BIOL 3361/CHEM 3361/BIOL6352 **FORM A**

EXAM No. 3 Spring 2012 Marsh & Spiro

There are 45 multiple-choice questions, one bonus question, and two short answer questions. Write your answer to the short answer question on the back of the Scantron. Make sure your name is also on the back of the Scantron. The exam is 75 minutes, allow 10-15 minutes for the free response questions.

Useful information

The molar extinction coefficient (ε) of NADH at 340 nm is 6,300 litres/mole

The Beer-Lambert equation:

$$A = \varepsilon.c.l$$

Where A is absorbance, ε is the molar extinction coefficient, c is concentration, and l is the path length of the solution in the spectrophotometer. The path length is almost always 1 cm, so l can be disregarded in this equation.

Enzyme regulation

1. Which of the following statements about allosteric regulation is NOT correct:
   a. Allosteric regulation is mediated by small molecules that interact non-covalently with an enzyme.
   b. Allosteric regulation depends upon covalent modification of the regulated enzyme.
   c. Allosteric regulation allows for very rapid response times.
   d. Allosteric effectors bind to a site that is distinct from the substrate binding site.
   e. Allosteric regulation depends upon conformational changes in the regulated enzyme.

2. cAMP dependent protein kinase is activated by:
   a. phosphorylation stimulated by cAMP.
   b. allosteric activation by cAMP.
   c. proteolytic cleavage of the polypeptide chain.
   d. dephosphorylation stimulated by cAMP.
   e. cAMP binding to the regulatory subunits.

3. For a K system type enzyme, what is the effect of an allosteric inhibitor on substrate binding kinetics?
    a. Substrate binds with lower affinity and decreased cooperativity.
    b. Substrate binds with lower affinity and increased cooperativity.
    c. Substrate binds with higher affinity and increased cooperativity.
    d. Substrate binds with the same affinity but V_{max} decreases.
    e. Substrate binds with lower affinity and the degree of cooperativity remains unchanged.

4. Which of the following is NOT an assumption of the MWC model?
    a. The tense form is more abundant than the relaxed form of the enzyme.
    b. Substrate and activators bind preferentially to the relaxed form.
    c. Inhibitors bind preferentially to the tense form.
    d. Substrate binding induces a conformational change.
    e. All subunits of the enzyme adopt the same conformation.

5. Which of the following is an assumption of the KNF model?
    a. There is an equilibrium between tense and relaxed forms.
    b. All subunits change conformation simultaneously.
    c. Substrate binding induces a conformational change.
    d. All subunits of the enzyme adopt the same conformation.
    e. Enzymes are monomeric.

6. Which statement about oxygen binding to hemoglobin is FALSE?
    a. When oxygen binds, the iron is pushed out of the plane of the porphyrin ring of the heme prosthetic group.
    b. The first oxygen binds to an α subunit, inducing a small change in its conformation.
    c. When two oxygens are bound, there is a large change in the quaternary structure of hemoglobin.
    d. Oxygen binds with lower affinity at lower pH values.
    e. Deoxy hemoglobin binds oxygen with low affinity, and the heme groups of the ß subunits are inaccessible to oxygen.

7. In the interaction of hemoglobin with O_2 which steps are consistent with the KNF model for cooperative substrate binding?

(i) an induced conformational change in the α subunit when the first O_2 binds

(ii) a conformational change transmitted to the second α subunit after O_2 binds to the first α subunit

(iii) a large change in quaternary structure when two oxygens are bound to two α subunits

a. (i)
b. (ii)
c. (iii)
d. (i) and (ii)
e. (i), (ii) and (iii)

8. Oxygen binds to adult hemoglobin (Hb A) with lower affinity than to fetal hemoglobin (Hb F) because:

a. There is a low concentration of carbon monoxide in fetal blood.
b. Oxygen binding to fetal hemoglobin is not cooperative.
c. The CO_2 concentration is higher in adult blood than in fetal blood.
d. The pH of adult blood is lower than the pH of fetal blood.
e. Adult hemoglobin has a binding site for 2,3-bisphosphoglycerate and fetal hemoglobin does not.

