6. 25 mL of 0.1M NaOH 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) 3.17
   C) 4.13
   D) 3.65
   E) 9.60

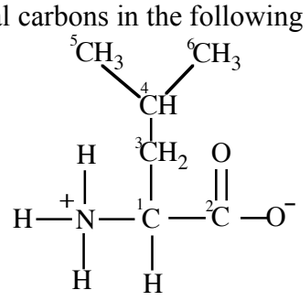
7. When preparing an acetate buffer at pH 4.5 with 0.01 M solutions of acetic acid (pK_a = 4.8) and sodium acetate, the volume of acetic acid needed would be _____ the volume of sodium acetate solution.
   A) equal to
   B) about six times
   C) more than half of
   D) less than half of
   E) about twice

8. Which collection of amino acids is hydrophilic?
   A) Ala, Pro, Phe
   B) Ser, Asn Gln
   C) Met, Val, Leu
   D) Val, Ile, Ala
   E) Trp, Phe, Pro

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

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

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



   A) 1 only
   B) 3 and 5
   C) 1 and 6
   D) 1 and 4
   E) 4 only

12. By adding SDS (sodium dodecyl sulfate) during the electrophoresis of proteins, it is possible to:
    A) determine a protein's isoelectric point.
    B) determine an enzyme's specific activity.
    C) determine the amino acid composition of a protein.
    D) preserve a protein's native structure and biological activity.
    E) separate proteins exclusively on the basis of molecular weight.

13. Which amino acid acts as a helix breaker due to steric interactions between its side-chain and the carbonyl of the preceding amino acid?
    A) Histidine
    B) Arginine
    C) Proline
    D) Serine
    E) Tyrosine

14. Identify the correct description of hydrogen bonding in an α-helix:
    A) $C{=}O_i \cdots H\text{-}N_i$
    B) $C{=}O_i \cdots H\text{-}N_{i+1}$
    C) $C{=}O_i \cdots H\text{-}N_{i+2}$
    D) $C{=}O_i \cdots H\text{-}N_{i+3}$
    E) $C{=}O_i \cdots H\text{-}N_{i+4}$

15. Proteolytic enzymes, phenylisothiocyanate, and careful control of pH are important in:
    A) protein sequencing.
    B) amino acid analysis.
    C) preventing genetic mutations.
    D) protein purification.
    E) lipid analysis.

16. Concerning metal co-factors in enzyme-catalyzed reactions identify the ***incorrect*** statement:
    A) Electron flow in metalloenzymes is from Cys→His→Ser.
    B) About 1/3 of all enzymes use metal co-factors.
    C) In carbonic anhydrase zinc helps orient and bind H_2O and CO_2.
    D) Metal cofactors help lower the energy of the transitions state.
    E) In some enzymes, metals donate and accept electrons in redox reactions.

17. Enzymes have active sites which have the greatest complementarity to the:
    A) substrate.
    B) transition state.
    C) product.
    D) both substrate and product.
    E) none of the above.

18. AMP is an activator of allosteric Phosphofructokinase. It:
    A) causes a shift to the right in the sigmoid V_o *vs.* [S] curve.
    B) stabilizes the R-state, decreasing $S_{0.5}$, and making the curve more sigmoid.
    C) decreases the cooperativity of the substrate.
    D) stabilizes the T-state, increasing $S_{0.5}$, and making the curve less sigmoid.
    E) increases the number of T conformations.

19. An enzyme has a K_m for its substrate of 6.3 $x10^{-5}$ M and a V_{max} of 8.1$x10^{-3}$ moles per litre per second. What would the initial rate of reaction be for this enzyme at a substrate concentration of 2.0 x 10^{-6} M?
    A) 2.5$x10^{-3}$ moles per litre per second
    B) 0.255 moles per litre per second
    C) 2.5$x10^{-4}$ moles per litre per second
    D) 4.05$x10^{+3}$ moles per litre per second
    E) Cannot be determined from the information given.

20. All of the following disaccharides are reducing sugars ***EXCEPT***:
    A) lactose.
    B) maltose.
    C) sucrose.
    D) cellobiose.
    E) isomaltose.

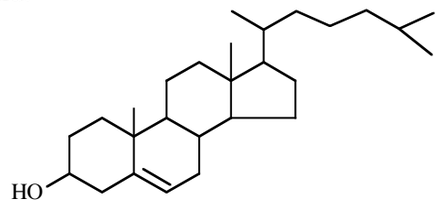
21. Carbohydrate characteristic chemical features include all ***EXCEPT***:
    A) the potential to form multiple hydrogen bonds.
    B) the existence of one or more asymmetric centers.
    C) the capacity to form polymeric structures.
    D) the ability to exist in either linear or ring structures.
    E) all are true.

22. All of the following statements about cyclic sugars are true ***EXCEPT***:
    A) The α-anomer has the -OH of the anomeric carbon positioned on the opposite side of the sugar ring from the -CH_2OH.
    B) The 5- and 6-membered rings are more frequently observed due to stability.
    C) In a chair conformation, the predominant form has the bulkiest substituents occupying axial positions.
    D) The carbonyl carbon becomes a chiral center.
    E) They can be formed by the intramolecular reactions to hemiacetals or hemiketals.

