CHAPTER > 14

Respiration in Plants

NEET KEY NOTES

- **Cellular respiration** It is the mechanism of breakdown of food materials within the cell to release energy and trapping of this energy for synthesis of ATP.
- The process by which breaking of the C—C bonds of complex compounds through oxidation within the cells, leading to release of considerable amount of energy is called **respiration**.
- The compounds that are oxidised during the process of respiration are called **respiratory substrates**. Usually carbohydrates are oxidised to release energy, but proteins, fats and even organic acids can be used as respiratory substrates in some plants, under certain conditions.
- During the process of oxidation of food within a cell, all the energy contained in the respiratory substrates is not released free into the cell, or in a single step. Instead, it gets released in a series of slow stepwise reactions controlled by enzymes and it is trapped as chemical energy in the form of **ATP**, which is considered as the **energy currency of the cell**.

Do Plants Breathe?

- For the process of respiration, plants take O_2 and release CO_2.
- The plants have stomata and lenticels for gaseous exchange instead of specialised organs.
- There are several reasons why plants can get along without respiratory organs.
  - First, each plant part takes care of its own gaseous exchange needs. There is very little transport of gases from one plant part to another.
  - Second, plants do not have great demands for gas exchange. Roots, stems and leaves respire at rates for lower than animal do.
  - Third, the distance that gases must diffuse even in large, bulky plant is not great. Each living cell in a plant is located quite close to the surface of the plant.

Combustion of Glucose

- The complete combustion of glucose, which produces CO_2 and H_2O as end products, yield energy most of which is given out as heat

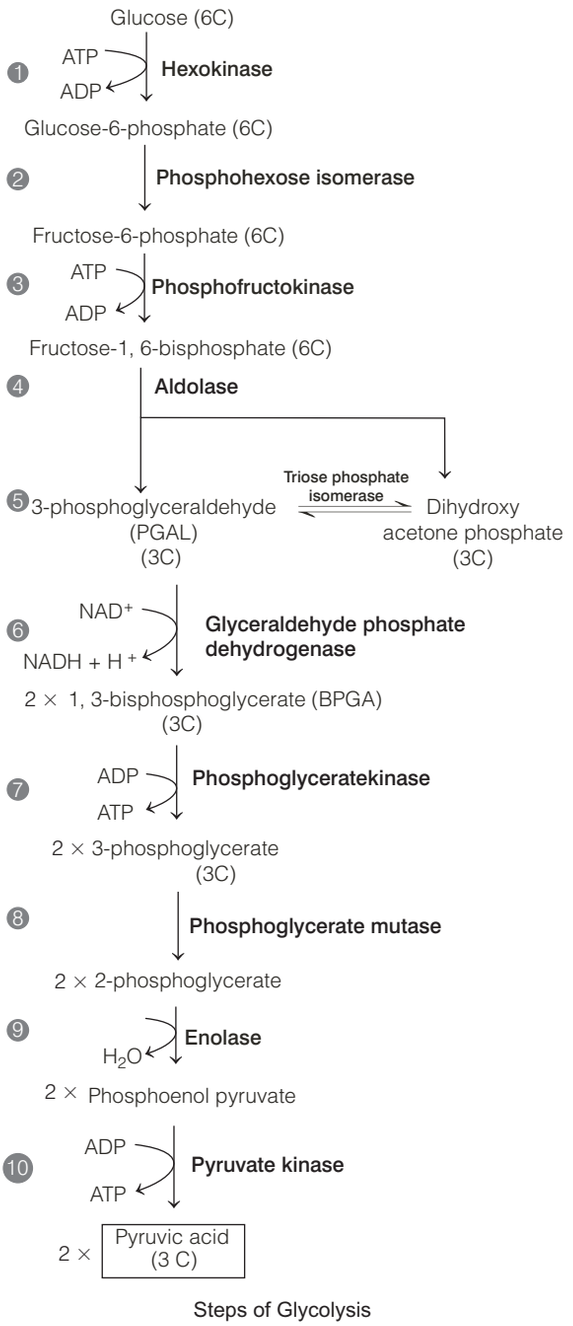
$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{Energy}$$

- The strategy that the plant cell uses, is to catabolise the glucose molecule in such a way that not all the liberated energy goes out as heat.
- The key is to oxidise glucose not in one step, but in several small steps enabling some steps to be just large enough such that the energy released can be coupled to ATP synthesis.

Glycolysis

- The term glycolysis originated from Greek words *glycos* for sugar and *lysis* for splitting.
- This scheme was given by **Gustav Embden, Otto Meyerhof** and **J Parnas** and is often referred to as **EMP pathway**.
- It is a stepwise process by which one molecule of glucose (6C) breaks down into two molecules of pyruvic acid (3C) without the help of oxygen.
- It occurs in the cytoplasm of the cell. In glycolysis, a chain of 10 reactions occurs under the control of different enzymes.

- A net gain of 8 ATP molecules occurs during glycolysis. The complete steps of glycolysis can be summarised as



Steps of Glycolysis

- **Anaerobic respiration** It is the process which involves the incomplete breakdown of organic substrate without using oxygen as oxidant. Its common products are **CO_2, ethyl alcohol** and **lactic acid**.

Fermentation

- In yeast, incomplete oxidation of glucose is achieved under anaerobic conditions.
- In this, pyruvic acid is converted to CO_2 and ethanol.
- In particular, following two types of fermentations are most common.
  - **Alcoholic fermentation** occurs in many fungi (yeast, *Rhizopus,* etc). Its step involves

$$\text{Pyruvic acid} \xrightarrow{\text{Pyruvate decarboxylase}} \text{Acetaldehyde} + CO_2$$

$$\text{Acetaldehyde} \xrightarrow[NADH + H^+ \;\; NAD^+]{\text{Alcohol dehydrogenase}} \text{Ethyl alcohol}$$

  - **Lactic acid fermentation** occurs in muscle cells or certain bacteria when oxygen is inadequate for cellular respiration.

$$\text{Pyruvic acid} \xrightarrow[NADH + H^+ \;\; NAD^+]{\text{Lactic dehydrogenase}} \text{Lactic acid}$$

Note Yeasts poison themselves to death when concentration of alcohol reaches about 13 per cent.

