**UNIVERSITY OF TORONTO**

**FACULTY OF ARTS AND SCIENCE**

**BIOCHEMISTRY 210H1F**

**DECEMBER FINAL EXAMINATION 2007**

**DURATION: 3 hours**

**EXAMINER: Dr. R.R. Baker**

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

This examination is worth 45% of the final grade for the course. There are 30 multiple choice questions worth one mark each for a total of 30 marks and 4 short answer questions worth, in total, 15 marks.

For the multiple choice questions you are to choose **ONE** answer for each question and fill in the appropriate circle on the computer card with a soft lead pencil (**not pen**!). Marks are not deducted for wrong choices but no marks are given if more than one circle is filled in per question.

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

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

When not entering answers on your card you should cover the answer card with your question paper.

****Please note that the examiners make every effort to ensure there is only one suitable answer for each multiple choice question. However, if you are convinced that a particular question has two answers, you should select the answer that seems MOST appropriate.**

**Answer all the multiple choice questions and all the short answer questions.**
Place your short answers in the examination booklet(s) provided.

**Please print your name and student number on your examination booklet(s).**

## PART I: MULTIPLE CHOICE QUESTIONS (30 MARKS)

Please answer all the questions

1. Considering the Case Study Nat, which ONE of the following is INCORRECT concerning the use of Aspirin?

a) Nat was not immediately given ASA because his symptoms could be associated with a brain hemorrhage.

b) ASA prevents platelet aggregation by irreversibly inhibiting the activity of the enzyme COX.

c) For each molecule of COX that is acetylated at Ser 530, there will be one less molecule of $TXA_2$ made by platelets.

d) COX has α-helices that form the tunnel that allows 20:4 access to the COX active site.

2. Which ONE of the following would NOT be associated with a transient blockage of a small artery supplying a specific brain region X?

a) There will be an increased production of NADH in region X during the ischemic period.

b) The pH in region X will decline during the ischemic period.

c) There will be elevated rates of anaerobic glycolysis in region X during ischemia.

d) There will likely be a specific neurological deficit such as blindness or blurred vision, dizziness, aphasia or unintelligible speech during the blockage.

3. Which ONE of the following concerning lipoproteins is INCORRECT?

a) The 10-year risk of coronary artery disease is calculated using risk points for several factors including a patient's total cholesterol and HDL-C levels.

b) Oily fish (e.g. salmon and herring) are beneficial in the diet because they substantially lower LDL cholesterol levels in patients with arterial plaque.

c) If Nat stays away from fast fried food and restricts himself to olive oil as his main source of fat, and also has a glass of wine once a day with dinner, it is likely that his total cholesterol/HDL ratio will decline.

d) High risk categories are associated with 10-year risk levels of CAD > 20% and have the lowest LDL treatment targets.

4. Which ONE of the following is INCORRECT?

a) Platelets are found in the circulation and are important components of thrombi and emboli.

b) The cholesterol found in atherosclerotic plaque is derived from oxidized LDL that entered the artery wall using scavenger LDL receptors.

c) The attack of VLDL by LPL will produce the smaller, more dense lipoprotein LDL which contains many more molecules of cholesterol and cholesterol esters per lipoprotein than were found in the substrate VLDL.

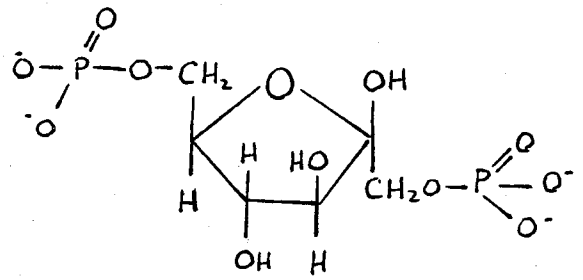
d) Turbulence in blood flow at the surface of atherosclerotic plaque can contribute to the production of $TXA_2$ in platelets.

