THE UNIVERSITY OF MANITOBA

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DEPARTMENT & COURSE NO: Chemistry 2.277 / 60.277   TIME: 1 HOUR

EXAMINATION: Elements of Biochemistry I   EXAMINER: J. O'Neil

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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. If the free energy change ΔG for a reaction is -46.11 kJ/mol, the reaction is:
   - A) at equilibrium.
   - B) endergonic.
   - C) endothermic.
   - D) exergonic.
   - E) exothermic.

2. Entropy change, ΔS, is
   - A) the sum of heat absorbed and work.
   - B) not a thermodynamic state function.
   - C) a measure of disorder in a system.
   - D) determined by pressure change at a constant temperature.
   - E) equal to the heat transferred at constant pressure and volume.

3. Ice melts spontaneously at room temperature
   - A) despite the fact that its free energy change is positive.
   - B) because ice is less ordered than liquid water.
   - C) because heat naturally flows from a cold body.
   - D) because the entropy of water is greater than the entropy of ice.
   - E) in order to maximize the enthalpy content of the ice.

4. In micelles:
   - A) polar ends form hydrophobic interactions with water.
   - B) nonpolar ends form hydrophilic interactions with water
   - C) hydrocarbon tails form hydrophobic interactions with water.
   - D) polar ends are hydrophobic and nonpolar ends are hydrophilic.
   - E) hydrocarbon tails are excluded from the water into hydrophobic domains.

5. 50 mL of 0.072 M HCl solution is added to 50 mL of pure water. What is the pH of the resulting solution?
   - A) 3.6
   - B) 1.84
   - C) 1.44
   - D) 7.2
   - E) $10^{-0.072}$

6. Grapefruit juice at pH 3.2 contains about _____ times as much H^+ as orange juice at pH 4.3.
   - A) 0.9
   - B) $10^{-7.5}$
   - C) 10^{-2}
   - D) 12
   - E) 101

7.   pH = pK_a when:
        A) $[A^-]/[HA] = 0$
        B) $\log([A^-]/[HA]) = 1$
        C) $[A^-] \gg [HA]$
        D) $[A^-] = [HA]$
        E) $\log([HA]/[A^-]) = 1$

8.   Titration of valine by a strong base, for example NaOH, reveals two pK's. The titration reaction occurring at pK_2 (pK_2 = 9.62) is:
        A) —COOH + OH^- →   —COO^- + H_2O.
        B) —COOH + —NH_2 →   —COO^- + —NH_2^+.
        C) —COO^- + —NH_2^+ →   —COOH + —NH_2.
        D) —NH_3^+ + OH^- →   —NH_2 + H_2O.
        E) —NH_2 + OH^- →   —NH^- + H_2O.

9.   The enzyme fumarase has a pH optimum of about 7.6. What would be the buffer of choice to study this enzyme?
        A) lactic acid ($K_a = 1.38 \times 10^{-4}$, $pK_a = 3.86$)
        B) bicarbonate ($K_a = 6.3 \times 10^{-11}$, $pK_a = 10.24$)
        C) acetic acid ($K_a = 1.74 \times 10^{-5}$, $pK_a = 4.76$)
        D) succinate ($K_a = 2.34 \times 10^{-6}$, $pK_a = 5.63$)
        E) tris-hydroxymethyl aminomethane ($K_a = 8.32 \times 10^{-9}$, $pK_a = 8.07$)

10.   To 25 mL of a 0.1 M solution of isoleucine at pH = pK_a for its amino group was added X mL of 0.05M HCl. The new pH was found to be equal to the pK_a for its carboxyl group. What is the value of X?
        A) 12.5 mL
        B) 25 mL
        C) 50 mL
        D) 100 mL
        E) The problem cannot be solved without knowing the pK_a value.

11.   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

12.   All of the statements about the classification of these amino acids are correct EXCEPT:
        A) Aspartic acid and asparagine are acidic amino acids.
        B) Alanine and valine are neutral, nonpolar amino acids.
        C) Serine and glutamine are polar, uncharged amino acids.
        D) Lysine and arginine are basic amino acids.
        E) Tyrosine and phenylalanine are aromatic amino acids.

13.   Which of the following amino acids has more than one chiral carbon?
        A) serine
        B) lysine
        C) threonine
        D) cysteine
        E) aspartic acid

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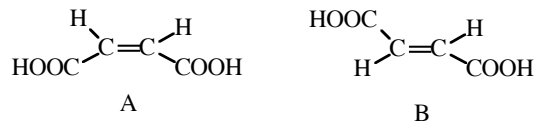
A) Moronic acid and Fumaric acid
B) Non-superimposible mirror images
C) Dextrorotatory and levorotatory
D) Epimers at C2
E) Sterioisomers but not enantiomers

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

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

16. 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—N—C—C—N—C_α
C) C—N—C_α—C_α—C—N
D) C_α—C—N—C_α—C—N
E) C_α—C_α—C—N—C_α—C_α—C

17. In an α helix, the R groups on the amino acid residues:
A) alternate between the outside and the inside of the helix.
B) are found on the outside of the helix spiral.
C) cause only right-handed helices to form.
D) generate the hydrogen bonds that form the helix.
E) stack within the interior of the helix.

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

19. In a mixture of the five proteins listed below, which should elute second in size-exclusion (gel- filtration) chromatography?
A) cytochrome *c* M_r = 13,000
B) immunoglobulin G M_r = 145,000
C) ribonuclease A M_r = 13,700
D) RNA polymerase M_r = 450,000
E) serum albumin M_r = 68,500

20. Which of the following is *least* likely to result in protein denaturation?
   A) Altering net charge by changing pH
   B) Changing the salt concentration
   C) Disruption of weak interactions by boiling
   D) Exposure to detergents
   E) Mixing with organic solvents such as acetone

21. The unique composition of collagen is accommodated in a structure called a:
   A) β-pleated sheet.
   B) triple helix.
   C) helix-turn-helix motif.
   D) coiled coils.
   E) all are true.

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

V_0 (µmol/min)	Substrate added (M)
0.33	0.001
1.52	0.005
2.5	0.010
8.0	0.050
12.7	0.200
15.3	0.500

The K_m for this enzyme is approximately:
   A) 1 mM.
   B) 0.2 M.
   C) 10 mM.
   D) 50 mM.
   E) 15.3 mM.

23. Enzymes are biological catalysts that enhance the rate of a reaction by:
   A) decreasing the activation energy.
   B) decreasing the amount of free energy released.
   C) increasing the activation energy.
   D) increasing the amount of free energy released.
   E) increasing the energy of the transition state.

24. Which statement correctly describes the flow of electrons during the hydrolysis of a peptide bond by chymotrypsin?
   A. Electrons flow from the catalytic triad into the amide nitrogen of the substrate.
   B. Electrons flow out of the enzyme and into the substrate, and then return to the enzyme.
   C. Electrons do not flow during enzyme catalyzed reactions.
   D. Electrons flow out of the substrate and into the enzyme, and then back again.
   E. Electrons flow from the oxyanion hole into the substrate, and then return to the hole.

25. An enzyme-catalyzed reaction was carried out with the substrate concentration initially a thousand times greater than the K_m for that substrate. After 9 minutes, 1% of the substrate had been converted to product, and the amount of product formed in the reaction mixture was 12 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 (12 µmol) of product to be formed?

   A) 1.5 min
   B) 13.5 min
   C) 27 min
   D) 3 min
   E) 6 min