**INSTRUCTIONS**

1. **You must mark the answer sheet with pencil (not pen).**
2. **Put your name and enter your student number on the answer sheet.**
3. **The examination consists of multiple choice questions. Choose the answer that you think is correct and record your choice on the answer sheet. There is only ONE CORRECT answer.**
4. **This exam will count for 60% of your final mark.**
5. **There is a blank page at the end of the exam for rough work.**

1. The pK_a values for histidine are: 1.82, 6.0 (R-group), and 9.17. At pH 8.5, the two predominant forms of histidine in solution have net charges of:

A) +2 and +1   B) 0 and -1   C) +1 and 0   D) +1 and -1   E) -1 and -2

2. In a solution of histidine at pH 8.5 the percentage of histidine molecules carrying zero net charge is:

A) 0%   B) 26%   C) 63%   D) 82%   E) 94%

3. The volume of 0.05M HCl needed to reduce the pH of 20 mL of a 0.2M solution of histidine at pH=pI to a value of 1.82 is:

A) 30 mL   B) 60 mL   C) 90 mL   D) 120 mL   E) 160 mL

4. For any amino acid with a non-polar R-group, at any pH between the two pK_a values for the amino acid, the predominant form in solution will:

A) be neutral without any charge   B) have no net charge   C) have a net positive charge
D) have a net negative charge   E) have equal numbers of positive and negative charges

5. What reaction is occurring when a solution of isoleucine 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) $-NH_3^+ + OH- \rightarrow NH_2 + H_2O$

E) $-NH_2 + OH^- \rightarrow -NH^+ + H_2O$

For questions 6 & 7 please refer to the molecule shown here:
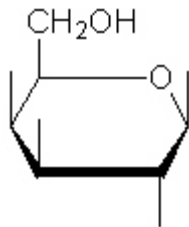
6.   Give the correct name for the molecule.

   A) β-D-galactopyranose   B) α-D-deoxyribose C) α-D-galactofuranose
   D) β-D-fructofuranose   E) α-D-glucopyranose

7.   Which of the following disaccharides contains this molecule as a component?

   1. Maltose   2. Cellobiose   3. Lactose   4. Sucrose   5. Isomaltose

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

8..   Which of the following pairs of monosaccharides are epimers?

   A) D-ribose & D-deoxyribose   B) D-glucose & D-ribose   C) D-glucose & D-galactose
   D) D-glucose and L-glucose   E) D-erythrose & D-ribose

9.   Which of the following is not a reducing sugar?

   A) 2-deoxyribose   B) sucrose   C) isomaltose
   D) glyceraldehyde   E) cellobiose

USE THE FOLLOWING DATA TO ANSWER QUESTIONS 10 & 11
Freshly prepared solutions of α and β-D-galactose, with identical concentrations, show optical rotations of $+150.7°$ and $X°$ respectively. After standing for a prolonged period, both solutions exhibit the same optical rotation, $+80.2°$.

10.   α and β-D-galactose are   ?

   A) disaccharides   B) anomers   C) mirror images   D) ketoses   E) hemiketals

11.   The percentage of α-D-galactose in the solution with optical rotation $+80.2°$ was found to be 28%. What is the optical rotation of β-D-galactose?

   A) 28.5°   B) 52.8°   C) 88.6°   D) 112.7°   E) 133.4°

12.   Which statement about α-D-galactose is incorrect ?

A) In aqueous solution, it is in equilibrium with β-D-galactose as well as its straight chain form.
B) Carbon 1 is the anomeric carbon and it can be oxidized by Cu^{2+}
C) It is an aldohexose
D) In the process of mutarotation it is converted to α-L-galactose
E) It is an epimer of α-D-glucose

13.   Following treatment of glycogen isolated from human muscle under conditions causing partial hydrolysis of polysaccharides, which of the following disaccharides could be isolated from the reaction mix?

1. Maltose 2. Lactose   3. Cellobiose 4. Sucrose   5. Isomaltose

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

USE THE FOLLOWING DATA TO ANSWER QUESTIONS 14 and 15.
An enzyme obeying Michaelis-Menten kinetics has a K_m for its substrate of 1 x 10^{-6} M and, at a substrate concentration of 0.01 M, catalyzes the formation of product at v = 20 micromole/min.