5. How many of the following carbohydrates can be described by the general formula $(CH_2O)n$?

α-D-ribose, α-D-glucose-6-phosphate, amylose, β-D-fructose-1,6-bisphosphate, β-2-deoxy-D-ribose, β anomer of D-glucuronate, α-pyranose anomer of D-mannose, β anomer of maltose

a) 1
b) 2
c) 3
d) 4

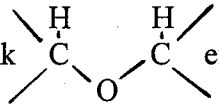
6. Which ONE of the following concerning the monosaccharide X shown below is INCORRECT?



a) X is not a reducing sugar
b) X is formed by the action of the enzyme phosphofructokinase-1.
c) X can allosterically activate pyruvate kinase
d) Hydrolysis of esters in X will yield an uncharged monosaccharide that also is found in glycosidic linkage in sucrose.

7. Which ONE of the following is INCORRECT?

a) The enzyme amylase, which hydrolyses α(1→4) glycosidic links in glucose polymers, can degrade both amylose and amylopectin to form the same kinds of smaller carbohydrate products.

b) An α(1→4) glycosidic link indicates that the link  exists between two monosaccharides and that one carbon involved in the link is an α anomeric carbon.

c) The α anomer of lactose is a disaccharide and both component monosaccharides are pyranose hemiacetals.

d) Lactose intolerance is associated with osmotic effects within the intestine, because the prolonged presence of lactose can draw water away from intestinal cells.

8. Which ONE of the following is INCORRECT concerning hemiacetals formed during the cyclization of D-glucose?

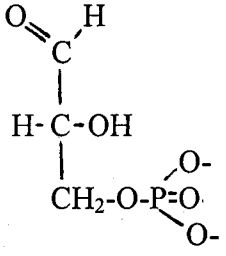
a) Hemiacetals are formed by the interaction of an –OH group with –C(H)=O.

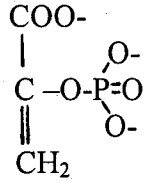
b) In your cells, a monosaccharide with hemiacetal structure cannot be converted into a monosaccharide with hemiketal structure.

c) Anomers of a monosaccharide hemiacetal can exist in equilibrium, and the Keq of this chemical reaction is related to the stability of the two anomers.

d) Formation of a monosaccharide hemiacetal creates a new chiral C centre in the molecule, so that 2 new stereoisomers can exist.

9. Which ONE of the following is NOT a compound that can be used in a kinase reaction as phosphate donor to generate ATP?

a) 

b) 

c) GTP

d) Phosphocreatine

10. In the Krebs cycle the enzyme succinyl CoA synthetase catalyses the formation of succinate and GTP and has a $\Delta G^{o'}$ value of -2.9 kJ/mol.

Which ONE of the following is closest to the K'eq value for this reaction?

a) 0.5
b) 1.1
c) 3.2
d) 12.6

(R = 8.315 J/K°.mol)

11. Considering the succinyl CoA synthetase reaction noted in question 9, which ONE of the following is INCORRECT?

a) Under standard conditions, likely the $\Delta G^{o'}$ value for the hydrolytic reaction below is close to -32.9 kJ/mol:

succinyl CoA + $H_2O$ → succinate + CoASH

b) The reaction noted in question 9 is linked to an auxiliary kinase that allows ATP production from one of the products of succinyl CoA synthetase, and this auxiliary enzyme reaction has a $\Delta G^{o'}$ value close to 0.

c) Succinyl CoA has a thioester linkage.

d) Water is a necessary substrate for the succinyl CoA synthetase reaction.

12. Which ONE of the following concerning glycolysis, occurring in Soon-yi's muscle, is INCORRECT?

a) ATP is needed for muscle contraction, and during contraction ATP in the presence of water is degraded to ADP + Pi.

b) A surge in α-D-glucose uptake into muscle cells can be followed rapidly by an increase in the level of β-D-fructose-6-phosphate in the muscle cell cytoplasm.

c) PFK-2 activity can increase in response both to increasing levels of β-D-fructose-2,6-bisphosphate and AMP.

d) Besides PFK-1, two other important control points for glycolysis are hexokinase and pyruvate kinase.

13. Soon-yi did not eat that morning of her practice, and as she runs along the beach, glucagon is a dominant hormone in her circulation. How many of the following enzymes are activated in Soon-yi's liver, following glucagon binding to its receptor?

