Mount Kenya University

UNIVERSITY EXAMINATION 2020/2021

MEDICAL SCHOOL
DEPARTMENT OF MEDICAL BIOCHEMISTRY

BACHELOR OF MEDICINE AND BACHELOR OF SURGERY
PAPER C
REGULAR

UNIT CODE: MBMB1200 **UNIT TITLE: MEDICAL BIOCHEMISTRY I**

(MBMB 1236A: BIOENERGETICS AND CARBOHYDRATE METABOLISM AND BIOENERGETICS, MBMB 1336B: LIPID METABOLISM AND MBMB 1236C: NITROGEN METABOLISM)

DATE: FRI 9TH JULY 2021 8.00AM **MAIN EXAM** **TIME: 3 HOURS**

INSTRUCTIONS: Answer All Questions in section A and B and two questions in section C

SECTION A : MULTIPLE CHOICE QUESTIONS [35 MARKS]

1. Which of the following is *not* true of the reaction catalyzed by the pyruvate dehydrogenase complex?
   A. Biotin participates in the decarboxylation.
   B. Both NAD^+ and a flavin nucleotide act as electron carriers.
   C. The reaction occurs in the mitochondrial matrix.
   D. The substrate is held by the lipoyl-lysine "swinging arm."
   E. Two different cofactors containing —SH groups participate.

2. Which of the below is *not* required for the oxidative decarboxylation of pyruvate to form acetyl-CoA?
   A. ATP
   B. CoA-SH
   C. FAD
   D. Lipoic acid
   E. NAD+

3. Which of the following is *not* true of the citric acid cycle?
   A. All enzymes of the cycle are located in the cytoplasm, except succinate dehydrogenase, which is bound to the inner mitochondrial membrane.
   B. In the presence of malonate, one would expect succinate to accumulate.
   C. Oxaloacetate is used as a substrate but is not consumed in the cycle.
   D. Succinate dehydrogenase channels electrons directly into the electron transfer chain.
   E. The condensing enzyme is subject to allosteric regulation by ATP and NADH.

4. Which of the following is *not* an intermediate of the citric acid cycle?
   A. Acetyl-CoA
   B. Citrate
   C. Oxaloacetate
   D. Succinyl-CoA
   E. a-Ketoglutarate

5. In mammals, each of the following occurs during the citric acid cycle *except*:
   A. Formation of a-ketoglutarate.
   B. Generation of NADH and $FADH_2$.
   C. Metabolism of acetate to carbon dioxide and water.
   D. Net synthesis of oxaloacetate from acetyl-CoA.
   E. Oxidation of acetyl-CoA.

6. Citrate synthase and the NAD^+-specific isocitrate dehydrogenase are two key regulatory enzymes of the citric acid cycle. These enzymes are inhibited by:
   A. Acetyl-CoA and fructose 6-phosphate.
   B. AMP and/or NAD^+.

C. AMP and/or NADH.
D. ATP and/or NAD^+.
E. ATP and/or NADH.

7. The glyoxylate cycle is:
A. A means of using acetate for both energy and biosynthetic precursors.
B. An alternative path of glucose metabolism in cells that do not have enough O_2.
C. Defective in people with phenylketonuria.
D. Is not active in a mammalian liver.
E. The most direct way of providing the precursors for synthesis of nucleic acids (e.g., ribose).

8. Entry of acetyl-CoA into the citric acid cycle is *decreased* when:
A. [AMP] is high.
B. NADH is rapidly oxidized through the respiratory chain.
C. the ratio of [ATP]/[ADP is low
D. the ratio of [ATP]/[ADP] is high.
E. the ratio of [NAD^+]/[NADH] is high.

9. Intermediates in the citric acid cycle are used as precursors in the biosynthesis of:
A. Amino acids.
B. Nucleotides.
C. Fatty acids.
D. Sterols.
E. All of the above

10. The conversion of 1 mol of pyruvate to 3 mol of CO_2 via pyruvate dehydrogenase and the citric acid cycle also yields ____ mol of NADH, ____ mol of $FADH_2$, and ____ mol of ATP (or GTP).
A. 2; 2; 2
B. 3; 1; 1
C. 3; 2; 0
D. 4; 1; 1
E. 4; 2; 1

10. Which of the following is *not* required in the synthesis of fatty acids?
A) Acetyl-CoA

B) Biotin

C) HCO_3^- (CO_2)

D) Malonyl-CoA

E) NADH

11. Carnitine is:

A) a 15-carbon fatty acid.

B) an essential cofactor for the citric acid cycle.

C) essential for intracellular transport of fatty acids.

D) one of the amino acids commonly found in protein.

E) present only in carnivorous animals.

