FACULTY OF SCIENCE

DEPARTMENT OF BIOCHEMISTRY

MODULE : BIC02B2/BIC 2B01

CAMPUS : APK

SUPPLIMENTARY EXAM

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DURATION: 3 HOURS	**MARKS: 100**

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Please read the following instructions carefully

1. Answer all the questions.
2. Answer all the questions in the exam answer sheet/book provided.
3. Hand in the question paper and answer sheets/book.

Section A [50]

1. In presence of the following cofactor, pyruvate carboxylase converts pyruvate to oxaloacetate:

a) ATP, protein and CO_2

b) CO_2 and ATP

c) CO_2

d) protein

e) ATP

2. Electron transport and phosphorylation can be uncoupled by compounds that increase the permeability of the inner mitochondrial membrane of

a) electrons

b) protons

c) uncouplers

e) neutrons

d) divalent cations

3. All of the following statements about the enzyme complex that carries out the synthesis of ATP during oxidative phosphorylation are correct except

a) it is located on the matrix side of the inner mitochondrial membrane

b) it is inhibited by oligomycin

c) it can exhibit ATPase activity

d) it can bind molecular O_2

e) both (a),(b) and (c) are correct

4. The free energy change, ΔG

a) is directly proportional to the standard free energy change, ΔG

b) is equal to zero at equilibrium

c) can only be calculated when the reactants and products are present at 1mol/1 concentrations

d) is equal to –RT in keq

e) none of the above are correct

5. The conversion of pyruvate to acetyl-CoA and CO_2

a) is reversible

b) Involves the participation of lipoic acid

c) depends on the coenzyme biotin

d) occurs in the cytosol

e) occurs in the inner membrane of mitochondria

6. The "Cori" cycle is the

a) synthesis of glucose

b) reuse of glucose

c) uptake of glycose

d) both (a) & (b) are correct

e) break down of glucose

7. Cane sugar is known as

a) galactose

b) sucrose

c) fructose

d) maltose

e) glucose

8. Which of the following is not a reducing sugar?

a) lactose

b) maltose

c) sucrose

d) fructose

e) glucose

9. A dissaccharide linked by α-1-4 glycosidic linkages is

a) lactose

b) sucrose

c) cellulose

d) maltose

e) glucose

10. Glucose-6-phosphatase is not present in

a) liver and kidneys

b) kidneys and muscles

c) kidneys and adipose tissue

d) muscles and adipose tissue

e) heart and liver

11. In cellular respiration, energy-depleted electrons are donated to an inorganic molecule. In fermentation, what molecule accepts these electrons?

a) oxygen

b) an organic molecule

c) sulphur

d) an inorganic molecule other than O_2

e) water

12. The electrons generated from the Krebs cycle are transferred to _____ and then are shuttled to _____.

a) NAD^+ / oxygen

b) NAD^+ / electron transport chain

c) NADH / oxygen

d) NADH / electron transport chain

e) NADPH/oxygen

13. The final electron acceptor in lactic acid fermentation is:

a) pyruvate

b) NAD^+

c) lactic acid

d) O_2

e) water

14. How many molecules of CO_2 are produced for each molecule of glucose that passes through glycolysis and the Krebs' cycle?

a) 2

b) 3

c) 6

d) 7

e) 4

15. Cellular respiration harvests the most chemical energy from which process?

a) converting oxygen to ATP

b) generating carbon dioxide and oxygen in the electron transport chain

c) transferring electrons from organic molecules to oxygen

d) substrate-level phosphorylation

e) forming lactate from pyruvate

16. A major function of the mitochondrial inner membrane is the conversion of energy from electrons to the stored energy of the phosphate bond in ATP. To accomplish this function, this membrane must have all of the following features except

a) proton pumps embedded in the membrane

b) integral, transverse ATP synthase

c) the electron transport chain of proteins

d) proteins to accept electrons from NADH

e) high permeability to protons

17. When hydrogen ions are pumped from the mitochondrial matrix across the inner membrane and into the intermembrane space, the result is

a) the formation of ATP

b) the creation of a proton gradient

c) the restoration of the Na^+-K^+ balance across the membrane

d) the reduction of NAD^+

e) the lowering of pH in the mitochondrial matrix

18. Where is ATP synthase located in the mitochondrion?

a) cytochrome system

b) inner membrane

c) ribosomes

d) outer membrane

e) matrix

19. Which of the following statements concerning the breakdown of glucose to CO_2 and water is (are) true?

a) adding electrons to a substance is known as reduction.