9. What is the effect of carbon monoxide on oxygen binding to hemoglobin?

a. CO has no effect on the oxygen binding capacity of hemoglobin.
b. In the presence of CO, oxygen dissociates from hemoglobin more readily.
c. In the presence of CO, oxygen binding to hemoglobin is more cooperative.
d. The binding of CO to one subunit increases the affinity of oxygen binding to other subunits.
e. The binding of CO to one subunit decreases the affinity of oxygen binding to other subunits.

Carbohydrates

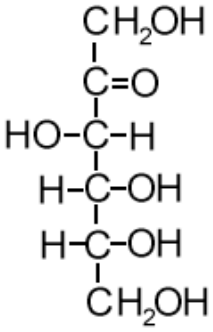
10. The simplest aldose is:

a. Glucose.
b. Glyceraldehyde.
c. Dihydroxyacetone.
d. Aldose.
e. Pyran.

11. In a ketohexose such as fructose, which carbon is the carbonyl carbon?

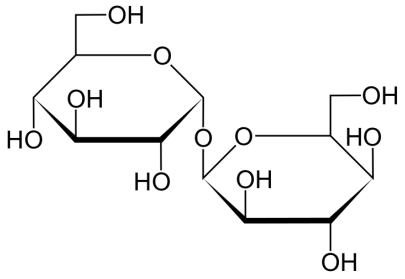
a. 1.
b. 2.
c. 3.
d. 4.
e. 6.

12. How would you describe this structure?



a. The D isomer of an aldohexose.
b. The L isomer of an aldohexose.
c. The D isomer of a ketohexose.
d. The L isomer of a ketohexose.
e. None of the above.

13. The structure shown below is of trehalose, a disaccharide of two glucose units. What is the correct designation of the glycosidic bond in trehalose?



a. α-1,4.
b. α-1,1.
c. ß-1,4.
d. α-1,6.
e. ß-1,6.

14. Lactose is a disaccharide of:
    a. Two glucose molecules.
    b. Galactose and glucose.
    c. Two galactose molecules.
    d. Glucose and fructose.
    e. Galactose and maltose.

15. The starch phosphorylase reaction is energetically favorable because:
    a. ADP is utilized to break the glycosidic bond in starch.
    b. It generates one molecule of ATP by substrate level phosphorylation.
    c. It is an oxidation coupled to the reduction of NAD^+ to NADH.
    d. The product is glucose-phosphate, which can be metabolized by glycolysis with the expenditure of one fewer molecules of ATP.
    e. None of the above is true.

16. Amylose is a polymer of glucose monomers linked by α (1 → 4) glycosidic bonds. How is cellulose different?
    a. In cellulose the monomer is N-acetylglucosamine.
    b. In cellulose the glucose monomers are linked by α (1 → 6) glycosidic bonds.
    c. Cellulose is a branched polymer.
    d. In cellulose the glucose monomers are linked by ß (1 → 6) glycosidic bonds.
    e. In cellulose the glucose monomers are linked by ß (1 → 4) glycosidic bonds.

17. Which of the following statements about peptidoglycan is <u>INCORRECT</u>?
    a. The polysaccharide backbone has alternating monomers of N-acetylglucosamine and N-acetylmuramic acid.
    b. Hydrogen bonding between chains and between sheets accounts for the structural strength of peptidoglycan.
    c. N-acetylmuramic acid residues are modified by the addition of a tetra-peptide side chain.
    d. Tetra-peptide side chains are cross-linked directly (in Gram negative bacteria) or by a penta-glycine bridge (in Gram positive bacteria).
    e. The bacterial cell is surrounded by a single peptidoglycan molecule.

Glycolysis

18. In the conversion of glucose to lactate, what is the overall yield of ATP and NADH, for each molecule of glucose?
    a. 2 ATP and 0 NADH.
    b. 2 ATP and 1 NADH.
    c. 2 ATP and 2 NADH.
    d. 4 ATP and 0 NADH.
    e. 4 ATP and 2 NADH.

