THE UNIVERSITY OF MANITOBA

December 11, 2017 | 1:30 pm – 4:30 pm | Page 1 of 12
CHEM / MBIO 2770 | Elements of Biochemistry I | Final Examination
Frank Kennedy Brown Gym | | Seats 1-134
Examiner: J. O'Neil

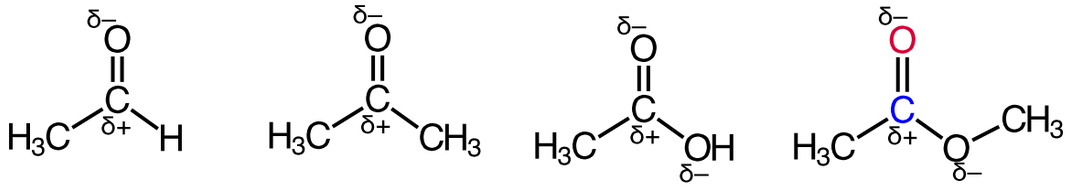
Instructions

- *Please mark the Answer Sheet using PENCIL ONLY.*
- *Enter your NAME and STUDENT NUMBER on the Answer Sheet.*
- *The exam consists of 50 multiple-choice questions. Enter your answers on the Answer Sheet.*
- *There is only 1 correct answer for each question.*
- *Please read each question CAREFULLY.*
- *Please protect your Answer Sheet from the view of other students.*
- *Scratch Paper is available at the back of the examination.*
- *All test material must be returned at the end of the exam.*

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

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

3. Identify the correct names of the functional groups from left to right.



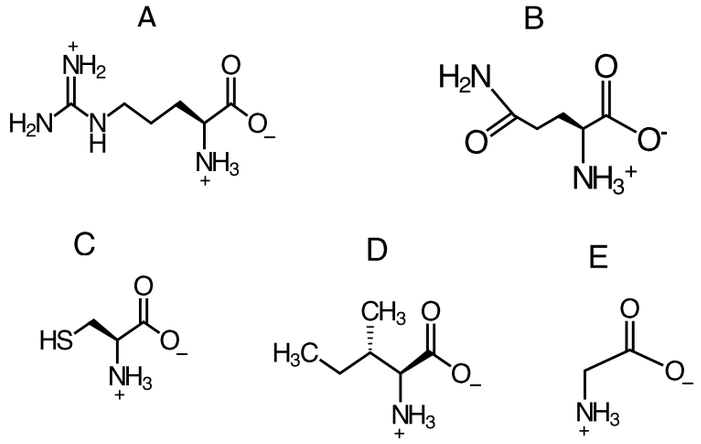
   A) Ketone, aldehyde, thiolate, carboxylic acid.
   B) Carboxylic acid, ester, ketone, thiolate.
   C) Aldehyde, ketone, carboxylic acid, ester.
   D) Thiolate, vinegar, ketone, aldehyde.
   E) Alcohol, aldehyde, ester, thiolate.

4. Identify the **incorrect** statement.
   A) The Gibb's free energy is the amount of energy available to do work.
   B) Entropy is the degree of disorder in a system.
   C) Enthalpy is the heat content of a system.
   D) An exergonic reaction absorbs free energy.
   E) An endothermic reaction absorbs heat.

5. The lysosome at pH 4.7 contains about ___ times as much H^+ as the matrix of the mitochondrion at pH 8.0.
   A) 5.0×10^{-4}
   B) $10^{-3.3}$
   C) 3.3
   D) 37.6
   E) 1995

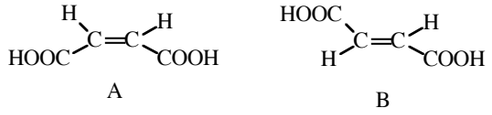
6. 200 mL of 0.1 M HCl were added to 200 mL of 0.1 M glutamate solution having pH = pKa of the amino group. What is the new pH? pKa values for glutamate are 2.19, 4.20 (R-group) and 9.67.
   A) 2.19
   B) 3.19
   C) 4.20
   D) 6.93
   E) 9.67

7. Identify the amino acid cysteine.



8. The **net** charge on the dipeptide arginyl-lysine at pH 7 is _____
   A) +3.
   B) +2.
   C) +1.
   D) 0.
   E) -1.

9. Molecules A and B are:



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

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

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

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

13. For the following irreversible reaction, the relationship between the rate constant and the activation energy of the reaction can be found by using which of the following equations?