b) the breakdown of glucose is exergonic.

c) an electron acceptor is called the reducing agent.

d) A and B only are correct.

e) a), b), and c) are correct.

20. The oxygen consumed during cellular respiration is directly involved in

a) the oxidation of pyruvate to acetyl-CoA.

b) accepting electrons at the end of the electron transport chain.

c) glycolysis.

d) the citric acid cycle.

e) the phosphorylation of ADP.

21. All of the following statements about NAD^+ are true except:

a) NAD^+ is reduced to NADH during both glycolysis and the Krebs' cycle.

b) NAD^+ is reduced by the action of dehydrogenases.

c) NAD^+ can receive electrons for use in oxidative phosphorylation.

d) NAD^+ has more chemical energy than NADH.

e) In the absence of NAD^+, glycolysis cannot function.

22. Glycolysis is believed to be one of the most ancient of metabolic processes. Which statement below least supports this idea?

a) glycolysis is found in all eukaryotic cells.
b) bacteria, the most primitive of cells, make extensive use of glycolysis.
c) the enzymes of glycolysis are found in the cytosol rather than in a membrane-enclosed organelle.
d) glycolysis neither uses nor needs O_2.
e) If run in reverse, glycolysis will build glucose molecules.

23. Which kind of metabolic poison would most directly interfere with glycolysis?

a) an agent that binds to pyruvate and inactivates it
b) an agent that reacts with oxygen and depletes its concentration in the cell
c) an agent that closely mimics the structure of glucose but is not metabolized
d) an agent that inhibits the formation of acetyl coenzyme A
e) an agent that reacts with NADH and oxidizes it to NAD^+

24. Which process in eukaryotic cells will normally proceed whether O_2 is present or absent?

a) oxidative phosphorylation
b) fermentation
c) electron transport
d) glycolysis
e) the Krebs' cycle

25. In addition to ATP, what are the end products of glycolysis?

a) CO_2 and H_2O
b) H_2O and ethyl alcohol
c) NADH and pyruvate
d) CO_2 and ethyl alcohol
e) CO_2 and NADH

26. All of the following are functions of the Krebs' cycle except the

a) production of ATP
b) adding electrons and protons to oxygen to form water
c) production of $FADH_2$
d) production of NADH
e) release of carbon dioxide

27. Fructose-2,6-biphosphate is formed by the action of the enzyme.

a) phosphofructokinase-1

b) phosphofructokinase-2

c) fructose biphosphate isomerase

d) fructose-1, 6-biphosphatase

e) phosphofructokinase

28. How many ATP equivalents per mole of glucose input are required for gluconeogenesis?

a) 2

b) 6

c) 8

d) 4

e) 3

29. A young relative of yours has never had much energy. He goes to a doctor for help and is sent to the hospital for some tests. There they discover his mitochondria can use only fatty acids and amino acids for respiration, and his cells produce more lactate than normal. Of the following, which is the best explanation of his condition?

a) his cells contain something that inhibits oxygen use in his mitochondria

b) his cells cannot move NADH from glycolysis into the mitochondria

c) his cells lack the enzyme in glycolysis that forms pyruvate

d) his mitochondria lack the transport protein that moves pyruvate across the outer mitochondrial membrane

e) his cells have a defective electron transport chain, so glucose goes to lactate instead of to acetyl CoA