19. In phase 2 of glycolysis, the correct sequence of enzymes is:
    A. Pyruvate kinase.
    B. Glyceraldehyde-3-phosphate dehydrogenase.
    C. Enolase.
    D. Phosphoglycerate kinase.
    E. Phosphoglycerate mutase.

    a. A, C, B, E, D
    b. B, C, D, E, A
    c. B, D, C, A, E
    d. D, B, A, C, E
    e. B, D, E, C, A

20. The consumption of ATP in the hexokinase reaction reduces the ATP yield of glycolysis. Why is the use of ATP necessary at this step?
    a. Phosphorylation of glucose facilitates its transport into cells.
    b. Because inorganic phosphate is unavailable in cells, ATP is the only possible source of a phosphate group.
    c. Because the phosphorylation of glucose with inorganic phosphate is thermodynamically unfavorable.
    d. ATP is an allosteric activator of hexokinase.
    e. All of the above.

21. Which of the following processes are stimulated by insulin?
    (i) gluconeogenesis
    (ii) glycolysis
    (iii) glucose uptake
    (iv) glycogen synthesis
    (v) glycogen breakdown

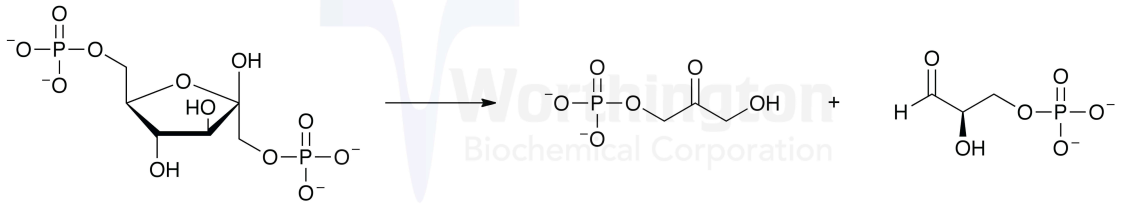
    a. (i) and (v).
    b. (ii) only.
    c. all of them.
    d. (ii), (iii) and (iv).
    e. (i) only.

22. Which step of glycolysis commits the cell to metabolizing glucose to pyruvate?
    a. Hexokinase.
    b. Phosphoglucoisomerase.
    c. Phosphofructokinase.
    d. Fructose bisphosphate aldolase.
    e. Triose phosphate isomerase

23. What is the role of adenylate kinase?
    a. It phosphorylates ADP to make ATP
    b. It phosphorylates aldose sugars.
    c. It makes more energy available by converting 2ADP into ATP + AMP.
    d. It phosphorylates AMP to make ADP.
    e. It makes energy available by converting ATP to ADP.

24. In phase 2 of the glycolytic pathway, there are _____ substrate level phosphorylations, generating _____ ATP molecules for each glucose that entered the pathway. Thus the net yield of glycolysis is _____ ATP molecules per glucose.
    a. four; four; zero
    b. four; two; two
    c. two; four; two
    d. two; two; two
    e. four; two; four

25. What enzyme catalyzes the reaction shown below?



    a. Fructose-1,6-bisphosphatase.
    b. Phosphofructokinase.
    c. Triose phosphate isomerase.
    d. Fructose bisphosphate aldolase.
    e. Phosphoglucoisomerase.

26. What is the function of fructose-2,6-bisphosphate in glycolysis?
    a. It is an allosteric activator of fructose bisphosphate aldolase.
    b. It acts to slow down glycolysis when energy levels are high.
    c. It is an allosteric activator of phosphofructokinase 1.
    d. It is an intermediate of the pathway.
    e. It phosphorylates fructose-6-phosphate.

27. The glyceraldehyde-3-phosphate dehydrogenase reaction is unique to glycolysis because:

(i) It is an oxidation
(ii) It consumes inorganic phosphate
(iii) It produces NADH

a. (i).
b. (ii).
c. (iii).
d. (ii) and (iii).
e. (i), (ii) and (iii).