$$A \rightarrow P$$

    A) $K_m = \frac{k_{-1} + k_2}{k_1}$
    B) $\Delta G^\circ = -RT \bullet \ln_e(K_{eq})$
    C) $V = \frac{d[P]}{dt} = -\frac{d[S]}{dt}$
    D) $V_0 = \frac{V_{max}[S]}{[S] + K_m}$
    E) $k = \frac{k_B \bullet T}{h} \bullet e^{(-\Delta G^{\ddagger}/R \bullet T)}$

14. 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]

15. The role of the enzyme in an enzyme-catalyzed reaction is to _____
    A) ensure the product is more stable than the substrate.
    B) make the overall free energy change for the reaction more favourable.
    C) increase the rate of conversion of substrate to product.
    D) increase the equilibrium constant for the reaction.
    E) ensure all the product is converted to substrate.

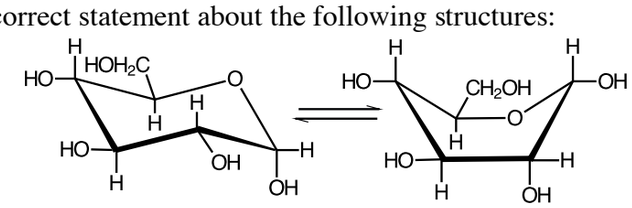
16. What percent of an enzyme is saturated when the substrate concentration is 5 μM and the K_M is 10 μm?
    A) 15%
    B) 25%
    C) 33%
    D) 50%
    E) 150%

17. An enzyme displays a Vo of 6 μmoles/sec when the enzyme concentration is 5 μM. What would the Vo be if the enzyme concentration was increased to 35 μM.
    A) 6 μmoles/sec.
    B) 11 μmoles/sec.
    C) 30 μmoles/sec.
    D) 42 μmoles/sec.
    E) 210 μmoles/sec.

18. 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) the ability to form micellar structures.

19. Identify the correct statement about the following structures:



A) Chair and boat conformations of α-D-glucose are in equilibrium.
B) α-D-glucose is shown in 2 puckered configurations.
C) A ketone and an alcohol are in equilibrium with a ketal.
D) An aldehyde and an acid are in equilibrium with a hemiacetal.
E) β-D-glucose is shown in 2 puckered configurations.

20. Primates and fruit bats have lost the ability to make _____ so it is an essential nutrient for them.

A) vitamin A.
B) vitamin B.
C) vitamin D.
D) vitamin E.
E) vitamin C.

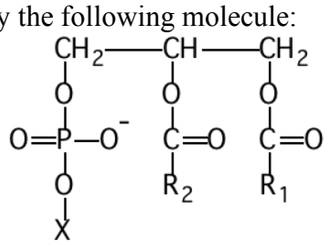
21. Which of the following definitions **correctly** identifies the common name of the compound?

A) Lactose = Gal (β1→4) Fru
B) Maltose = Glc (β1→4) Glc
C) Iso-maltose = Glc (α1→6) Glc
D) Sucrose = Fru (α1→β2) Fru
E) Cellulose = (Glc (α1→4) Glc)$_n$

22. The cell walls of bacteria contain a cross-linked network of short peptides and sugars called _____

A) cellulose.
B) peptidoglycan.
C) starch.
D) proteoglycan.
E) levan.

23. Identify the following molecule:



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

24. Which vitamin is important in calcium metabolism?

A) B_1 B) B_{12} C) C D) D_3 E) K

25. Which statement about *trans*-fats is **incorrect**:

A) They are found in small amounts in dairy products and meat.
B) Like saturated fatty acids they are a risk factor for coronary artery disease.
C) They raise levels of "*good*" HDL cholesterol.
D) They are produced as a result of partial hydrogenation of vegetable oils that raises the melting points of fats.
E) When mixed with flour in baking products partially hydrogenated semi-solid fats produce a desirable texture.

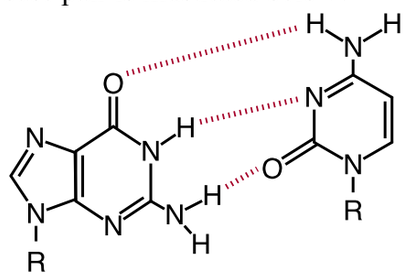
26. Identify the **CORRECT** statement:

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.

27. Identify the **INCORRECT** statement about the Fluid-Mosaic model of membranes.

A) Lipid bilayers are 5 - 8 nm thick.
B) Membranes undergo a phase transition in which the lipid hydrocarbon chains become rigid at high temperatures.
C) Lipids diffuse laterally in the membrane whereas transbilayer movement is rare.
D) Membrane fluidity depends on the amount of cholesterol in the membrane.
E) Some proteins are free to move in the membrane whereas others are anchored to the cytoskeleton.