14.   The reaction velocity (v) at a substrate concentration of 1 x 10^{-6} M is _?_ micromole/min.

A) 1.8   B) 2.5   C) 5.0   D) 10   E) 15

15.   The reaction velocity (v) at a substrate concentration of 1 x 10^{-7} M is _?_ micromole/min.

A) 1.8   B) 2.5   C) 5.0   D) 10   E) 15

16.   Which of the following statements is *false*?

1) A reaction may not occur at a detectable rate even though it has a large, negative $\Delta G^{o'}$
2) For an enzyme having Michaelis-Menten kinetics, K_m is the [S] at which $v = V_{max}$
3) The larger the K_m for a substrate, the more tightly it binds to the enzyme.
4) Enzymes catalyze reactions by shifting the equilibrium in favour of the product.
5) Lowering the temperature of a reaction will lower the reaction rate.

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

Use the following to answer questions 17 and 18.
The reaction catalyzed by an enzyme following Michaelis-Menten kinetics may be represented as follows:

$$E + S \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} ES \xrightarrow{k_2} E + P$$
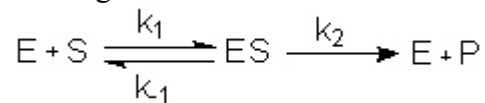
17.   Which of the following statements is true?

1) The formation of ES from E and S is a rapid equilibrium
2) The formation of ES is the rate-limiting step in the overall reaction
3) k_2 is very much smaller than k_1 and k_{-1}
4) At V_{max} all enzyme is combined with substrate
5) The value of K_m depends on the values of k_1 and k_{-1}

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

18.   Which of the following statements is false?

1) The overall rate (v) of the reaction depends on the value of k_2
2) In the simple mechanism shown above, K_m is equal to the dissociation constant for ES
3) A substrate with a high K_m binds more tightly to the enzyme than one with a lower K_m
4) The overall rate (v) of the reaction depends on the rate of the ES → E + P step
5) A competitive inhibitor lowers the V_{max} of the reaction

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

19.   The common (trivial) name of the fatty acid whose structure is
       $CH_3(CH_2)_7CH=CH(CH_2)_7COOH$ is ?

A) palmitoleic acid   B) oleic acid   C) arachidic acid   D) linoleic acid   E) stearic acid

20.   The saturated fatty acid of the same chain length as the one in question 19 is ?

A) palmitoleic acid   B) oleic acid   C) arachidic acid   D) linoleic acid   E) stearic acid

21.   If ALL the ester bonds in a molecule of phosphatidylethanolamine were hydrolysed, the
       products would be:

1) one glycerol, one ethanol and one fatty acid molecule
2) one glycerol, one ethanolamine, one phosphoric acid and two fatty acid molecules
3) one ethanolamine, one cholesterol and one fatty acid molecule
4) one ethanolamine, one phosphoric acid and one fatty acid molecule
5) one sphingosine, one glycerol and two fatty acid molecules

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

22. Glycerophosphatides form micelles and bilayers principally because:

A) their hydrophobic tails attract one another
B) their polar head groups attract one another
C) their phosphate groups can form cross-links
4. entropy is maximized when their hydrophobic tails are buried in the interior of the micelle or bilayer
5. entropy is minimized when their polar heads interact with water at the surface of the micelle or bilayer.

23. Which of the following statements about peripheral (extrinsic) membrane proteins is TRUE?

1) They penetrate deeply into the lipid bilayer
2) They can be released from membranes by washing with salt solutions
3) They are usually denatured when released from membranes
4) They are generally noncovalently bound to membrane lipids
5) They behave like typical soluble proteins when released from the bilayer

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

24. Which of these statements is generally TRUE of integral membrane proteins?

1) They are usually completely buried in the bilayer.
2) They have one or more sequences of hydrophobic amino acids.
3) They can be released from the membrane by washing with salt solutions
4) They can be released from the membrane and solubilized by detergent treatment
5) They behave like typical soluble proteins when released from the bilayer

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

25. Facilitated diffusion through a cellular membrane ?

A) is usually irreversible   B) is driven by ATP hydrolysis   C) is endergonic
D) is driven by a difference of solute concentration
E) works only with uncharged solutes

26. Guanosine is ?

A) a purine ribonucleoside   B) a purine ribonucleotide   C) a deoxyribonucleotide
D) a mononucleotide   E) GMP

27. In double-stranded regions of RNA adenine typically base-pairs with ?

A) guanine   B) cytosine   C) thymine   D) adenine   E) uracil

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28.   Which of the following statements about double-stranded DNA are TRUE?