30. The free energy change, ΔG

a) is directly proportional to the standard free energy change, ΔG

b) is equal to zero at equilibrium

c) can only be calculated when the reactants and products are present at 1mol/1 concentrations

d) is equal to –RT in keq

e) none of the above are correct

31. A catabolic intermediate which stimulates phosphofructokinase would stimulate

a) gluconeogenesis

b) glycolysis

c) glycogen synthesis

d) none of the above

e) all of the above

32. The following characteristic(s) is/are associated with catabolic reactions

a) breakage of covalent bonds

b) energy production

c) oxidation of NADH

d) only a) and b) are correct

e) all a), b) and c) are correct

33. During electron transport, protons are not pumped out at this site

a) complex I

b) complex II

c) complex III

d) complex IV

e) complex V

34. What is the cause of the genetic disease known as Galactosemia?

a) deficiency in lactase

b) absence of galactose 1-phosphate uridyl transferase

c) absence of lactose synthetase

d) non-functioning of semnase

e) UDP-glucose 4-epimase

35. Consider the following reaction:

Fructose 6-phosphate ↔ glucose 6-phosphate K_{eq} = 1.97 (at 25°C)

If the free energy change (ΔG) is -4.4 kJ/mol and the concentration of glucose 6-phosphate is adjusted to 500 mM, what would be the concentration of fructose-6-phosphate at 25°C? [R= 8.315 J/mol.K]

a) 1.5 M

b) 1.5 mM

c) 0.165 mM

d) 0.165 M

e) 0.33 M

36. The reaction A + B ⇆ C is an exothermic reaction; if an equilibrium mixture of A, B, and C is heated slowly, what would happen to the concentrations of each species?

a) All three concentrations decrease

b) All three concentrations increase

c) A and B increase, C decreases

d) A and B decrease, C increases

e) None of the above

37. The end product(s) of photosynthesis in plants are oxygen plus:

a) Glucose

b) Starch

c) Starch and Sucrose

d) Water

e) Glycogen

38. Photosynthesis takes place in two separate but dependant series of steps, the light reactions and the photosynthetic carbon reduction cycle; this second cycle (also known as the dark reaction / light independent stage / or the Calvin-(Benson-Bassham)* cycle) of photosynthesis occurs:

a) Only in the dark in intact plants

b) In the light and dark in intact plants

c) Only in the light in intact plants, although will work in the dark in a test-tube

d) None of the above

e) a and b are correct

39. If the concentration of a solute is the same both inside and outside the cell, what might you expect with regard to its transport by an active membrane transport protein?

a) Since there is no concentration gradient, no transport either in or out of the cell is possible

b) Movement of the solute across the membrane could occur and cause accumulation on one side of the membrane

c) The transport protein would have been saturated and no movement would occur

d) The solute must be phosphorylated before further transport can occur

e) Movement could not occur

40. Which statement is not true about G proteins?

a) They are integral membrane proteins

b) They are multi-subunit proteins consisting of α, β and γ subunits

c) They are activated by exchanging GDP for GTP

d) They act as transducers for hydrophilic signalling hormones

e) They are farnesylated proteins

41. The toxins from cholera and whooping cough both interfere with the proper functioning of

a) G proteins

b) DNA polymerase

c) ATP synthesis

d) protein kinase A

e) protein synthesis

42. Match the description "paracrine signal transduction" to the signalling transduction descriptions below:

a) signal to neighboring cells

b) signal to self

c) signal to distant organ cells

d) signalling to the pituitary from the adrenal gland

e) signal to the thyroid from the adrenal gland

43. The transporter required for import of long chain fatty acids into the mitochondrion is called

a) co-enzyme A

b) carnitine

c) aconitase

d) the pyruvate dehydrogenase complex

e) acyl carrier protein (ACP)

44. Ketone bodies are produced due to

a) starvation or prolonged fasting

b) excessive breakdown of fatty acids

c) diversion of acetyl-CoA by the liver

d) All of the above

e) None of the above

45. Ketone bodies

a) replace glucose as a major energy source during starvation

b) replace amino acids as a major energy source during starvation

c) examples are acetoacetate, acetone and 3-hydroxybutyrate

d) All of the above

Use Figure 1 below, showing the mechanism for freeing fatty acids from fat tissue stores to answer questions 46-49