Aerobic Respiration

- For aerobic respiration to take place within the mitochondria, the final product of glycolysis, i.e. pyruvate is transported from the cytoplasm into the mitochondria.
- This process leads to the complete oxidation of organic substances in the presence of oxygen and releases CO_2, water and a large amount of energy presents in the substrate. It comprises following interdependent major processes

Pyruvate Oxidation

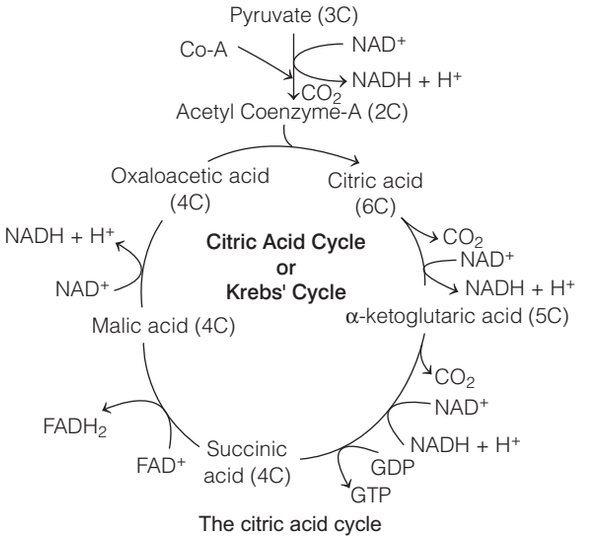
- It occurs in the mitochondrial matrix when pyruvate of cytoplasm from glycolysis enters with the help of a specific transport protein.
- It involves the conversion of glycolysis product, pyruvate into acetyl Co-A that enters the next step, i.e. Krebs' cycle.
- It is also called **link reaction** as it links glycolysis with Krebs' cycle.

$$\text{Pyruvic acid} + \text{Co-A} + NAD^+ \xrightarrow[Mg^{2+}]{\text{Pyruvate dehydrogenase}} \text{Acetyl Co-A} + CO_2 + NADH + H^+$$

Krebs' Cycle (Tricarboxylic Acid Cycle)

- It also occurs in the mitochondrial matrix. It is a cyclic process that involves the conversion of acetyl Co-A to oxaloacetate.

- It produces CO_2 (one of the end products of respiration), GTP and reduced coenzymes, i.e. NADH + H^+ and $FADH_2$.



The citric acid cycle

- The summary equation for this phase of respiration may be written as follows

$$\text{Pyruvic acid} + 4NAD^+ + FAD^+ + 2H_2O + ADP + Pi \xrightarrow[\text{matrix}]{\text{Mitochondrial}} 3CO_2 + 4NADH + 4H^+ + FADH_2 + ATP$$

Electron Transport System (ETS)

- The inner mitochondrial membrane contains groups of electron and proton transporting enzymes.
- In each group, the enzymes are arranged in a specific series called **Electron Transport Chain** (ETC) or mitochondrial respiration or **Electron Transport System** (ETS).
- An ETS is a series of coenzymes and cytochromes that take part in the passage of electrons through a series of activated chemical compounds to its ultimate acceptor, i.e. oxygen.

Complex	Description
Complex-I (NADH dehydrogenase or NADH coenzyme-Q reductase)	• It accepts electrons from NADH *via* FMN (Flavin mononucleotide) which gets reduced to $FMNH_2$. The latter transfer e^- to Co-Q or ubiquinone which gets reduced to Co-QH_2. • $2H^+$ received through NADH gets translocated from the matrix to intermembrane space.
Complex-II (succinate coenzyme-Q reductase)	• It receives e^- from succinate *via* FAD which gets reduced to $FADH_2$. The latter transfer e^- to Co-Q *via* FeS centre and Co-Q gets reduced to Co-QH_2.
Complex-III (cyt-*C* reductase)	• It consists of cyt-*b*, FeS centre and cyt-c_1. It receives e^- from Co-QH_2. • $4H^+$ gets transferred from matrix to intermembrane space.
Complex-IV (cyt-*c* oxidase)	• It consists of cyt-*a* , cyt-a_3 and 2 Cu^+ ions. • It receives e^- from cyt-*c* and ultimately transfers them to O_2 to form H_2O (terminal oxidation).

Oxidative Phosphorylation

- It is the synthesis of energy rich ATP molecules with the help of energy liberated during oxidation or reduction of coenzymes (NADH, $FADH_2$) produced in respiration.
- The enzyme required for this, is ATP synthase which is the complex-V of ETS. ATP synthase is located in F_1 or head piece of $F_0 - F_1$ elementary particles. This particle is present in inner mitochondrial membrane.
- This method of ATP formation is termed also as **chemiosmotic ATP synthesis.** It is suggested that most ATP synthesis in respiring cells comes from the electrochemical gradient (generated due to the movement of ions) across the inner membrane of mitochondria by utilising the energy of NADH and $FADH_2$ formed from oxidation of molecules is glucose.
- The hydrogen ions diffuse from higher proton gradient to lower proton gradient.
- This electrochemical concentration gradient of proton across a membrane is established to form ATP. As the process is related to osmosis, thus it is known as **chemiosmosis**.

Respiratory Balance Sheet

- Complete oxidation of a glucose molecule to CO_2 and H_2O takes just in a second and produces 38 ATP molecules.