1) the proportion of bases that are purines must be the same in both strands
2) the planes of the bases are 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 greater the proportion of adenine the higher the melting temperature

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

29.   Which of the following best describes the relationship between $\Delta G^{o'}$ and reaction rate?

A) $\Delta G^{o'}$ is linearly proportional to rate   B) $\Delta G^{o'}$ is exponentially proportional to rate
C) If $\Delta G^{o'}$ is zero, the rate is zero   D) $\Delta G^{o'}$ is inversely proportional to rate
E) $\Delta G^{o'}$ provides no information about rate

30.   Which of the following statements about the relationship between $\Delta G^{o'}$ and equilibrium constant (K_{eq}) are TRUE?

1) $\Delta G^{o'}$ is linearly proportional to K_{eq} 2) $\Delta G^{o'}$ is exponentially proportional to K_{eq}
3) If $\Delta G^{o'}$ is zero, $K_{eq} = 1.0$ 4) $\Delta G^{o'}$ is inversely proportional to K_{eq}
5) $\Delta G^{o'}$ provides no information about K_{eq}

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

31.   The $\Delta G^{o'}$ values for the hydrolysis of fructose-1,6-bisphosphate to fructose-6-phosphate and for hydrolysis of ATP to ADP and P_i are -16 kJ/mole and -30.5 kJ/mole respectively. The $\Delta G^{o'}$ for the reaction catalyzed by the enzyme phosphofructokinase is:

A) -46.5 kJ/mole   B) -14.5 kJ/mole   C) +46.5 kJ/moleq   D) +14.5 kJ/mole
E) impossible to calculate from the data given

32.   Given that the standard free energy change, $\Delta G^{o'}$, for the overall reaction catalysed by pyruvate kinase is -31.4 kJ/mol and the $\Delta G^{o'}$ for the hydrolysis of ATP is -30.5 kJ/mol, what is the equilibrium constant for the hydrolysis of phosphoenol pyruvate? R = 8.3 J/mol/^{o}K and T = 298K

A) 1.3×10^{-11} B) 0.6   C) 1.4   D) 3.3×10^{5} E) 7.4×10^{10}

33.   When a mixture of glucose-6-phosphate and fructose-6-phosphate is incubated with the enzyme phosphohexose isomerase (which catalyzes the interconversion of these two compounds) until equilibrium is reached, the final mixture contains half as much fructose-6-phosphate as glucose-6-phosphate. Which one of the following statements is most nearly correct, when applied to the reaction below? R = 8.3 J/mol.K and T = 298K

Glucose-6-phosphate ---->fructose-6-phosphate

A) $\Delta G^{o'}$ is incalculably large and negative   B) $\Delta G^{o'}$ is zero
C) $\Delta G^{o'}$ is -1.7 kJ/mol   D) $\Delta G^{o'}$ is + 1.7 kJ/mol
E) $\Delta G^{o'}$ is incalculably large and positive.

34.   For the reaction $R \rightleftharpoons P$, $\Delta G^{\circ'}$ is -5.7 kJ/mol. The reaction is started by mixing 5 mmol of R
       and 6 mmol of P. When equilibrium is reached the mixture will contain:

       A) No R & 11 mmol of P   B) 1 mmol of R and 10 mmol of P
       C) 11 mmol of R & no P   D) 10 mmol of R and 1 mmol of P
       E) 8 mmol of R & 3 mmol of P

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

                       oxaloacetate/malate $E^{\circ'}$ = -0.166 V
                       NAD^+/NADH + H^+ $E^{'\circ}$ = -0.320V
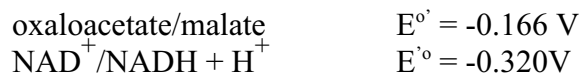
       If you mixed oxaloacetate, malate, NAD^+ and NADH + H^+ together, all at 1 M concentrations
       and in the presence of the TCA cycle enzyme malate dehydrogenase, which of the following
       would happen ?