23. As a result of mutarotation, D-glucose exists in all of the following forms ***EXCEPT***:
    A) *L*-glucopyranose.
    B) β-anomer.
    C) free aldehyde.
    D) α-anomer.
    E) All are true.

24. Alkali hydrolysis of triacylglycerols is called _____ and yields _____and _____.
    A) triacylation; fatty acids; glycerol
    B) saponification; fatty alcohols; fatty acids
    C) triesteration; salts of fatty acids, fatty alcohols
    D) saponification; salts of fatty acids; glycerol
    E) none are true

25. Name the following compound:



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

26. Steroid hormones include all of the following ***EXCEPT***:
A) dihydroxyacetone.
B) progesterone.
C) cortisol.
D) estradiol.
E) testosterone.

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

28. 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.

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

30. All are true for the DNA double helix ***EXCEPT***:
A) The two strands are held together by interchain hydrogen bonds.
B) The two strands are parallel.
C) The two strands have complementary base pairing.
D) Information is accessed through transcription of the information into RNA.
E) All are true.

31. In the laboratory, several factors are known to cause alteration of the chemical structure of DNA. The factor(s) likely to be important in a *living* cell is (are):
A) heat.
B) low pH.
C) oxygen.
D) UV light.
E) Both C and D.

32. Which of the following is a palindromic sequence?
    A) AGGTCC
       TCCAGG
    B) CCTTCC
       GGAAGG
    C) GAATCC
       CTTAGG
    D) GGATCC
       CCTAGG
    E) GTATCC
       CATAGG

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

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. Substrate-level phosphorylation occurs in glycolysis in the reaction catalyzed by _____.
    A) Phosphoglycerate kinase.
    B) Hexokinase.
    C) Phosphofructokinase.
    D) Glucokinase.
    E) Glyceraldehyde-3-phosphate dehydrogenase.

36. Under anaerobic conditions, skeletal muscle generates lactate from pyruvate to:
    A) lower the pH.
    B) promote release of oxygen from hemoglobin.
    C) generate additional ATP.
    D) be a warning of muscle fatigue.
    E) regenerate NAD^+ for further glycolysis.

37. Phosphoglycerate mutase catalyzes the reaction 3-phosphoglycerate $\rightleftharpoons$ 2-phosphoglycerate. The equilibrium constant for this reaction is 0.169 at 298 K. (R = 8.3 J/mol*degree). The $\Delta G'^0$ for this reaction is:
    A) +1.9 kJ/mol
    B) +4.4 kJ/mol
    C) -4.2 kJ/mol
    D) 6.8×10^{-5} kJ/mol
    E) 306.5 kJ/mol

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

$CoQ / CoQH_2$ +0.06 V
$FAD / FADH_2$ -0.22 V

Calculate the equilibrium constant for the reduction of Coenzyme Q by $FADH_2$ as catalyzed by Complex II in the electron transport chain. R = 8.3 J/mol*K, T = 298 K, $\mathcal{F}$ (Faraday constant) = 96.4 kJ/volt*mol The value is:

A) 0.27
B) 2.6×10^{5}
C) 3.3×10^{-10}
D) 3.8×10^{-6}
E) 3×10^{9}

39. The coenzymes listed below are associated with α-ketoglutarate dehydrogenase complex ***EXCEPT***:

A) [FAD].
B) TPP.
C) lipoic acid.
D) NAD^{+}.
E) Heme.

40. The only reaction of the citric acid cycle that provides substrate-level phosphorylation is catalyzed by:

A) Malate dehydrogenase.
B) Citrate synthase.
C) Isocitrate dehydrogenase.
D) Succinyl-CoA synthetase.
E) Nucleotide triphosphate kinase.

41. 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) oxaloacetate is used in the next reaction which has a negative ΔG.
E) the previous reaction has a large negative ΔG.

42. All are principal allosteric regulatory "signals" controlling the TCA cycle activity ***EXCEPT***:

A) NADH.
B) NAD^{+}.
C) ATP.
D) Fructose-2,6-bisphosphate.
E) Succinyl-CoA.

43. Where does the energy that drives ATP synthesis come from?

A) The proton gradient.
B) NAD^{+} and FAD.
C) The electron gradient.
D) The oxidation states of the complexes.
E) Molecular oxygen.

44. Which of the following is a two-electron donor?
    A) FAD
    B) Fumarate
    C) NADH
    D) NAD^+
    E) Cyt c

45. Complex I and Complex II of the electron transport chain produce a common product which is:
    A) NAD^+.
    B) FAD.
    C) reduced Coenzyme Q.
    D) reduced Cyt *c*.
    E) reduced O_2.

THE LABORATORY SECTION BEGINS ON THE FOLLOWING PAGE.

LAB SECTION (Questions 46 to 60)

46. A 10 mL volume of a 0.1 M solution of an amino acid, initially at its pI, required 20 mL of 0.1M NaOH to titrate this amino acid to a final pH of 13. When another 10 mL of the 0.1 M amino acid solution was titrated with 0.1M HCl it required 10 mL to lower the pH to 1.0. Which of the following amino acids are consistent with this data?