The Respiratory Balance Sheet

Process	ATP formed by substrate level phosphorylation	Number of NADH and $FADH_2$ formed
Glycolysis	2	2NADH = 6ATP
Formation of acetyl Co-A	–	2NADH = 6ATP
Krebs' cycle	2	2 $FADH_2$ = 4ATP 6 NADH = 18 ATP
Total	4	34

Amphibolic Pathway

- The respiratory pathway involves both anabolism and catabolism, therefore it is known as amphibolic pathway, e.g.
  - All carbohydrates are converted into glucose before being used in respiration.
  - Fats get broken down into gycerol and fatty acid which is further converted into acetyl Co-A and enters the respiratory pathway.
  - Proteins are broken down into amino acids, which then enter the Krebs' cycle.

Respiratory Quotient

- The ratio of the volume of CO_2 evolved to the volume of O_2 consumed in respiration is called the **Respiratory Quotient** (RQ) or **respiratory ratio**.

$$RQ = \frac{\text{Volume of } CO_2 \text{ evolved}}{\text{Volume of } O_2 \text{ consumed}}$$

- For carbohydrates, fats and proteins, the RQ will be 1, less than 1 and 0.9 (approximately), respectively.

Mastering NCERT

MULTIPLE CHOICE QUESTIONS

TOPIC 1 ~ *Do Plants Breathe?*

1 Choose the correct combination of *A* and *B*.
All living organisms need … *A*… for carrying out daily life activities and is obtained by … *B* … of macromolecules.
(a) A–oxygen; B–reduction (b) A–energy; B–reduction
(c) A–energy; B–oxidation (d) A–oxygen; B–oxidation

2 The mechanism of breakdown of food materials within the cell to release energy and the trapping of this energy for ATP synthesis is called
(a) Krebs' cycle (b) cellular respiration
(c) photosynthesis (d) phosphorylation

3 In the eukaryotes, ……*A*…… takes place within the chloroplasts, whereas the breakdown of complex molecules to yield energy takes place in the ……*B*…… and in the ……*C*…… .
(a) A–photosynthesis, B–cytoplasm, C–mitochondria
(b) A–respiration, B–cytoplasm, C–mitochondria
(c) A–respiration, B–chloroplast, C–cytoplasm
(d) A–photosynthesis, B–chloroplast, C–cytoplasm

4 Release of energy by breaking down of C–C bond of various organic molecules by oxidation process for cellular use is known as
(a) respiration
(b) photorespiration
(c) oxidative phosphorylation
(d) combustion

5 Respiratory substrates are the organic substances, which are……during respiration to liberate energy.
(a) oxidised (b) reduced
(c) synthesised (d) Both (a) and (b)

6 Steps of respiration are controlled by
(a) substrates (b) enzymes (c) hormone (d) bile juice

7 The released energy obtained by oxidation is stored as
(a) A concentration gradient across a membrane
(b) ADP
(c) ATP
(d) NAD^+

8 In respiration, the respiratory substrates used is/are
(a) carbohydrate (b) protein
(c) organic acid (d) All of these

9 Which of the following option(s) state true feature(s) of plants?
(a) Have stomata and lenticels for gaseous exchange
(b) Lack breathing mechanism
(c) Unlike animals, plants have no special organs for gaseous exchange
(d) All of the above

10 The complete combustion of glucose in respiration is represented by
(a) $C_6H_{12}O_6 + 6O_2 \rightarrow +6CO_2 + 6H_2O +$ Energy
(b) $C_6H_{12}O_6 + 6CO_2 \rightarrow + 6O_2 + 6H_2O +$ Energy
(c) $C_6H_{12}O_6 + 6O_2 + 6CO_2 \rightarrow + 6CO_2 + 6H_2O +$ Energy
(d) $C_6H_{12}O_6 + 6O_2 + 6CO_2 + ATP \rightarrow 6CO_2 + 6H_2O + 6O_2 +$ Energy

11 The main purpose of respiration is to
(a) convert potential energy to kinetic energy
(b) convert kinetic energy to potential energy
(c) create energy in the cell
(d) catabolise the glucose molecule in such a way that most of the liberated energy can be coupled for ATP synthesis

TOPIC 2 ~ *Glycolysis*

12 All living organisms retain the enzymatic machinery to partially oxidise glucose without the help of oxygen. This breakdown of glucose into pyruvic acid is called
(a) respiration
(b) glycolysis
(c) substrate level phosphorylation
(d) Calvin cycle

13 Glycolysis is also known as
(a) EMP pathway (b) PME pathway
(c) CMT pathway (d) TMC pathway

14 Glycolysis takes place in the cytoplasm of
(a) all living cells (b) eukaryotic cells
(c) anaerobic cells (d) most muscle cells

15 In plants, glucose is primarily derived from which of the following?
(a) Protein (b) Fat (c) Oxalic acid (d) Sucrose

16 In order to enter the glycolytic pathway, sucrose is converted into glucose and fructose by the enzyme
(a) invertase (b) zymase
(c) isomerase (d) triose phosphatase

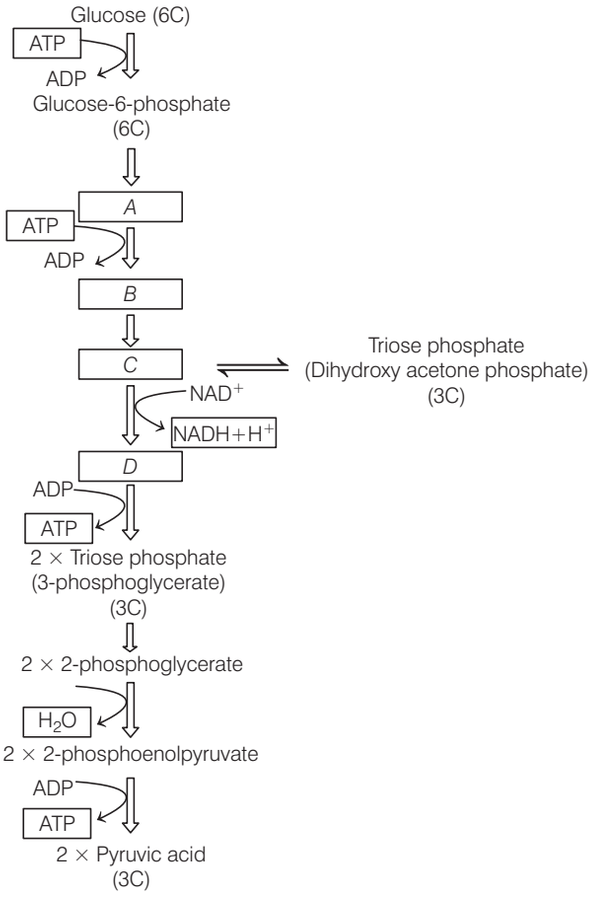
17 Conversion of glucose to glucose-6-phosphate, the first irreversible reaction of glycolysis, is catalysed by ***NEET 2019***