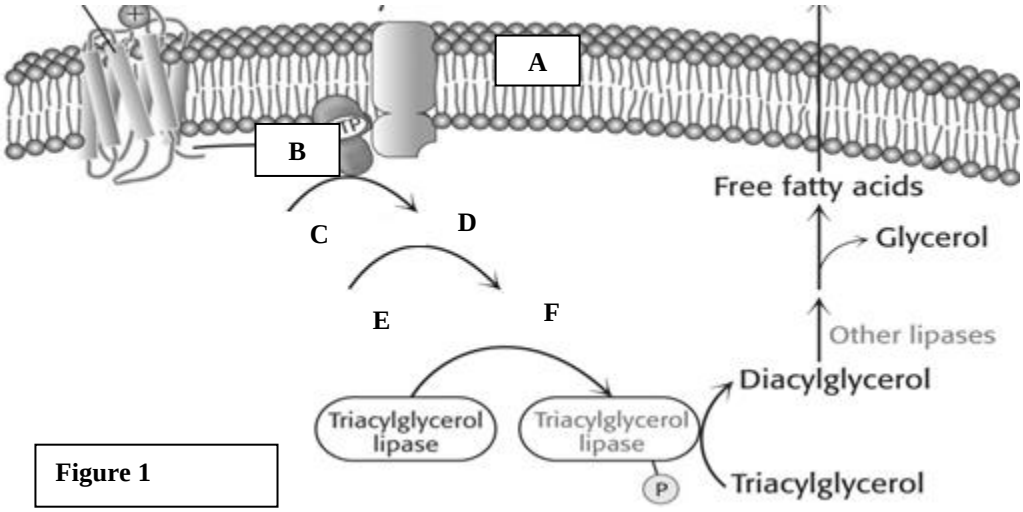


Figure 1

46. The protein labelled "A" is

a) an ATP-dependent phosphorylating enzyme

b) APD-ribosylating enzyme

c) a G protein

d) an adenylate cyclase enzyme

e) an NADH-dependent enzyme

47. The protein labelled "B" is

a) an ATP-dependent phosphorylating enzyme

b) APD-ribosylating enzyme

c) a G protein

d) an adenylate cyclase enzyme

e) an NADH dependant enzyme

48. C and D represent

a) ATP and cAMP, respectively

b) cAMP and ATP, respectively

c) cAMP and PKA

d) cGMP and GTP

e) ADP and ATP

49. E and F represent

a) ATP and cAMP, respectively

b) cAMP and ATP, respectively

c) inactive and active PKA, respectively

d) cGMP and GTP

e) ADP and ATP

50. Breakdown of fatty acids (beta-oxidation) in the cell occurs

a) in the cytoplasm and requires the action of PKA

b) in the mitochondrial inner membrane and requires an aconitase enzyme

c) in the mitochondrial matrix and requires an aconitase enzyme

d) in the mitochondrial matrix and requires an acyl carnitine transport

e) in the smooth ER

Section B [50]

Please note: Complete this section in your answer book.

CANDIDATES ARE REQUESTED, IN THEIR OWN INTERESTS, TO WRITE LEGIBLY

1. For the hydrolysis of 1 mole of ATP to ADP at 37 ˚C, the standard free enthalpy change $\Delta G^0 = -35$ kJ . mol-1. Calculate the free enthalpy change ***ΔG*** at the ratio ATP/ADP =100:1.