28. Which base pair is illustrated below?



A) G:C
B) A:C
C) A:T
D) G:I
E) None of the above.

29. Which of the following is a palindromic sequence?
    A) 5'TGGTGC3'
       3'ACCACG5'
    B) 5'CCTTCC3'
       3'GGAAGG5'
    C) 5'TAATCC3'
       3'ATTAGG5'
    D) 5'GGATCC3'
       3'CCTAGG5'
    E) 5'GTTTCG3'
       3'CAAAGC5'

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

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

31. The fact that DNA contains thymine and RNA contains uracil is important because:
    A) depurination is a frequent occurrence in all cells.
    B) deamination of cytosine is a frequent occurrence in all cells.
    C) demethylation of thymine is a frequent occurrence in all cells.
    D) oxidation of adenine is a frequent occurrence in all cells.
    E) knowing this helps biochemistry students pass their exams.

32. Double-stranded DNA was isolated from two different species. In species 1, cytosine was found to make up 35% of the bases and, in species 2, adenine made up 20% of the bases. Which of the following statements is **true** about the melting temperatures (T_m) of the two DNA samples?
    A) The T_m values will be identical.
    B) DNA from species 1 will have the higher T_m.
    C) DNA from species 2 will have the higher T_m.
    D) The question cannot be answered without knowing the percentages of all bases in each DNA.
    E) Relative T_m values cannot be predicted but must be measured experimentally.

33. To live, organisms must obtain _____ from their environment and use it to do the _____ of building and organizing cell components such as proteins, enzymes, nucleic acids, membranes, organelles *etc*.
    A) heat, metabolism
    B) entropy, calories
    C) energy, work
    D) sunlight, activity
    E) entropy; free energy

34. 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) Glycolysis.
    C) Oxidative phosphorylation.
    D) Citric acid cycle.
    E) Fermentation.

35. Aconitase catalyzes the stereoisomerization of Citrate $\rightleftharpoons$ Isocitrate. The $\Delta G'^{\circ}$ for this reaction is +6.7 kJ/mole at 298 K. (R = 8.3 J/mol*degree). The equilibrium constant for this reaction is:
    A) 0
    B) 0.997
    C) 0.67
    D) 0.067
    E) 0.00195

36. Identify the **correct** statement about the following reactions:
    $FADH_2 \rightarrow FAD + 2H^+ + 2e^-$
    $Fumarate + 2H^+ + 2e^- \rightarrow Succinate$
    A) Fumarate is reduced to succinate and $FADH_2$ is oxidized to FAD.
    B) The electrons in the first reaction are reduced and in the second reaction are oxidized.
    C) Fumarate is reduced by 2 protons to succinate.
    D) The reactions cannot form a redox couple.
    E) $FADH_2$ is reduced to FAD and fumarate is oxidized to succinate.

37. Which of the following co-enzymes contains a nucleotide base also found in DNA and RNA?
    1. Thiamine Pyrophosphate
    2. Coenzyme A
    3. Lipoic acid
    4. FAD
    5. NAD

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

38. What do CTP, Acetyl-Coenzyme A, 1,3-bisphosphoglycerate, and phosphoenolpyruvate **all** have in common?
    A) They are resonance stabilized.
    B) They store enough free energy to power the phosphorylation of ADP.
    C) They are high-energy phosphate carriers.
    D) They contain a nitrogenous base.
    E) They are strong bases.

39. Identify the glycolytic enzymes that result in the formation of ATP from ADP and P_i.
    A) enolase; triosephosphate isomerase
    B) glyceraldehyde-3-phosphate dehydrogenase; aconitase
    C) phosphofructokinase; hexokinase
    D) triose phosphate isomerase; succinyl CoA synthetase
    E) phosphoglycerate kinase; pyruvate kinase

40. Identify the **correct** statement:
    A) Glycolysis is an aerobic pathway.
    B) During glycolysis two ATP molecules are consumed in the preparatory phase and 2 ATP molecules are produced in the payoff phase.
    C) Glycolysis is a metabolic pathway that can function to oxidize fructose.
    D) An example of a "*substrate-level phosphorylation*" is the phosphorylation of glucose by hexokinase using ATP.
    E) Glycolysis reduces glucose to pyruvate.