       A) malate would be oxidized, NAD^+ would be reduced.
       B) malate would be oxidized, NAD+ would be unchanged
       C) malate and oxaloacetate would be oxidized; NADH + H^+ would be reduced.
       D) oxaloacetate would be reduced, NADH + H^+ would be oxidized.
       E) No reaction would occur, because all reactants and products are already in the standard state.

36.   Given the information provided in question 35 and that the Faraday Constant = 96.5 kJ/V•mol,
       the $\Delta G^{\circ'}$ for the reaction catalyzed by malate dehydrogenase, in the direction it operates in the
       TCA cycle, is close to:

       A) +30 kJ/mole   B) +15 kJ/mole   C) -30 kJ/mole   D) +15 kJ/mole   E) -94 kJ/mole

37.   The conversion of one mole of glyceraldehyde-3-phosphate to pyruvate by the glycolytic
       pathway results in a net formation of which of the following?

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

38.   The final electron acceptor in the fermentation of glucose to ethanol is ?

       A) Pyruvate   B) Acetate   C) Acetaldehyde   D) Ethanol   E) NAD^+

39.   The conversion of glyceraldehyde-3-phosphate to 3-phosphoglycerate during glycolysis does
       NOT involve:

       A) formation of an acid anhydride bond   B) substrate-level phosphorylation
       C) oxidation and reduction of substrates   D) formation of an ester bond
       E) phosphoglycerate kinase

40.   Which of the following are NOT required for the reaction where α ketoglutarate is converted
        to succinyl-S-CoA?

        1) NAD$^+$ 2) Lipoic acid   3) ATP   4) NADPH + H$^+$ 5) FAD

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

41.   Complete oxidation of one mole of acetyl-CoA via the citric acid (TCA) cycle results in ?

        1. Net production of one mole of citrate.
        2. Net consumption of one mole of oxaloacetate.
        3. Net production of 2 moles of CO_2
        4. Net production of 7 moles of ATP.
        5. Net production of one mole of succinate.

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

42.   Which of the following reactions result in formation of ATP (or GTP) by substrate-level
        phosphorylation?

        1) conversion of dihydroxyacetone phosphate to glyceraldehyde-3-phosphate
        2) conversion of phosphoenolpyruvate to pyruvate
        3) conversion of succinate to fumarate
        4) conversion of succinyl-S-CoA to succinate
        5) conversion of malate to oxaloacetate

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

43.   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) 1   B) 1 & 3   C) 4   D) 2 & 5   E) 5

44.   The conversion of 1 mol of pyruvate to 3 mol of CO_2 via pyruvate dehydrogenase and the citric
        acid (TCA) cycle also yields ____ mol of NADH + H$^+$, ____ mol of FADH$_2$, and ____ mol
        of ATP (or GTP).

        A) 3; 2; 0   B) 4; 2; 1   C) 4; 1; 1   D) 3; 1; 1   E) 2; 2; 2

THE UNIVERSITY OF MANITOBA

DATE: Dec. 9, 2002

 Final EXAMINATION

PAPER NO.: 126/127

PAGE NO.: 9 of 12

DEPARTMENT & COURSE NO.: 2.277/60.277

Time: 2 HOURS

EXAMINATION: Elem. of Biochemistry I

EXAMINER: Drs. Burton/Scoot

45.   Which of the following statements about electron transport and oxidative phosphorylation in eukaryotic cells is FALSE?

A)   electron transfer in mitochondria is accompanied by vectorial proton transport across the inner membrane

B)   the energy released when protons flow down their concentration gradient from the mitochondrial matrix to the intermembrane space is used by the membrane ATP synthase to generate ATP

C)   coupling of ATP synthesis to electron transport requires a closed membrane system with an inside and outside

D)   ubiquinone transfers electrons from complex II to complex III of the electron transport chain

E)   ATP synthesis can be uncoupled from electron transport by compounds that carry protons across the inner membrane

LAB SECTION (Questions 46 to 60)

For questions 46, 47 and 48 please refer to the following curve resulting from the complete titration of 20 mL of 0.05 M histidine initially at a pH of 9.2 with 0.10 M HCl. The pK$_a$ values for histidine are 1.8, 6.0 and 9.2.