(a) hexokinase (b) enolase
(c) phosphofructokinase (d) aldolase

18 Glucose- 6-phosphate $\xrightarrow{A}$ Fructose-6- phosphate
Identify the enzyme used in the above reaction from the options given below.

(a) Aldolase (b) Phosphofructokinase
(c) Hexokinase (d) Isomerase

19 The flowchart given below shows the steps in glycolysis. Select the option that correctly fills in the missing steps *A*, *B*, *C* and *D*.



(a) A–Fructose-6-phosphate, B–Fructose-1, 6-bisphosphate, C–3 PGAL, D–1, 3-bisphosphoglyceric acid
(b) A–Fructose-1, 6-bisphosphate, B–3 PGAL, C–1, 3-bisphosphoglyceric acid, D–3 PGA
(c) A–3 PGA, B–1, 3-bisphosphoglyceric acid, C–3 PGAL, D–Fructose-1, 6-bisphosphate
(d) A–Fructose-1, 6-bisphosphate, B–Fructose-6-phosphate, C–3 PGAL, D–1, 3-bisphosphoglyceric acid

20 In glycolysis production of pyruvic acid from glucose involves a chain of ten reactions. Each individual reaction needs

(a) one molecule of ATP
(b) one molecule of ADP
(c) one molecule of NAD
(d) one molecule of specific enzyme

21 Which of the following steps during glycolysis is associated with utilisation of ATP ?

(a) Glucose to Glucose-6-phosphate
(b) Fructose-6-phosphate to fructose-1,6-bisphosphate
(c) PEP to pyruvic acid
(d) Both (a) and (b)

22 In which of the following reactions of glycolysis, oxidation takes place?

(a) Glucose-6-PO_4 to fructose-6-PO_4
(b) Glyceraldehyde-3-phosphate to 1, 3-bisphosphoglycerate
(c) 1, 3-diphosphoglycerate to 3-phosphoglycerate
(d) 2-phosphoglycerate to phosphoglycerate

23 In glycolysis, $NADH + H^+$ is formed from NAD, when

(a) 3-phosphoglyceraldehyde (PGAL) is converted to 1, 3- bisphosphoglycerate (BPGA)
(b) triose phosphate is converted to 2-phosphoglycerate
(c) 2-phosphoglycerate is converted to 2- phosphopyruvate
(d) 2-phosphopyruvate is converted to 2-pyruvic acid

24 In which of the following conversions ATP synthesis occurs during glycolysis?

(a) Glucose → Glucose-6-phosphate
(b) Fructose-6- phosphate → Fructose-1,6-bisphosphate
(c) 1,3-bisphosphoglyceric acid (BPGA) →3-phosphoglyceric acid (PGA)
(d) All of the above

25 The end product of glycolysis

(a) pyruvic acid (b) acetyl coenzyme
(c) citric acid (d) oxaloacetic acid

26 How many molecules of pyruvic acid are formed in glycolysis? ***JIPMER 2018***

(a) 2 (b) 1 (c) 15 (d) 16

27 Which one is correct sequence in glycolysis?

(a) G-6-P ⟶ PEP ⟶ 3PGAL ⟶ 3PGA
(b) G-6-P ⟶ 3PGAL ⟶ 3PGA ⟶ PEP
(c) G-6-P ⟶ PEP ⟶ 3 PGA ⟶ 3PGAL
(d) G-6-P ⟶ 3 PGA ⟶ 3 PGAL ⟶ PEP

28 2NADH (H^+) produced during aerobic glycolysis yield

(a) 6 ATP molecules (b) 4 ATP molecules
(c) 8 ATP molecules (d) None of these

29 Net gain of ATP from one molecule of glucose in glycolysis is

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

30 The metabolic fate of pyruvic acid formed after glycolysis is

(a) lactic acid fermentation (b) alcoholic fermentation
(c) aerobic respiration (d) All of these

TOPIC 3 ~ *Fermentation*

31 Choose the correct option for fermentation.
(a) It takes place under anaerobic conditions
(b) It may occur in prokaryotes and unicellular eukaryotes
(c) It is the incomplete oxidation of glucose
(d) All of the above

32 Fermentation cannot produce
(a) CO_2 (b) ethanol
(c) lactic acid (d) H_2O

33 Fermentation is called as
(a) anaerobic respiration in yeast
(b) alcoholic fermentation in yeast
(c) lactic acid fermentation in muscle cells
(d) All of the above

34 Anaerobic respiration generally occurs in
(a) lower organisms, e.g. bacteria and fungi
(b) higher organisms, e.g. animal
(c) viruses
(d) Both (a) and (b)

35 Incomplete breakdown of sugar in anaerobic respiration forms
(a) glucose and carbon dioxide
(b) alcohol and carbon dioxide
(c) water and carbon dioxide
(d) fructose and water

36 In anaerobic respiration in yeast
(a) H_2O and CO_2 are the end products
(b) CO_2, ethanol and energy are the end products
(c) CO_2 and H_2O are the end products
(d) CO_2, acetic acid and energy are the end products

