

UNIVERSITY OF TORONTO
FACULTY OF ARTS AND SCIENCE
BIOCHEMISTRY 210H1Y
August Examinations 2006
Duration: 3 hours
Examiner: Dr. R.R. Baker

Candidates may use simple, non-programmable calculators (supplied by candidates).

This examination is worth 50% of the mark for the course. There are 35 multiple choice questions. The exam will be graded out of 35 points and the percent grade used to calculate a mark out of 50. This mark will be added to the term test result (out of 50) for a final mark.

For the multiple choice questions you are to choose ONE answer for each question and fill in the appropriate circle on the computer card provided with a soft lead pencil. Marks are not deducted for wrong choices.

CAREFULLY fill in the appropriate circles on the computer card for your name and student number. Please also print in your name and number on the card.

It is NOT a good idea to leave the entering of your answers on the computer card until the last few minutes of the exam. We cannot help you if you make transcriptional errors.

Please answer all the questions.

When you are not entering answers on your computer card, please cover the answer card with your question paper.

Please note that the examiner has made every effort to have only one suitable answer per question. However, if you are convinced that a particular question may have two possible answers, it is in your best interest to select the answer that seems MOST appropriate. Do NOT skip the question.

Please place your answers on the computer card provided.
Please answer all questions.

1. Which ONE of the following is INCORRECT?

- a) Glyceraldehyde is an aldotriose that exists as either of two enantiomers, while dihydroxyacetone is a ketotriose which has no chiral or asymmetric carbons.
- b) α -D-glucopyranose is broken into two molecules of the 3 carbon compound pyruvate in aerobic glycolysis.
- c) Aldopentoses (in their straight chain forms) can exist as 8 different stereoisomers and D-ribose is one of these.
- d) D-galactose, D-mannose and D-glucose, in their straight chain forms, are 3 stereoisomers out of a possible 16 stereoisomers found for the aldohexoses.
- e) β -2- Deoxy-D-ribose in its straight chain form cannot undergo a cyclization reaction to form a hemiacetal.

2. In the cyclization reaction for D-fructose, which ONE of the following is INCORRECT?

- a) The anomeric carbon is carbon-2 and two different stereoisomers, called anomers, can be formed in the production of the hemiketal.
- b) Likely β -D-fructofuranose is the more stable of the two anomers, and its formation from α -D-fructofuranose in solution can likely be measured by the rotation of plane polarized light.
- c) The furan ring structure is made of 4 carbons and one oxygen.
- d) The distinction between β -D-fructofuranose and α -D-fructofuranose lies in the orientation of the -OH at carbon 2 with respect to the furan ring.
- e) The cyclization reaction involves the attack on the ketone group at C-2 by an -OH found in the group -CH₂-OH in the straight chain form of D-fructose.

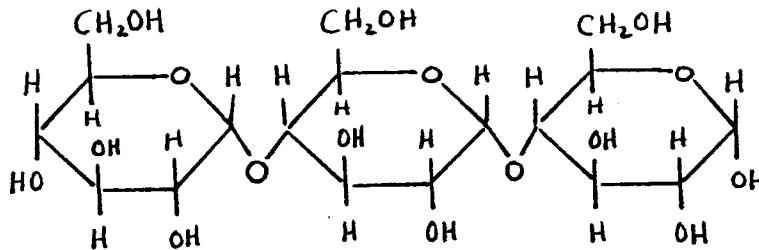
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3. How many of the following sugar derivatives listed below are reducing sugars?

α -D-glucose-1-phosphate, cellobiose (β anomer), β -D-fructose-6-phosphate, β -D-fructose-2,6-bisphosphate, α -D-ribose-5-phosphate, sucrose, the ribose unit in ATP

- a) 2
- b) 3
- c) 4
- d) 5
- e) 6

4. Which ONE of the following concerning the structure X shown below is INCORRECT?



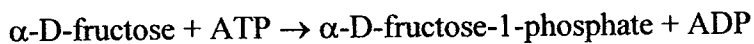
- a) X is a reducing sugar.
- b) One mole of X would require two moles of water for its hydrolysis to 3 moles of α -D-glucose.
- c) X can be formed during the attack of α -amylase on amylose but not during the attack of this enzyme on amylopectin.
- d) Both glycosidic links shown are α (1 \rightarrow 4).
- e) X is an oligosaccharide called maltotriose

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5. Which ONE of the following concerning ATP is INCORRECT?