   (Temperature 37^0C, R = 8.3143 J K^{-1} mol^{-1}. Concentrations of water and inorganic phosphate are to be omitted from the equilibrium equation, assuming that they do not change significantly) **(5)**

ATP + H2O <-> ADP + Pi
100 1

$$\Delta G = -35\,000 + 8.3143 \times 310.15 \times \ln \frac{1}{100} =$$

$$= -35\,000 - 11\,875.26 =$$
$$= -46\,875.26 =$$
$$\cong -46.9 \text{ kJ mol } -1$$

2. Three molecules of Carbon Dioxide are evolved during complete oxidation of each of the two pyruvates in the TCA cycle. What are those reactions? **(3)**

Oxidative Decarboxylation of pyruvate to acetyl CoA (1)

Decarboxylation of Oxalosuccinate to α – Ketoglutarate (1)

Decarboxylation of α – Ketoglutarate to succinyl CoA (1)

3. Cyanide inhibits cytochrome c oxidase, a component of the electron transport chain. If cyanide poisoning occurs, would you expect the pH of the intermembrane space to increase or decrease? What effect would cyanide have on ATP synthesis? **(3)**

After cyanide poisoning, the electron transport chain can no longer pump electrons into the intermembrane space (1). The pH of the intermembrane space would increase (1), the pH gradient would decrease, and ATP synthesis would stop (1).

4. Compare and contrast the characteristics and functions of Photosystem II and Photosystem I in a process of photosynthesis. **(9)**

Photosystem II (PS II): oxidises H2O (1)

PS I: reduces NADP+ (1)

PS I: generates strong reducing agent that reduces NADP+ (1)

PS II: generates a strong oxidizing agent that oxidizes H2O (1)

PS I & PS II form a 2-step electron energizer. Both PS systems are necessary for photosynthesis (thus e-transfer from H2O to NADPH) (1).

PS I activated by far-red light, while yellow-green light stimulates PS II to provide electrons (1).

PS I & PS II are linked by cytochrome f = c-type cytochrome of ET (1).

O_2-producing photosynthesis mediated by 3 trans-membrane protein complexes linked by mobile carriers = embedded in thylakoid membrane (1)

Mobile carriers = Plastoquinone (Q) is reduced to plastoquinol (QH2) = links PS II to cytochrome b6-f complex, that in turn interacts with PS I via plastocyanin (P.C.) (1).