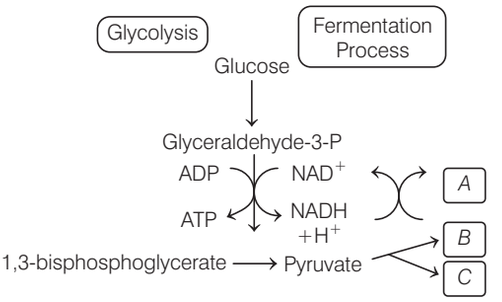
37 Pyruvate $\longrightarrow$ Ethyl alcohol + CO_2

The above reaction needs two enzymes which are
(a) pyruvate decarboxylase and alcohol dehydrogenase
(b) pyruvate decarboxylase and enolase
(c) pyruvate decarboxylase and pyruvate kinase
(d) pyruvate carboxylase and aldolase

38 In the production of ethanol, pyruvic acid is first converted to acetaldehyde by the enzyme
(a) alcohol dehydrogenase (b) alcohol oxidase
(c) pyruvate dehydrogenase (d) pyruvate decarboxylase

39 In alcoholic fermentation,
(a) there is no electron donor
(b) oxygen is the electron acceptor
(c) triose phosphate is the electron donor, while pyruvic acid is the electron acceptor
(d) triose phosphate is the electron donor, while acetaldehyde is the electron acceptor

40 Choose the correct combination of labelling the molecules involved in the pathway of anaerobic respiration in yeast.



(a) A–Ethanol, B–H_2O, C–Acetaldehyde
(b) A–CO_2, B–Ethanol, C–Acetaldehyde
(c) A–Acetaldehyde, B–CO_2, C–Ethanol
(d) A–Ethanol, B–Acetaldehyde, C– CO_2

41 In yeast during anaerobic respiration, how many glucose molecules are required for the production of 38 ATP molecules?
(a) 1 (b) 2
(c) 19 (d) 38

42 In anaerobic respiration, bacteria produce
(a) lactic acid (b) formic acid
(c) acetic acid (d) glutamic acid

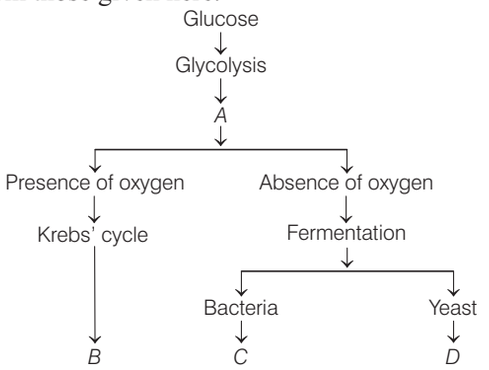
43 In hurdle race, which of the following is accumulated in the leg muscle?
(a) Performed ATP
(b) Glycolysis
(c) Lactate
(d) Oxidative metabolism

44 In animal cells, like muscle, during exercise when O_2 is inadequate for cellular respiration, pyruvic acid is reduced into lactic acid by
(a) O_2
(b) carboxylation
(c) lactate dehydrogenase
(d) None of the above

45 In which one of the following processes, CO_2 is not released? ***CBSE-AIPMT 2014***
(a) Aerobic respiration in plants
(b) Aerobic respiration in animals
(c) Alcoholic fermentation
(d) Lactate fermentation

46 The number of ATP produced when a molecule of glucose undergoes fermentation is
(a) 4 (b) 36 (c) 2 (d) 38

47 The following is a simplified scheme showing the fate of glucose during aerobic and anaerobic respiration. Identify the end products that are formed at stages indicated as *A, B, C* and *D*. Identify the correct option from those given here.



(a) A–Carbon dioxide and water, B–Pyruvic acid, C–Ethyl alcohol and carbon dioxide, D–Lactic acid
(b) A–Pyruvic acid, B–Carbon dioxide and water, C–Lactic acid, D– Ethyl alcohol and carbon dioxide
(c) A–Pyruvic acid, B–Carbon dioxide and water, C–Ethyl alcohol and carbon dioxide , D– Lactic acid
(d) A–Pyruvic acid, B–Ethyl alcohol and carbon dioxide, C–Lactic acid, D–Carbon dioxide and water

48 Four respiratory enzymes are given below. Choose the correct combination(s) of the carbon number of the substrates on which they act.

I. Enolase–2-phosphoglyceric acid
II. Aconitase – Citric acid
III. Fumarase – Alcohol dehydrogenase
IV. Alcohol dehydrogenase – Pyruvic acid

Choose the correct option.

(a) II and IV
(b) II and III
(c) I and II
(d) I and III

TOPIC 4 ~ *Aerobic Respiration and Tricarboxylic Acid Cycle*

49 Aerobic respiration is
(a) the process in which complete oxidation of organic substances takes place in the absence of oxygen
(b) the process in which complete oxidation of organic substances takes place in the presence of oxygen
(c) the process in which incomplete oxidation of organic substances takes place in the absence of oxygen
(d) the process in which incomplete oxidation of organic substances takes place in the presence of oxygen

50 What is the correct order of the stages of aerobic cellular respiration?
(a) Krebs' cycle → Electron transport chain → Glycolysis
(b) Electron transport chain → Krebs' cycle → Glycolysis
(c) Glycolysis → Krebs' cycle → Electron transport chain
(d) Glycolysis → Electron transport chain → Krebs' cycle

51 Phase common in aerobic and anaerobic respiration is
(a) Krebs' cycle (b) glycolysis
(c) glycogenolysis (d) ETS

52 The driving force of aerobic respiration is the presence of
(a) glucose molecule (b) O_2 in electron transport chain
(c) acetyl Co-A (d) None of these

53 Which one of the following is the product of aerobic respiration?
(a) CO_2 and H_2O (b) Ethyl alcohol
(c) Lactic acid (d) Pyruvic acid

54 Following are the crucial events in aerobic respiration
I. The complete oxidation of pyruvate by the stepwise removal of all the hydrogen atoms, leaving three molecules of CO_2.
II. The passing on of the electrons removed as part of the hydrogen atoms to molecules of O_2 with simultaneous synthesis of ATP.