1. Arginine 2. Aspartate 3. Glutamate 4. Lysine 5. Phenylalanine

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

47. When 15 mL of 0.2 M NaOH was added to 10 mL of 0.2 M histidine the pH of the solution rose to the pI of the histidine. What was the original pH of the solution? The pK_a values for histidine are 1.8, 6.0 and 9.2.

A) 1.8 B) 3.9 C) 6.0 D) 7.6 E) 9.2

48. What reaction is occurring when a solution of glycine at its pI is titrated with NaOH?

A) $-COOH + OH^- \rightarrow -COO^- + H_2O$ B) $-COOH + -NH_2 \rightarrow -COO^- + -NH_3^+$
C) $-COO^- + -NH_3^+ \rightarrow -COOH + -NH_2$ D) $-NH^+ + OH^- \rightarrow -NH^+ + H_2O$
E) $-NH_3^+ + OH^- \rightarrow NH_2 + H_2O$

49. In order to confirm the identity of an unknown amino acid it was subjected to paper chromatography together with five known amino acids. In order to measure the Rf it was necessary to visualise the spots. This was achieved by which of the following?

A) Adding Biuret reagent to produce purple spots.
B) Adding phenol red to give a colour change.
C) Adding ninhydrin to produce a purple pigment.
D) Adding aniline hydrogen phthalate to yield brown spots.
E) Adding ethanol:ammonia:water (8:1:1)

50. Which of the following are required for a colour change to occur with Biuret reagent?

1) The presence of a disaccharide.
2) The presence of Cu^{2+}.
3) The presence of a peptide bond.
4) The presence of alkaline phosphatase.
5) The presence of acidic conditions.

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

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

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

52. An amino acid solution with a concentration of 0.005 mg/mL had an absorbance of 0.280 at 278 nm with a 1 cm sample holder. The molar extinction coefficient, E, for the amino acid at 278 nm is 5600. Using this information what is the molecular weight of the amino acid?

A) 20 B) 100 C) 150 D) 200 E) 20,000

53. The double-reciprocal transformation of the Michaelis-Menten equation, the Lineweaver-Burk plot, is given by $1/V_0 = K_M/(V_{max}[S]) + 1/V_{max}$

To determine K_M from a Lineweaver-Burk plot you would do which of the following?

A) Multiply the reciprocal of the X-axis intercept by −1.
B) Multiply the reciprocal of the Y-axis intercept by −1.
C) Take the reciprocal of the X-axis intercept.
D) Take the reciprocal of the Y-axis intercept.
E) Take the X-axis intercept where $V_0 = 1/2V_{max}$.

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

1. Construction of a calibration curve.
2. Alkaline conditions.
3. The presence of $CuSO_4$ to provide an oxidising agent.
4. A phosphorylated substrate.
5. The presence of sodium potassium tartrate.

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

55. If the assay time was increased from 5 min to 10 min during an enzyme assay how would this affect the values of K_M and V_{max}?

A)	K_M	doubled	V_{max}	doubled
B)	K_M	unchanged	V_{max}	doubled
C)	K_M	unchanged	V_{max}	unchanged
D)	K_M	doubled	V_{max}	unchanged
E)	K_M	unchanged	V_{max}	halved

56. When DNA was isolated from salmon sperm nuclei sodium dodecyl sulphate performed which of the following roles?

1. Disruption of the salmon sperm nuclei.
2. Freeing of the DNA from nucleoproteins.
3. Inhibition of DNase present in the nuclei.
4. Precipitation of protein.
5. Precipitation of the DNA to form sticky fibres.

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

57. Which of the following statements describe the role of ethyl acetate in the isolation of DNA from salmon sperm nuclei.

1. It disrupts the nuclei.
2. Together with SDS it frees the DNA from nucleoproteins.
3. Together with iso-pentyl alcohol it precipitates the protein.
4. It precipitates the DNA to form sticky fibers.
5. It precipitates RNA as a flocculent precipitate

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

58. Which of the following statements describe Bial's test?

1. It is used to distinguish between monosaccharides and disaccharides.
2. The reagent contains copper acetate.
3. The copper ion is oxidised.
4. The assay conditions are acidic.
5. A furfural intermediate is formed.

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

59. Three chemical tests; Barfoed's, Bial's and Seliwanoff's, were performed in the order listed on the following carbohydrate solutions; fructose, galactose, ribose and sucrose. Each test led to the identification of one of the carbohydrates which could then be eliminated. Which one of the four carbohydrates remained after this process of elimination?

A) Fructose B) Galactose C) Ribose D) Sucrose E) Unable to determine

60. Which of the following statements about a calibration curve are true?

1. It is used to find the concentration of an unknown.
2. It is constructed using various concentrations of the unknown or a similar substance.
3. Different assays must be used for the known and unknown since the assay for the unknown may not have been established.
4. If the results for an unknown fall outside the range of a linear calibration curve the line is extended to find results for the unknown.
5. An example of a calibration curve is the effect of pH on enzyme activity.

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