5. Discuss the absorption, mobilization and transport of dietary triacylglycerols **(8)**

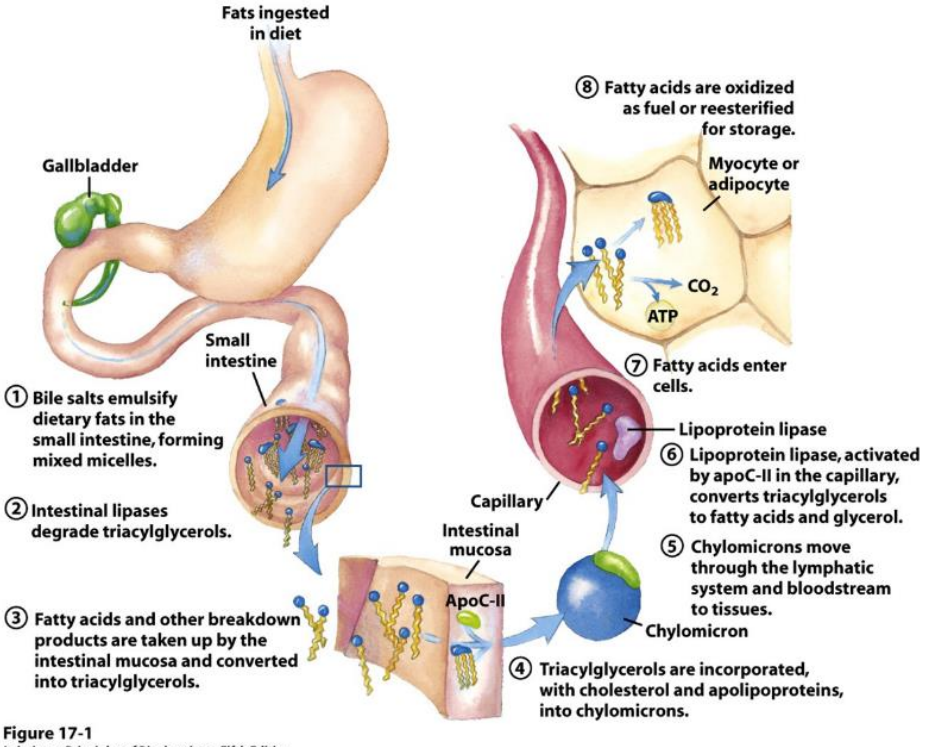
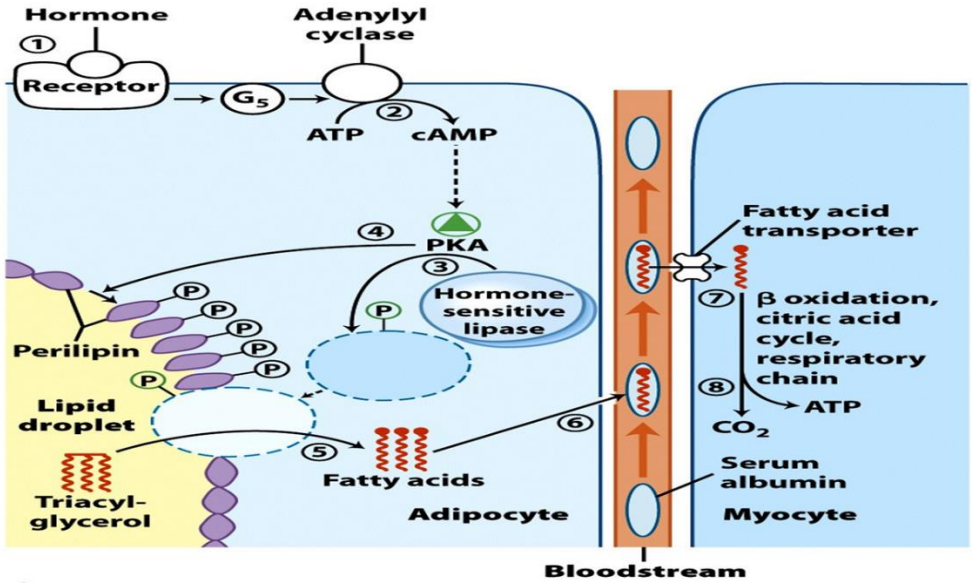


Figure 17-1
Lehninger Principles of Biochemistry, Fifth Edition

6. Discuss the mobilization of triacylglycerols stored in adipose tissue **(8)**



7. How are the fatty acids transported into the mitochondrion **(4)**

Activation and transfer to coenzyme A (CoA) carrier-------->Acyl-S-CoA (1)

Transfer to carnitine ----------→fatty acyl carnitine (1)

Transport (IM space ----------→ mitochondrial matrix) (1)

Removal of carnitine (1)

8. Ubiquitination requires three enzymes: Mention the enzymes and their functions **(6)**

ubiquitin-activating enzyme (E1)(1) ubiquitin-conjugating enzyme (E2) (1)

ubiquitin-protein ligase (E3) (1)

1. E1 forms a thio-esther bond with ubiquitin in a reaction that consumes one ATP (1).

2. E2 transfers the activated ubiquitin from E1 to itself, forming another thio-esther bond.(targets a protein for degradation) (1)

3. E3 transfers activated ubiquitin to the Lys ε-amino group of a previously selected target protein (condemned protein) (1).

9. What is the biochemical explanation of gout? **(4)**

Gout caused by elevated levels of uric acid in body fluids (1).
Poor/weak uric acid excretion due to crystals (sodium urate) that accumulates in joints (=inflammation) (1)

Reason: metabolic inefficiency, e.g. HGPRT-deficiency (hypoxanthine-guanine phosphoryl transferase) = PRPP accumulation, leads to excess uric acid production (1).
Overproduction of uric acid can also be caused by G-6-Ptase deficiency (Von Gierke's glycogen storage disease): high [G-6-P] = stimulates Pentose Phosphate Pathway = elevated [ribose-5-phosphate] = elevated PRPP = stimulates purine biosynthesis (1).

TOTAL = 100 marks