12. Which of the following is *not* true of the reaction producing malonyl-CoA during fatty acid synthesis?

A) It is stimulated by citrate.

B) It requires acyl carrier protein (ACP).

C) It requires CO_2 (or bicarbonate).

D) One mole of ATP is converted to ADP + P_i for each malonyl-CoA synthesized.

E) The cofactor is biotin.

13. Which of these is able to cross the inner mitochondrial membrane?

A) Acetyl–CoA

B) Fatty acyl–carnitine

C) Fatty acyl–CoA

D) Malonyl–CoA

E) None of the above can cross.

14. What is the correct order of function of the following enzymes of □ -oxidation?

1. β-Hydroxyacyl-CoA dehydrogenase
2. Thiolase
3. Enoyl-CoA hydratase
4. Acyl-CoA dehydrogenase

A) 1, 2, 3, 4

B) 3, 1, 4, 2

C) 4, 3, 1, 2
D) 1, 4, 3, 2
E) 4, 2, 3, 1

15. The rate-limiting step in fatty acid synthesis is:
A) condensation of acetyl-CoA and malonyl-CoA.
B) formation of acetyl-CoA from acetate.
C) formation of malonyl-CoA from malonate and coenzyme A.
D) the reaction catalyzed by acetyl-CoA carboxylase.
E) the reduction of the acetoacetyl group to a □-hydroxybutyryl group.

16. In comparing fatty acid biosynthesis with □ oxidation of fatty acids, which of the following statements is *incorrect*?

A) A thioester derivative of crotonic acid (*trans*-2-butenoic acid) is an intermediate in the synthetic path, but not in the degradative path.
B) A thioester derivative of D-□-hydroxybutyrate is an intermediate in the synthetic path, not in the degradative path.
C) Fatty acid biosynthesis uses NADPH exclusively, whereas □ oxidation uses NAD^+ exclusively.
D) Fatty acid degradation is catalyzed by cytosolic enzymes; fatty acid synthesis by mitochondrial enzymes.
E) The condensation of two moles of acetyl-CoA in the presence of a crude extract is more rapid in bicarbonate buffer than in phosphate buffer at the same pH; the cleavage of acetoacetyl-CoA proceeds equally well in either buffer.

17. Which of these can be synthesized by plants but *not* by humans?
A) Linoleate [18:2($\Delta^{9,12}$)]
B) Palmitate (16:0)
C) Phosphatidylcholine
D) Pyruvate
E) Stearate (18:0)

18. The biosynthesis of triacylglycerols from acetate occurs mainly in:
A) Animals but not in plants.
B) Humans after ingestion of excess carbohydrate.

C) Humans with low carbohydrate intake.
D) Plants but not in animals.
E) None of the above

19. Transport of fatty acids from the cytoplasm to the mitochondrial matrix requires:
A) ATP, carnitine, and coenzyme A.
B) ATP, carnitine, and pyruvate dehydrogenase.
C) ATP, coenzyme A, and hexokinase.
D) ATP, coenzyme A, and pyruvate dehydrogenase.
E) Carnitine, coenzyme A, and hexokinase.

20. Precursors of polyamines are:
A. Arginine and Methionine
B. Arginine and Asparagine
C. Arginine and Glutamine
D. Arginine and Lysine
E. Arginine and Serine

21. Which of the following is a recognized effect of nitric oxide?
A. Arrhythmia
B. Bronchoconstriction
C. Constipation
D. Inhibition of acute graft rejection
E. Pulmonary vasodilation

22. Which of the following chemicals is most likely to function as a neurotransmitter in hierarchical systems?
A. *Dopamine*
B. *Glutamate*
C. *Metenkephalin*
D. Norepinephrine
E. Serotonin

23. Which of the following steps of pyrimidine biosynthesis occurs in mitochondria?
A. Synthesis of carbamoyl phosphate catalyzed by CPS II

B. Conversion of carbamoyl phosphate to carbamoyl aspartate catalyzed by aspartate transcarbamoylase
C. Synthesis of dihydroorotate catalyzed by dihydroorotase
D. Formation of orotic acid catalyzed by dihydroorotase dehydrogenase
E. All the above

24. Orotic aciduria is an inherited genetic disorder caused by a deficiency of the following enzyme:

A. OMP decarboxylase
B. CPS II
C. Aspartate transcarbamoylase
D. Dihydroorotase dehydrogenase
E. IMP synthase

25. Fluorouracil is an anti-tumor agent that binds and irreversibly inhibits which of the following enzyme:

A. Ribonucleotide reductase
B. Dihydrofolate reductase
C. PRPP-amidotransferase
D. Thymidylate synthase
E. None of the above

26. Which of the following is not the precursor for the *de novo* purine biosynthesis?

A. Aspartic Acid
B. Glycine
C. Glutamine
D. Arginine
E. All the above

27. Which of the following serves as the cofactor for the *de novo* synthesis of purine metabolism?

A. Thiamine
B. Biotin
C. Folate
D. Flavin

E. All the above

28. What is an activator of the enzyme "Glutamine: Phosphoribosylpyrophosphate amidotransferase" a committed step of de novo biosynthesis of purines?