Adenylate cyclase, glycogen synthase, PKA, phosphorylase kinase, glycogen phosphorylase, pyruvate kinase, PFK-2

a) 2
b) 3
c) 4
d) 5

14. Which ONE of the following is NOT an adequate description for ONE of the organs/tissues noted below?

a) Brain: Consumer, uses glucose supplied by the blood, and also activates considerable glycogen breakdown in nerve cells in response to rising levels of glucagon and adrenaline.

b) Muscle: Consumer, utilizes its own glycogen stores for energy and can use blood glucose and fatty acids as fuels.

c) Adipose tissue: Major storage depot for most of your fuel energy reserves, noted for its triglyceride storage capacities, and can degrade triglyceride in response to rising adrenaline.

d) Liver: Provider, has glycogen that can be used to maintain blood glucose, and under anabolic conditions will make fat from carbohydrate and assemble VLDL.

15. Which ONE of the following is INCORRECT concerning the PDH complex?

a) It is located in mitochondria and decreases in activity in response to rising levels of NADH and acetyl CoA.

b) It relies on the supply of a three carbon substrate produced directly by the reaction catalyzed by the glycolytic enzyme enolase.

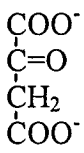
c) It catalyases a very favourable reaction as judged by the $\Delta G^{0'}$ for the reaction.

d) If the $\Delta G^{0'}$ for the reaction catalyzed by the PDH complex is -37 kJ/mol, and the $\Delta G^{0'}$ of hydrolysis for acetyl CoA is -32 kJ/mol, it is likely that chemical decarboxylation of pyruvate produces more than 69 kJ of free energy/mol under standard conditions.

16. Which ONE of the following statements concerning the Krebs cycle in Soon yi's muscle mitochondria is INCORRECT?

a) The first turn of the Krebs cycle will release, as 2 $CO_2$, the two carbons that entered the cycle as acetyl CoA (in the first citrate synthase reaction).

b) The compound below is the intermediate in the Krebs Cycle likely found in lowest concentration in the mitochondrial matrix and can limit the overall rate of the Krebs cycle:



c) The action of the four dehydrogenase enzymes in the cycle generate 3 molecules of NADH and 1 molecule of $FADH_2$ ($QH_2$) for one turn of the cycle.

d) The one substrate level phosphorylation reaction in the Krebs cycle produces GTP.

17. Which ONE of the following is INCORRECT?

a) The number of molecules of ATP produced during mitochondrial oxidative phosphorylation (coupled to electron transport) is related to the number of protons pumped across the inner mitochondrial membrane during electron transport.

b) The production of ATP by $FoF_1$ATPase will generate water, as a result of the formation of an anhydride bond in ATP.

c) The production of ATP in substrate level phosphorylation reactions does not involve a net release of water.

d) Water is a good electron acceptor in mitochondrial electron transport because it is such a poor oxidizing agent.

**Continued...**

18. Which ONE of the following concerning oxidative phosphorylation is INCORRECT?

a) In respiring cells it can be shown that the mitochondrial matrix is more alkaline when compared with the mitochondrial intermembrane space.

b) If the standard free energy available in mitochondrial NADH is about -220 kJ/mol, more than 50% of this reduction potential is conserved as ATP by the action of electron transport and oxidative phosphorylation.

c) The introduction of a channel or pore in the inner mitochondrial membrane can lead to a loss of mitochondrial ATP production in respiring cells.

d) When 2,4-DNP is added to mitochondria, ATP synthesis stops but electron transport will continue and the energy lost during electron transport will likely be released as heat.

19 Which ONE of the following is INCORRECT?

a) In muscle, NADH generated by glyceraldehyde-3-phosphate dehydrogenase in aerobic glycolysis yields less ATP than does NADH generated by the PDH complex.

b) In muscle, one molecule of 16:0 CoA will yield more than 3 times the ATP generated by one molecule of α-D-glucose (considering complete breakdown of each substrate).

c) Most of the water produced by the complete breakdown of α-D-glucose as a result of aerobic glycolysis, Krebs Cycle, electron transport and oxidative phosphorylation comes from the last oxidation/reduction reaction in electron transport.

d) The production of lactate in cramping muscle leads to a loss of mitochondrial ATP production using α-D-glucose as fuel, but this loss can be recovered if lactate is converted back to pyruvate.