28. The pyruvate kinase reaction is a(n):

a. Oxidative decarboxylation.
b. Substrate level phosphorylation.
c. Phosphorylation.
d. Oxidative phosphorylation.
e. Electron transfer reaction.

29. Phosphoenolpyruvate and 2-phosphoglycerate have similar amounts of potential metabolic energy with respect to decomposition to P_i, CO_2 and H_2O, but the enolase reaction:

a. creates a much more unstable reactive intermediate.
b. rearranges the molecule into a form from which more potential energy can be released by the subsequent hydrolysis.
c. rearranges 2-phosphoglycerate to a form with greater binding potential to the enzyme.
d. changes the $\Delta G'$ to increase the potential energy.
e. none is true.

30. What is the fate of the NADH made during glycolysis?

a. Nothing happens to it – it is an end product of glycolysis.
b. It is reduced to NAD^+ by lactate dehydrogenase.
c. It is reoxidized to NAD^+ by glyceraldehyde-3-phosphate dehydrogenase.
d. It is transferred to the liver in the bloodstream and is reoxidized to NAD^+ by the reactions of gluconeogenesis.
e. It is reoxidized to NAD^+ by the reactions of fermentation or oxidative phosphorylation

31. The conversion of one mole of glucose to pyruvate by glycolysis yields:
    a. Two moles of pyruvate and four moles of ATP.
    b. Two moles of pyruvate, two moles of NADH, and two moles of ATP.
    c. Two moles of pyruvate and six moles of ATP.
    d. One mole of pyruvate, two moles of NADH and two moles of ATP.
    e. Two moles of pyruvate, two moles of NADH, and four moles of ATP.

32. What is the fate of the lactate made in muscle during exercise?
    a. It is converted to glucose by gluconeogenesis in liver.
    b. It is oxidized to pyruvate as a mechanism for regenerating NADH.
    c. It is converted to glucose by gluconeogenesis in muscle.
    d. It is oxidized to CO_2 as means of generating additional energy.
    e. It is converted to glycogen as an energy store.

33. Fermentation is a process for ATP generation in which:
    a. Oxidation of NADH is coupled to the reduction of oxygen.
    b. An organic compound functions as the electron acceptor.
    c. Lactate functions as the electron acceptor.
    d. An inorganic compound functions as the electron acceptor.
    e. The enzymes involved are localized to mitochondria.

34. The pyruvate kinase reaction has a large negative ΔG. Which of the following contributes to the exergonic nature of this reaction?
    a. The use of ADP in the reaction.
    b. The use of ATP to phosphorylate pyruvate.
    c. Rapid conversion of the enol tautomer of pyruvate to the keto tautomer.
    d. Regulation of pyruvate kinase activity by allosteric effectors and covalent modification.
    e. Rapid conversion of the keto tautomer of pyruvate to the enol tautomer.

35. After the oxidation of glucose to pyruvate in glycolysis, only a fraction of the released energy is conserved in ATP. Which molecules 'contain' the remainder of the biologically usable energy?
    a. Carbon dioxide and NAD^+.
    b. NADH and ADP.
    c. Pyruvate and NAD^+.
    d. Pyruvate and NADH.
    e. NAD^+ and NADH.

36. Galactose enters glycolysis after being converted to:
    a. Glucose.
    b. Glucose-6-phosphate.
    c. Fructose-6-phosphate.
    d. Dihydroxyacetone phosphate.
    e. Glyceraldehyde-3-phosphate.

Metabolism

37. What is the source of energy that drives rotation of the bacterial flagellum?
    a. The proton motive force.
    b. Light.
    c. ATP hydrolysis.
    d. NADH oxidation.
    e. Hydrogen oxidation.

38. Catabolic metabolism is characterized by:
    a. The degradation of complex organic molecules.
    b. The use of ATP as an energy source.
    c. Pathways that are overall chemical reductions.
    d. Pathways that are endergonic.
    e. The consumption of NADH.