Choose the correct option for the place these steps occurs in
(a) I–Matrix of mitochondria, II–Inner membrane of mitochondria
(b) I–Inner membrane of mitochondria, II–Matrix of mitochondria
(c) I–Matrix of mitochondria, II–Outer membrane of mitochondria
(d) I–Inner membrane of mitochondria, II–Outer membrane of mitochondria

55 Pyruvic acid + Co-A + NAD^+ → Acetyl Co-A + CO_2 + NADH + H^+. This reaction is known as
(a) Pyruvate oxidation (b) Link reaction
(c) Both (a) and (b) (d) None of these

56 Link enzyme in cellular respiration is
(a) citrate synthetase
(b) pyruvate dehydrogenase
(c) isocitrate dehydrogenase
(d) succinyl thiokinase

57 Connecting link between glycolysis and Krebs' cycle is
(a) acetyl Co-A (b) pyruvic acid
(c) CO_2 (d) None of these

58 What is the role of NAD^+ in cellular respiration? ***NEET 2018***
(a) It is a nucleotide source of ATP synthesis
(b) It functions as an electron carrier
(c) It functions as an enzyme
(d) It is the final electron acceptor for anaerobic respiration

59 Which of the metabolites is common to respiration mediated breakdown of fats, carbohydrates and proteins? ***CBSE-AIPMT 2013, NEET 2016, AIIMS 2018***

(a) Glucose-6-phosphate (b) Fructose-1, 6-bisphosphate
(c) Pyruvic acid (d) Acetyl Co-A

60 Which one of the following reactions is an example of oxidative decarboxylation?

(a) Conversion of succinate to fumarate
(b) Conversion of fumarate to malate
(c) Conversion of pyruvate to acetyl Co-A
(d) Conversion of citrate to isocitrate

61 In oxidative decarboxylation, only a carbon molecule of pyruvic acid gets oxidised, other two carbon molecules go to form

(a) acetyl Co-A (b) CO_2
(c) citric acid (d) Both (a) and (b)

62 In eukaryotes, most of the TCA cycle enzymes are present in

(a) cytoplasm
(b) intermembrane space of mitochondria
(c) mitochondrial matrix
(d) inner membrane of mitochondria

63 Which option is incorrect about Krebs' cycle?

(a) It is also called citric acid cycle
(b) The intermediate compound, which links glycolysis with Krebs' cycle is malic acid
(c) It occurs in mitochondria
(d) It starts with six carbon compound

64 In citric acid cycle, the first step involves the combination of

(a) acetyl Co-A with oxaloacetic acid
(b) acetyl Co-A with citric acid
(c) citric acid with oxaloacetic acid
(d) citric acid with malic acid

65 The enzyme ..... used to catalyse condensation of acetyl group with oxaloacetic acid to yield citric acid.

(a) citrate permeate
(b) citrate synthase
(c) citrate burate
(d) citrate maliate

66 α-ketoglutarate acid, an intermediary compound of Krebs' cycle is a

(a) 5 carbon compound (b) 6 carbon compound
(c) 4 carbon compound (d) 3 carbon compound

67 Sequence of events in Krebs' cycle is

(a) Acetyl Co-A → Citrate → Pyruvate → Oxaloacetic acid Fumarate ← Malate ← Succinate ← α-ketoglutarate ←
(b) Acetyl Co-A → Citric acid → α-ketoglutarate acid Oxaloacetic acid ← Malic acid ← Fumaric acid ← → Succinic acid
(c) Acetyl Co-A →Citric acid→Malic acid → Oxaloacetic acid → Succinic acid → α-ketoglutaric acid
(d) All are wrong

68 Which of the following is a 4 carbon compound?

(a) Oxaloacetic acid (b) Phosphoglyceric acid
(c) Ribulose bisphosphate (d) Phosphoenol pyruvate

69 Which of these steps in Krebs' cycle indicates substrate level phosphorylation?

(a) Conversion of succinyl acid to α-ketoglutaric acid
(b) Conversion of succinic acid to malic acid
(c) Conversion of succinyl Co-A to succinic acid
(d) Conversion of malic acid to oxaloacetic acid

70 In which of the following, reduction of NAD does not occur?

(a) Isocitric acid → α- ketoglutaric acid
(b) Malic acid → Oxaloacetic acid
(c) Pyruvic acid → Acetyl Co-A
(d) Succinic acid → Fumaric acid

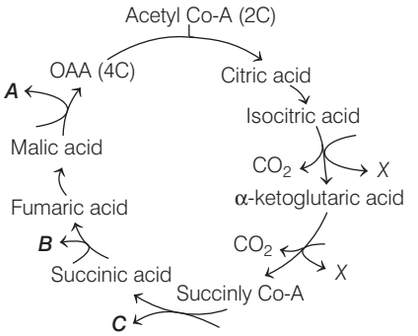
71 FAD is electron acceptor during oxidation of which of the following?

(a) α- ketoglutarate → Succinyl Co-A
(b) Succinic acid → Fumaric acid
(c) Succinyl Co-A → Succinic acid
(d) Fumaric acid → Malic acid

72 Krebs' cycle is completed with the formation of

(a) citric acid (b) Oxaloacetic acid (OAA)
(c) succinic acid (d) malic acid

73 Identify *A*, *B* and *C* in the given citric acid cycle.



	A	B	C
(a)	GTP	$NADH_2$	$FADH_2$
(b)	$FADH_2$	$NADH_2$	GTP
(c)	$NADH_2$	$FADH_2$	GTP
(d)	CO_2	$NADH_2$	ADP

74 α-ketoglutarate of Krebs' cycle produces an important amino acid called..... .

Fill up the blank with the given option.