20. Soon-yi has breakfast following her morning exercise. Which ONE of the following is INCORRECT?

a) Antioxidants are found in green tea, tomatoes, certain beans and a variety of berries.

b) Oils rich in linoleic acid (corn, sunflower oils) are considered less desirable than those enriched in monounsaturates (olive, canola oils).

c) Coconut and palm oils are enriched in saturates.

d) Flax, canola and soybean oils all have $CH_3$-$CH_2$-CH=CH-$CH_2$-CH=CH-$CH_2$-CH=CH-$(CH_2)_7$-COOH as their principal omega 6 fatty acid.

21. Which ONE of the following signaling events does NOT happen after insulin binds to its receptor on a muscle cell? (Consider blood glucose levels are rising.)

a) Glycogen synthase is activated

b) Several phosphorylated enzymes lose their phosphate groups.

c) Protein phosphatase 1 inactivates protein kinase A (PKA) by dephosphorylation.

d) There is an increased production of UDP-glucose that supports glycogen synthesis.

22. When Soon-yi is at the 32 km mark in her marathon in Beijing, which ONE of the following is INCORRECT?

a) Adrenaline and glucagon are the dominant hormones controlling energy metabolism.

b) In muscle, glycolysis rates are dropping significantly because pyruvate kinase activity and PFK-2 are phosphorylated and inactivated by PKA.

c) The small coffee Soon-yi consumed before the race allows a greater mobilization of her fat, by prolonging the activation of PKA.

d) If Soon-yi had no glycogen reserves at the 32 km mark her subsequent speeds would decrease substantially.

23. Which ONE of the following does NOT follow from the binding of adrenaline to its receptor at the fat cell surface? (Consider a fasting situation where blood glucose levels are falling.)

a) PKA activates hormone sensitive lipase.

b) There follows a release of three fatty acids and the compound: $CH_2OH$-CHOH-$CH_2OH$ from triglyceride stores in the fat cell.

c) There is an increased rate of activity of the enzymes hormone sensitive lipase and monoglyceride lipase.

d) Fatty acids are taken up principally by circulating lipoproteins for delivery to muscle cells and other tissues.

**Continued...**

24. Which ONE of the following is NOT an important feature of fatty acid catabolism by Soon-yi's muscle cells?

a) Acyl CoA synthetase utilizes CoASH, ATP and fatty acids and is assisted in its activity by the actions of inorganic pyrophosphatase and adenylate kinase.

b) Carnitine can exist as 2 different stereoisomers and it is the L-carnitine that is active in the carnitine shuttle system.

c) CAT I will catalyze the formation of an ester bond between the hydroxyl group of L-carnitine and a fatty acid.

d) CAT II promotes the formation of the fatty acyl CoA within the mitochondrial matrix by promoting hydrolysis of acylcarnitine.

25. Which ONE of the following is INCORRECT for the following compound:

$CH_3\text{-}(CH_2)_{12}\text{-}C(=O)\text{-}CH_2\text{-}C(=O)\text{-}S\text{-CoA}$ (formed using the substrate 16:0 CoA in β-oxidation)?

a) The compound is a β-ketoacyl CoA

b) The compound is produced in an oxidation-reduction reaction in which NADH is oxidized to $NAD^+$.

c) The compound can be used as substrate in a reaction that produces acetyl CoA

d) The enzymatic release of acetyl CoA from the compound is accompanied by the production of 14:0 CoA.

26. Which ONE of the following is INCORRECT?

a) The complete breakdown of 16:0 CoA within mitochondria yields considerable water, and most of this water produced comes from the metabolism of acetyl CoA within the Krebs cycle with associated electron transport and oxidative phosphorylation.

b) In gluconeogenesis Soon-yi utilizes glycerol released from triglyceride to generate glycerol phosphate as a 3C precursor in glucose synthesis.

c) Following glucagon binding to its receptor on a liver cell, levels of β-D-fructose-2,6-bisphosphate will rise, resulting in reduced rates of liver glycolysis.

d) Gluconeogenesis requires the activities of fructose-1,6-bisphosphatase and glucose-6-phosphatase, enzymes found in liver.