- a) There is a greater ΔG° of hydrolysis associated with the γ and β phosphate group linkages (anhydrides) than with the α phosphate group linkage to the ribose unit.
- b) ATP can be made from ADP by enzyme catalyzed phosphate transfer reactions using the following high energy phosphate donors: PEP, phosphocreatine, GTP, and 1,3-bisphosphoglycerate
- c) In the cytoplasm of liver cells all the kinases which participate in aerobic glycolysis catalyze reactions that have large equilibrium constants and are thus all irreversible reactions within the liver cell.
- d) ATP carries 4 negative charges at pH 7.4
- e) In cells which have a good supply of oxygen and glucose, much more ATP can be made by the complete breakdown of glucose than by aerobic glycolysis alone.

6. The enzyme fructokinase in liver cells catalyses the reaction:



The ΔG° value of hydrolysis for $\alpha\text{-D-fructose-1-phosphate}$ is -17 kJ/mol ($\alpha\text{-D-fructose-1-phosphate} + \text{water} \rightarrow \alpha\text{-D-fructose} + \text{phosphate}$).

Which ONE of the values below is closest to the ΔG° for the liver fructokinase reaction?

- a) -5 kJ/mol
- b) -13 kJ/mol
- c) -16 kJ/mol
- d) -30 kJ/mol
- e) $+2 \text{ kJ/mol}$

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7 Which ONE of the following is the BEST explanation of the function of fructokinase (FK) in liver?

- a) FK allows a greater yield of ATP from α -D-glucose during aerobic glycolysis.
- b) The FK reaction eliminates the need for the participation of PFK-1 in the conversion of α -D-glucose into two molecules of pyruvate.
- c) If α -D-fructose-1-phosphate can be further metabolized in liver cells to form 2 molecules of D-glyceraldehyde-3-phosphate, FK will allow energy production from α -D-fructose.
- d) FK is the only enzyme that allows fructose to be used as a source of energy in liver.
- e) FK produces a hexose phosphate that can be used in the synthesis of ATP.

8. Considering the enzyme catalyzed reaction:

Dihydroxyacetone phosphate \rightarrow D-glyceraldehyde-3-phosphate

The ΔG° value for the reaction is +7.6 kJ/mol. Under standard conditions what value below is closest to the equilibrium constant for this reaction? ($R = 8.315 \text{ J/K}^{\circ} \cdot \text{mol}$)

- a) 0.001
- b) 0.05
- c) 0.10
- d) 0.50
- e) 10

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9. Which ONE of the following concerning the enzymes hexokinase (HK) and glucokinase (GK) is INCORRECT?

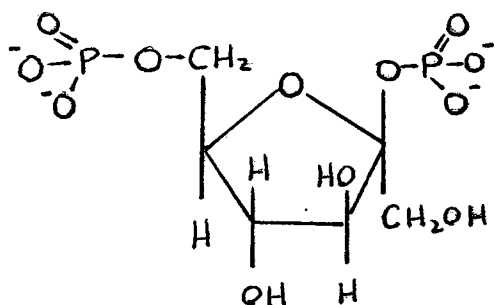
- a) HK can utilize ATP and α -D-glucose in the formation of α -D-glucose-6-phosphate and ADP.
- b) GK has a higher K_m for α -D-glucose than does HK, and GK is of particular importance when levels of blood glucose increase significantly following the ingestion of a sugary snack or beverage.
- c) α -D-glucose-6-phosphate is an allosteric inhibitor of HK.
- d) HK undergoes a conformational change, after binding α -D-glucose, to exclude water from the active site as water may simply promote hydrolysis of ATP without phosphorylation of α -D-glucose.
- e) Because it has a higher K_m for glucose than HK, GK should have a much lower equilibrium constant.

10. During anaerobic glycolysis which ONE of the following enzymes uses NADH in the reduction of a substrate?

- a) phosphoglucomutase
- b) aldolase
- c) glyceraldehyde-3-phosphate dehydrogenase
- d) enolase
- e) lactate dehydrogenase

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11. Which ONE of the following concerning the compound below is INCORRECT?