(a) succinate (b) glycine (c) glutamate (d) alanine

75 When two molecules of acetyl Co-A enter the TCA cycle, net gain at the end of this cycle is

(a) $2NADH_2 + 2FADH_2 + 1$ GTP
(b) $3NADH_2 + 2FADH_2 + 2$ GTP
(c) $6NADH_2 + 2FADH_2 + 2$ GTP
(d) $3NADH_2 + 1FADH_2 + 4$ GTP

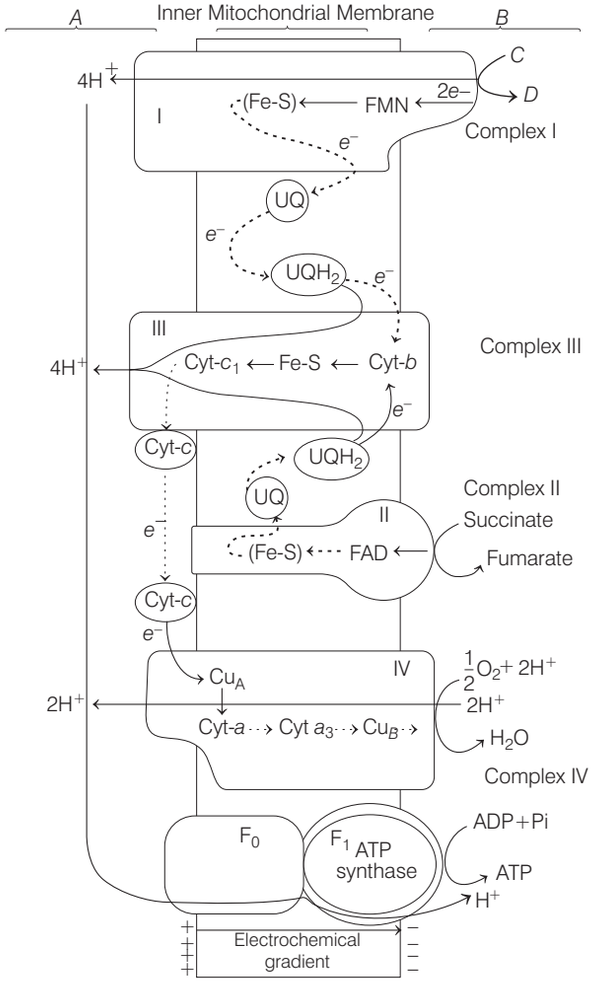
TOPIC 5 ~ *Electron Transport System (ETS) and Oxidative Phosphorylation*

76 During which stage in the complete oxidation of glucose are the greatest number of ATP molecules formed from ADP?
(a) Conversion of pyruvic acid to acetyl Co-A
(b) Electron transport chain
(c) Glycolysis
(d) Krebs' cycle

77 The main purpose of electron transport chain is to
(a) release and utilise energy stored in $NADH + H^+$ and $FADH_2$
(b) use the intermediate from TCA cycle
(c) breakdown pyruvic acid
(d) All of the above

78 The e^- carrier molecules and cytochrome
(a) are reduced as they pass electrons on to next molecule
(b) transfer electrons between the electron complexes
(c) shuttle protons to ATP synthase
(d) are found in outer mitochondrial membrane

79 Identify *A, B, C* and *D* in the given figure of electron transport chain.



	A	B	C	D
(a)	Matrix	Outer chamber	$FMNH_2$	$NADH_2$
(b)	Inter-membrane space	Matrix	$NADH + H^+$	NAD^+
(c)	Inter-membrane space	Cristae	NAD^+	$NADH + H^+$
(d)	Cristae	Outer chamber	$NADH + H^+$	NAD^+

80 The initial step in the biosynthesis of ATP by chemiosmosis in the mitochondria is the
(a) pumping of protons in the outer chamber
(b) pumping of electrons in the matrix
(c) action of ATP synthase
(d) formation of metabolic water

81 Which of the following shows correct order of flow of electrons in ETC ?
(a) Fe-S → NADH → Co-Q → Cyt-*b* → Fe-S → Cyt-*c* → Cyt-a_3 → O_2 → Cyt-*b*
(b) NADH → FMN → Fe-S → Co-Q → Cyt-*b* → Fe-S → Cyt-c_1 → Cyt-*e* → Cyt-*a* → Cyt-a_3 → O_2
(c) NADH → Cyt-c_1 → Cyt-*c* → Cyt-*a* → Cyt-a_3 → O_2 → FMN → Fe-S → Co-Q → Cyt-*b* → Fe-S
(d) Cyt-c_1 → Cyt-*c* → Cyt-*a* → Cyt-a_3 → NADH → FMN → Fe-S → Co-Q → Cyt-*b* → Fe-S → O_2

82 In the electron transport system present in the inner mitochondrial membrane, complex-I and IV are, respectively
(a) NADH dehydrogenase and $FADH_2$
(b) $NADH_2$ and NADH dehydrogenase
(c) NADH dehydrogenase and cytochrome oxidase complex
(d) NADH dehydrogenase and ATP synthetase

83 Which one of following is complex-V of the ETS of inner mitochondrial membrane?
(a) NADH dehydrogenase
(b) Cytochrome oxidase
(c) Ubiquinone
(d) ATP synthase

84 In electron transport system, which of the following acts as a final electron acceptor?
(a) Oxygen (b) Hydrogen
(c) Calcium (d) Ubiquinone

85 Which of the following processes takes place in mitochondria?
(a) Photolysis
(b) Photophosphorylation
(c) Carboxylation
(d) Oxidative phosphorylation

86 Oxidative phosphorylation is ***NEET 2016***

(a) formation of ATP by transfer of phosphate group from a substrate to ADP

(b) oxidation of phosphate group in ATP

(c) addition of phosphate to ATP

(d) formation of ATP by energy released from electron removed during substrate oxidation

87 In which part of mitochondria does ATP synthesis occur?

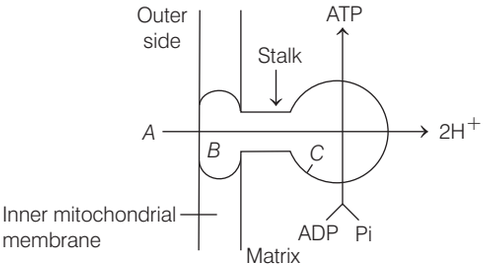
(a) F_1

(b) F_0

(c) Cristae

(d) Inner membrane of mitochondria

88 Given below is the diagrammatic presentation of ATP synthesis in mitochondria. Identify *A*-*C* and choose the correct option accordingly.