39. In the alcohol dehydrogenase reaction, the conversion of ethanol to acetaldehyde is coupled to:
    a. The phosphorylation of NADH to NADPH.
    b. The phosphorylation of ADP to ATP.
    c. The oxidation of NADH to NAD^+.
    d. The reduction of NAD^+ to NADH.
    e. The dephosphorylation of ATP to ADP.

40. Which of the following is the reducing agent used in anabolic metabolism?
    a. NAD^+
    b. NADPH
    c. NADH
    d. $NADP^+$
    e. ATP

41. Substrate level phosphorylation is:
    a. The phosphorylation of NADH to make NADPH.
    b. The synthesis of a 'high energy' phosphorylated intermediate, such as phosphoenol-pyruvate.
    c. The use of ATP to drive an endergonic anabolic reaction.
    d. A catabolic reaction coupled to the phosphorylation of ADP to make ATP.
    e. The phosphorylation of pyruvate to make phosphoenol-pyruvate, catalyzed by pyruvate kinase.

42. How many electrons are required to reduce NAD^+ to NADH?
    a. 0
    b. 0.5
    c. 1
    d. 2
    e. 3

43. An organism that oxidizes hydrogen as its source of energy and uses glucose as its source of carbon would be called a:
    a. Chemoorganoheterotroph.
    b. Chemolithoautotroph.
    c. Chemolithoheterotroph.
    d. Photoheterotroph.
    e. Chemoorganoautotroph.

44. Glycolysis occurs in the cytoplasm, and the citric acid cycle in mitochondria. Which molecule is transported from the cytoplasm into mitochondria?
    a. Pyruvate.
    b. Acetyl CoA.
    c. Glucose.
    d. Lactate.
    e. NAD^+

Problem

45. In an enzyme reaction measured in a spectrophotometer, NADH formation was measured at 340 nm. The rate of formation was 0.37 absorbance units per minute. What was the rate of formation of NADH in **micromoles per litre per minute**?

    a. 17,027
    b. 0.059
    c. 17.03
    d. 59
    e. 0.017

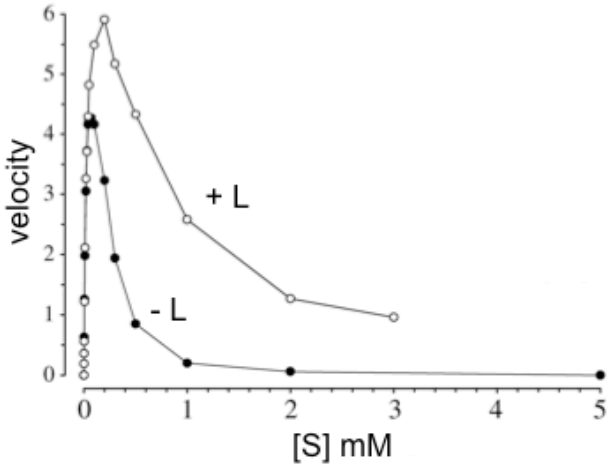
For Bonus

46. Please answer this question honestly, and any answer will receive credit. If you took this class again, which of the following textbook options would you prefer?

    a. A hardcover textbook with a web-based electronic version. Cost = $230
    b. A loose-leaf (3 hole binder format) textbook with a web-based electronic version. Cost = $155
    c. A web-based electronic version only, with 6 months access. Cost = $75
    d. A web-based electronic version only, with 24 months access. Cost = $100

SHORT ANSWER QUESTIONS

Write your answers to these questions AND YOUR NAME on the back of the Scantron.



1. The graph shows plots of reaction velocity against the concentration of a substrate S for a reaction catalyzed by enzyme E. Velocity was measured in the absence (filled circles) and presence (open circles) of a ligand L. Describe how the activity of E is regulated, and so explain the shapes of the two curves.

2. Sucrose is a disaccharide that can enter glycolysis by one of two routes, as indicated below:

   sucrose phophorylase: sucrose + Pi → fructose + glucose-1-phosphate

   invertase: sucrose + water → fructose + glucose

   Think about the subsequent metabolism of the two hexoses. Which of the above reactions is energetically more favorable, and why?