41. Identify the **correct** statement:
    A) The electron transport chain is the only metabolic pathway by which ATP can be formed from ADP and P_i.
    B) Oxidative phosphorylation is regulated by the supply of ADP and P_i.
    C) None of the TCA cycle enzymes play a role in the electron transport chain of reactions.
    D) The pyruvate dehydrogenase reaction takes place in the cytoplasm.
    E) Oxygen is not a direct substrate of the TCA cycle so lack of oxygen will have no effect on the cycle.

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

    $Fe^{3+} + e^- \rightarrow Fe^{2+}$ + 0.77 V

    $Cu^{2+} + e^- \rightarrow Cu^{+}$ + 0.37 V

    Calculate the equilibrium constant for the coupled redox reaction given that R = 8.3 J/mol*K, T = 298 K, and $\mathcal{F}$ (Faraday constant) = 96.4 kJ/volt*mol.
    A) 1.04
    B) 1.01.
    C) $5.89X10^6$
    D) $3.89X10^{15}$
    E) $3.48X10^{13}$

43. Which of the following statements about the enzyme succinate dehydrogenase (SDH) are true?
    1) Like the other TCA cycle enzymes, SDH is found in the mitochondrial matrix
    2) Unlike the other TCA cycle enzymes, SDH is located in the mitochondrial inner membrane
    3) Unlike the three other dehydrogenases functioning in the TCA cycle, SDH requires FAD as its coenzyme
    4) Like the three other dehydrogenases functioning in the TCA cycle, SDH requires NAD^+ as its coenzyme
    5) SDH is a component of Complex II of the electron transport chain.

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

44. When the painkiller Demerol is added to respiring mitochondria the concentrations of NADH and UQ increase whereas the concentrations of NAD^+ and UQH_2 decrease. Which electron transport chain enzyme is inhibited by Demerol?
    A) Complex I.
    B) Complex II.
    C) Complex III.
    D) Complex IV.
    E) ATP synthase.

45. Which of the following compounds is an indicator of a cell's low energy status?
    A) ATP.
    B) AMP.
    C) Succinyl-CoA.
    D) NADH.
    E) Citrate.

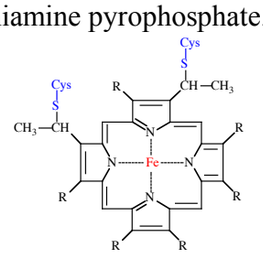
46. Choose the **best** explanation for why electron flow originating in $FADH_2$ results in the production of only 1.5 ATP molecules:
    A) $FADH_2$ is a product of the TCA cycle.
    B) When the electrons from $FADH_2$ are passed to UQ no energy is conserved in the pumping of protons by Complex II.
    C) NADH cannot reduce FAD.
    D) The electrons from $FADH_2$ are passed to UQ further down the electron transport chain.
    E) $FADH_2$ passes only one electron to UQ resulting in UQ with a lower free energy.

47. 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) Succinyl-CoA; CO_2; ATP; NADH;
    C) Acetyl-CoA; CO_2; NADH; GTP; NADPH.
    D) Acetyl-CoA; CO_2; GTP; NADH; $FADH_2$.
    E) Succinate; water; NADH; $FADH_2$; ATP.

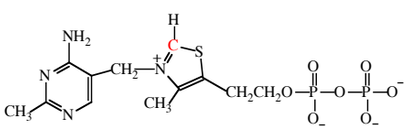
48. Which of the following complex(es) permit protons to flow into the matrix of the mitochondrion?
    1. Complex I
    2. Complex II
    3. Complex III
    4. Complex IV
    5. F_oF_1-ATP Synthase

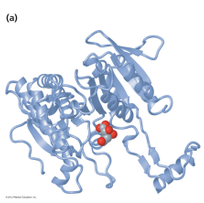
    A) 1, 2 & 4 only.
    B) 1 & 2 only.
    C) 3 only.
    D) 5 only.
    E) All of the above.

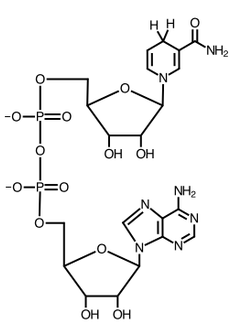
49. Identify thiamine pyrophosphate.

A) 

B) 

C) 

D) 

E) 

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

A) During electron transport, protons are pumped into the matrix of the mitochondrion.
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 10 protons through the ATP synthase releases enough free energy to make 2.5 ATP molecules from ADP and inorganic phosphate.
E) The free energy released in the oxidation of NADH is stored in an electrochemical proton gradient.

Scratch Paper