A. Adenosine Monophosphate
B. Guanosine Monophosphate
C. Inosine Monophosphate
D. Phosphoribosyl Pyrophosphate
E. Adenosine diphosphate

29. Trimethoprim is a potent antibacterial compound that selectively inhibits bacterial:

A. Formyltransferase
B. PRPP synthetase
C. Dihydrofolate reductase
D. Carbamoyl phosphate synthetase II
E. None of the above

30. Which one of the following is the coenzyme for the synthesis of deoxyribonucleotides catalyzed by an enzyme ribonucleotide reductase?

A. Glutathione
B. Thioredoxin
C. NADPH
D. FADH
E. $NADH_2$

31. Severe combined immunodeficiency disease is caused by the deficiency of the following enzymes?

A. AMP deaminase
B. Adenosine deaminase
C. PRPP synthetase
D. Dihydroorotase
E. None of the above

32. A one year old female patient is anemic. Her urine contain as elevated level of orotic acid. The intake of which one of the following compounds is most likely to control her condition:

A. Thymidine
B. Hypoxanthine
C. Uridine
D. Allopurinol
E. Adenine

33. Bilirubin is produced from catabolism of protoporphyrin IX by a microsomal enzyme in a two reaction step. The first step involves the opening of the tetrapyrrole ring to form biliverdin which is further reduced to form bilirubin. What are the enzymes responsible for these two steps?

A. Heme dehydrogenase and Bilirubin oxygenase
B. Heme oxygenase and Biliverdin reductase
C. Heme carboxylase and Biliverdin reductase
D. Heme deoxygenase and Biliverdin reductase
E. Heme oxygenase and Bilirubin reductase

34. The unconjugated bilirubin (non-polar form) is converted into more polar form by conjugating with glucuronic acid. The stepwise addition of two glucuronic acids to bilirubin results in bilirubin diglucuronides. The enzyme that catalyzes the formation of bilirubin diglucuronide is

A. Biliverdin UDP-gluronyltransferase
B. Bilirubin UDP-glucuronides synthase
C. Bilirubin UDP-glucuronides mutase
D. Bilirubin UDP-glucuronosyltransferase
E. Bilirubin UDP-glucuronosyl isomerase

35. In the intestine, bacterial degradation of bilirubin forms urobilinogen. Urobilinogen is a colorless bilirubin derived product which is further oxidized to form the following pigments except

A. Urobilin
B. Mesobilin
C. (B) and (C) above

D. Stercobilin
E. Exobilin

SECTION B : ANSWER ALL QUESTIONS [25 MARKS]

36. a) Briefly discuss TWO inhibitors of the ETC and oxidative phosphorylation (3 Marks)

b) List the TWO laws of thermodynamics (2 Marks)

37. Write short notes and use illustrations where necessary on the synthesis of mevalonate (5 Marks)

38. a) List TWO ways in which a patient of phenylketonuria can be diagnosed. (2 Marks)

b) Name the product formed in the reaction catalyzed by each enzyme below: (3 Marks)

i) Purine nucleotide phosphorylase
ii) Glutamic acid decarboxylase (GAD)
iii) Cystathionine lyase

39. a) List THREE secondary bile salts synthesized from cholesterol. (3 Marks)

b) Explain how NADH from the cytosol enters the mitochondria to participate in the electron transport chain and oxidative phosphorylation? (2 Marks)

40. a) Write down the chemical equation for the salvage of guanine. (3 Marks)

b) List FOUR key enzymes involved in the cycling steps of fatty acid synthesis (2 Marks)

SECTION C : ANSWER ANY TWO QUESTIONS [40 MARKS]

41. a) Discuss in detail the importance of the hexose monophosphate shunt. (10 Marks)

b) Describe the complete biosynthetic pathway for Uridine-5'-monophosphate. (10 Marks)

42. a) Discuss using illustrations the activation phase of glycolysis. (10 Marks)

b) Using illustrations discuss beta oxidation of fatty acids and its importance in the body. (10 Marks)

43. a) Show the complete biosynthetic pathway for catecholamines. (10 Marks)

b) Using illustrations indicate the ketone body synthesis pathway. (10 Marks)