46.   What volume of HCl was added to completely titrate the 20 mL of Histidine i.e. to point X on the graph?

A) 5 mL   B) 10 mL   C) 25 mL   D) 50 mL   E) 100 mL

47.   What volume of HCL was added to reach the pI of the amino acid?

A) 5 mL   B) 10 mL   C) 15 mL D) 20 mL   E) 25 mL

48.   What is the pH of the solution after the addition of the first 12.5 mL of 0.10 M HCl?

        A) 7.6   B) 6.0   C) 5.5   D) 3.9   E) 1.8

49.   Which of the following pK_a values apply to the dipeptide aspartylhistidine? The pK_a values
        for aspartate are 2.1, 3.9 and 9.8 and those for histidine are 1.8, 6.0 and 9.2?

        A)   1.8, 2.1, 9.2 and 9.8   B)   1.8, 3.9, 6.0 and 9.8
        C)   2.1, 3.9, 6.0 and 9.2   D)   1.8, 2.1, 3.9 and 6.0   E)   3.9, 6.0, 9.2 and 9.8

50.   A 1 in 5 dilution of an enzyme solution was used to measure its protein concentration. To 0.5
        mL of this solution, 0.5 mL of water and 4.0 mL of biuret reagent were added. This gave an
        absorbance of 0.200 at 540 nm. To 0.8 mL volume of a standard protein solution (5 mg
        protein/mL) 0.2 mL of water and 4.0 mL of biuret reagent were added. This gave an
        absorbance of 0.160 at 540 nm in the same size cuvette. What is the protein concentration of
        the undiluted enzyme solution?

        A) 1 mg/mL   B) 3.2 mg/mL   C) 5 mg/mL   D) 10 mg/mL   E) 50 mg/mL

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

        1. A calibration curve is used to find the concentration of an unknown.
        2. A calibration curve is constructed using various concentrations of the unknown or a similar
           substance.
        3. The substance is subject to the same assay as the unknown and results measured, for
           example absorbance of the product.
        4. If the absorbance of an unknown falls outside the range of a linear calibration curve, the line
           can be extended to enable one to find the concentration of the unknown.
        5. An example of a calibration curve is the effect of pH on enzyme activity.

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

52.   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.   Acid conditions
        4.   The addition of phenol red to form a complex with the product to give a coloured
                  compound.

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

        For questions 53 and 54 please refer to the following:

        An investigation into the kinetics of alkaline phosphatase in the presence and absence of an
inhibitor yielded data from which the Lineweaver-Burk plots shown below were derived.

The total assay volume was 5 mL and the assay time 10 min. A 1.0 mL volume of enzyme solution was added to each assay tube. The concentration of the enzyme solution was 5×10^{-7}M.

53.   What type of inhibition was seen in this investigation?

A) Competitive   B) Allosteric   C) Non competitive
D) Uncompetitive   E) It is infact not an inhibited reaction

54.   What are the values for K_m and V_{max} for the inhibited enzyme under these conditions?

A) K_m = 30 M V_{max} = 40 mmoles/min
B) K_m = 20 M V_{max} = 40 mmoles/min
C) K_m = 0.050 M V_{max} = 0.050 mmoles/min
D) K_m = 0.033 M V_{max} = 0.050 mmoles/min
E) K_m = 0.033 M V_{max} = 0.025 mmoles/min

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 colour development upon termination of the alkaline phosphatase assay?

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

57.   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) Cannot be determined

58.   Which of the following statements describe 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, 3 and 4
       D) 2 and 3   E) None of the above

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

       1) It is used to detect ketoses
       2) It requires heat and HCl
       3) A furfural intermediate is formed
       4) It requires orcinol and ferric ions
       5) Red condensation products are formed

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

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

       1) It disrupts the nuclei
       2) It frees the DNA from nucleoproteins
       3) It precipitates the protein
       4) It precipitates the DNA as sticky fibres
       5) It precipitates RNA as a flocculent precipitate

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

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