- a) It is formed by the action of phosphofructokinase-2.
- b) It will be found in high concentration in liver cells during fasting.
- c) It is an allosteric activator of PFK-1
- d) It has two phosphate groups in ester link with β -D-fructose.
- e) Its production in the cytoplasm allows for feed forward control of PFK-1 at times when concentrations of β -D-fructose-6-phosphate rise in the cytoplasm.

12. Which ONE of the following concerning glycolysis is INCORRECT?

- a) Cysteine and histidine are two important active site amino acid residues in the enzyme glyceraldehyde-3-phosphate dehydrogenase.
- b) Both pyruvate kinase and phosphoglycerate kinase are sites of ATP production in glycolysis.
- c) Enolase catalyzes a reaction in which the removal of a water molecule leads to the production of a high energy phosphate product.
- d) The least favourable reaction in aerobic glycolysis, based upon ΔG° values, is phosphoglucomutase.
- e) PFK-1 activity is inhibited by rising concentrations of cytoplasmic ATP and citrate.

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15. Which ONE of the following concerning the pyruvate dehydrogenase (PDH) complex of mitochondria is INCORRECT?

- a) The E₁ subunit catalyzes a decarboxylation reaction, and 2 of the 3 carbons of pyruvate are transferred to the TPP prosthetic group of E₁.
- b) The dihydrolipoamide group of E₂ receives an acetyl group and carries the group as an acetyl thioester.
- c) Dihydrolipoamide is restored to its oxidized lipoamide form by the action of the dihydrolipoamide dehydrogenase subunit (E₃).
- d) The activity of the PDH complex will decrease following phosphorylation of E₁ catalyzed by pyruvate dehydrogenase kinase.
- e) Because NADH has a greater standard reduction potential (E°') than FADH₂, NADH is used to reduce FAD produced during the reaction mechanism of the PDH complex.

16. Considering the carbons found in acetyl CoA which enter the Krebs cycle by the action of citrate synthase, how many of these carbons are found in succinate during the first turn of the Krebs cycle?

- a) 0
- b) 1
- c) 2
- d) 3
- e) 4

17. Which ONE of the following Krebs cycle enzymes catalyzes a substrate level phosphorylation?

- a) isocitrate dehydrogenase
- b) succinyl CoA synthetase
- c) aconitase
- d) succinate dehydrogenase
- e) fumarase

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18. The mitochondrial anaplerotic reaction catalyzed by pyruvate carboxylase is controlled by levels of acetyl CoA in mitochondria. Which ONE of the following concerning this regulation is CORRECT?

- a) Acetyl CoA not only increases the activity of pyruvate carboxylase, it can also increase the activity of the gluconeogenic pathway
- b) Acetyl CoA lowers the activity of pyruvate carboxylase because there is already sufficient acetyl CoA in the mitochondrial matrix.
- c) Levels of acetyl CoA rise in mitochondria principally because of a limitation in the level of mitochondrial citrate.
- d) Acetyl CoA stimulates pyruvate carboxylase by increasing mitochondrial ATP levels.
- e) Levels of acetyl CoA fall in mitochondria when levels of mitochondrial oxaloacetate are limiting.

19. Which ONE of the following concerning electron transport and oxidative phosphorylation is INCORRECT?

- a) CO is deadly because it not only binds to hemoglobin it also blocks electron transport at the level of cytochrome c oxidase (Complex IV).
- b) The P/O ratio associated with the oxidation of NADH is greater than the P/O ratio that can be calculated for the oxidation of the reduced form of cytochrome c (Fe^{2+}).
- c) In the Chemiosmotic Theory, the mitochondrial generation of ATP is driven by a Proton Motive Force that exists across the inner mitochondrial membrane as a result of electron transport.
- d) If you designed a compound that could transport H^+ across membranes you would likely see that its addition to actively respiring mitochondria would not block electron transport but would stop ATP synthesis and increase the energy released as heat during mitochondrial electron transport.
- e) Suspending mitochondria in weakly acidic solutions can result in increased flow of electrons down the electron transport chain that will increase mitochondrial ATP production.

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