27. Considering the Case Study Julian, which ONE of the following is INCORRECT?

a) If Julian (height 125 cm) began a physical activity program and reduced his weight to 38 kg he would have a BMI of 24.3

b) If Julian now eats more reasonably and restricts himself to 25 g of protein, 20 g of fat and 125 g of carbohydrate per meal, this will provide 780 kcal.

c) Arachidonic acid is an omega 6 fatty acid and can be made in the body using linoleate in the diet.

d) While monounsaturated fats and 18:2 can decrease blood LDL levels, 18:2 will also greatly increase HDL levels.

28. Julian synthesizes fat using excess carbohydrate from his carbohydrate rich diet. Which ONE of the following is INCORRECT?

a) Acetyl CoA in Julian's liver can be converted into the compound:

$^{-}OOC\text{-}CH_2\text{-}C(=O)\text{-}S\text{-}CoA$ by the action of acetyl CoA carboxylase.

b) Biotin is an important coenzyme within fatty acid synthase.

c) Rising insulin levels will promote both the synthesis of fatty acids and the synthesis of triglycerides.

d) Malonyl CoA can inhibit the acylation of L-carnitine and is also used to form growing fatty acid chains by fatty acid synthase.

29. Which ONE of the following symptoms or signs was NOT shown by Adil in his diabetes?

a) Increased rates of glycogen breakdown

b) Increased loss of water (polyuria)

c) Increased rates of malonyl CoA production

d) Increased fatty acid mobilization.

**Continued...**

30. Which ONE of the following concerning $CH_3$-C(=O)-$CH_2$-$COO^-$ is INCORRECT?

a) It is produced during ketogenesis and can be converted into β-hydroxybutyrate or acetone.

b) Banting's diabetic patients generally had elevated levels of this compound in their blood, before they received insulin.

c) The compound is acetoacetate and contributes to the increased ketosis and increased blood osmolality seen in diabetics.

d) The compound can be made in diabetic mitochondria mainly when there is a very low level of mitochondrial acetyl CoA.

## Part B: Short Answer Section (15 Marks)

**Please answer all FOUR questions (#31-34) in the ruled exam books provided.**

31. Nat Case Study: What is EPA and how can it reduce platelet aggregation? (2 marks)

32. Giving molecular structures, indicate how a fresh solution of α-D-glucose in water initially shows an optical rotation of polarized light of $+112^o$ but with time the optical rotation declines until the solution shows a stable optical rotation of $+50^o$ (2 marks).

33. Soon-yi Case Study:

a) Give the enzyme reaction in glycolysis that uses PEP to make ATP. Name the enzyme, substrates and products and give the structure of the compound with highest phosphate transfer potential. (1 mark)

b) Explain how rising $[Ca^{2+}]$ in muscle cells promotes the restoration of the activity of inactive PDH complex. (1 mark)

c) Name the components of Complex I in the mitochondrial inner membrane and show how they interact during electron transfer. (1 mark)

d) Describe how insulin, interacting with muscle, can cause a great increase in glucose entry into muscle cells. (1 mark)

e) "Hitting the wall" during running comes from a rapid loss of glycogen reserves when both fat and carbohydrate fuels are used for energy.
Runners who have low levels of this enzyme catalysed reaction are particularly at risk: $CH_3$-C(=O)-$COO^-$ + ATP + $HCO_3^-$ → $^-OOC$-$CH_2$-C(=O)-$COO^-$ +ADP + Pi
From this result, what mechanism might explain the need for glycolysis to support the efficient use of fatty acid fuels by muscle? (2 marks)

**CONTINUED...**

34. You are on a canoe trip with a number of young campers ages 12-14, one of whom, Danielle, has been diabetic since age 9. Halfway into the trip and during a difficult midmorning portage Danielle collapses and falls unconscious. (A portage happens when you carry the canoe from one lake to another.)

a) What might be the cause of Danielle's loss of consciousness?
Give two possible explanations (2 marks)

b) How could you determine (on the canoe trip) which cause is more likely?
(1 mark)

c) If you find out that Danielle took her usual insulin injection last evening, but she was not feeling well overnight and skipped breakfast-

i) What would you do if she briefly regained consciousness? (1 mark)

ii) If Danielle does **not** regain consciousness and you could obtain one hormone that you could give Danielle by injection, which one would you chose and what would it do? (1 mark)