(a) $A - H^+, B - F_1, C - F_0$ (b) $A - 3H^+, B - F_0, C - F_1$

(c) $A - 2H^+, B - F_0, C - F_1$ (d) $A - 5H^+, B - F_1, C - F_0$

TOPIC 6 ~ *Respiratory Balance Sheet and Amphibolic Pathway*

89 ATP formation occurs through which of the following? ***AIIMS 2019***

(a) Photophosphorylation

(b) Oxidative phosphorylation

(c) Substrate level phosphorylation

(d) All of the above

90 Fill in the blank with reference to text book. It is possible to make calculation of the net gain of ATP for every ..... molecule oxidised.

(a) sucrose (b) pyruvate

(c) glucose (d) fructose

91 Before entering into the respiratory pathway fats breakdown into

(a) fatty acid and glycerol

(b) fatty acid and citric acid

(c) fatty acid and ascorbic acid

(d) fatty acid and amino acid

92 When one molecule of glucose is completely oxidised during aerobic respiration, how many molecules of carbon dioxide are released due to tricarboxylic acid cycle?

(a) One (b) Two (c) Three (d) Six

93 How many $NADH + H^+$ molecules are released from a single pyruvate in Krebs' cycle?

(a) 3 (b) 6 (c) 12 (d) 8

94 Net gain of ATP molecules per hexose during aerobic respiration is

(a) 12 (b) 18

(c) 36 (d) 30

95 From one molecule of glucose during oxidative phosphorylation, the total gain of ATP is

(a) 40 (b) 38

(c) 34 (d) 30

96 Net yield of ATP molecules in aerobic respiration during Krebs' cycle per glucose molecule is

(a) 2 ATP molecules

(b) 8 ATP molecules

(c) 36 ATP molecules

(d) 38 ATP molecules

97 During Krebs' cycle, … *A* … NADH, … *B* … ATP is produced through ETS in mitochondria. Choose the correct pair from the options given below

(a) A–2; B–4

(b) A–4; B–2

(c) A–6; B–18

(d) A–2; B–8

98 How many ATP is released respectively when NADH and $FADH_2$ molecules get oxidised?

(a) 3 ATP, 2 ATP

(b) 2 ATP, 3 ATP

(c) 5 ATP, 4 ATP

(d) 3 ATP, 5 ATP

99 Choose the correct combination of *A* and *B*.

The NADH synthesised in … *A* … is transferred into the mitochondria and undergoes oxidative … *B* … .

(a) A–EMP; B–carboxylation

(b) A–ETS; B–phosphorylation

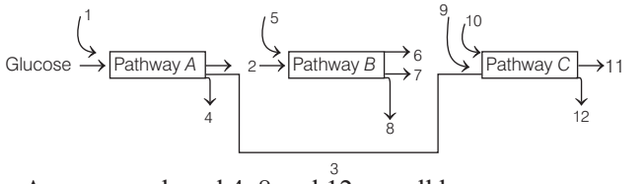
(c) A–glycolysis; B–phosphorylation

(d) A–TCA cycle; B–decarboxylation

100 Glycerol is a product of fat breakdown. It sometimes enters the respiratory pathway after being converted to

(a) Fatty acids
(b) PEP
(c) PGAL
(d) None of the above

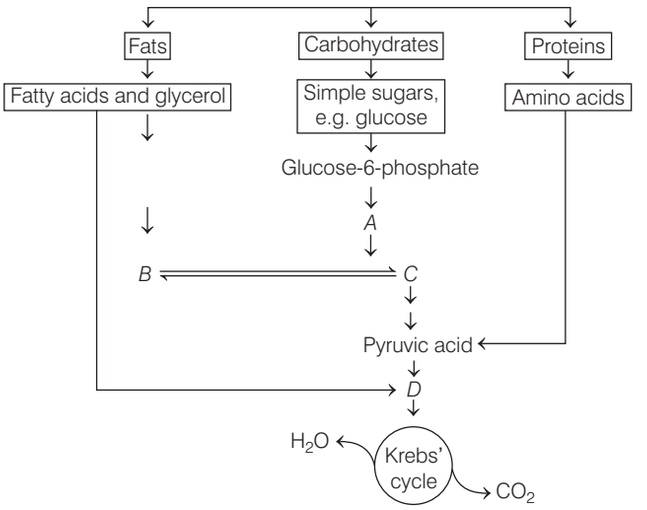
101 The three boxes in this diagram represent the three major biosynthetic pathways in aerobic respiration. Arrows represent net reactants or products. ***NEET 2013***



Arrows numbered 4, 8 and 12 can all be

(a) NADH
(b) ATP
(c) H_2O
(d) FAD^+ or $FADH_2$

102 The figure given below describes the inter relationship between metabolic pathways in which respiration-mediated breakdown of different organic substances into CO_2 and H_2O is taking place identify *A-D*.



	A	B	C	D
(a)	Glucose-1,6-bisphosphate	Glyceraldehyde -3- phophate	Dihydroxy acetone phosphate	Acetyl Co-A
(b)	Fructose-1,6-bisphosphate	Dihydroxy acetone phosphate	Glyceraldehyde -3- phosphate	Acetyl Co-A
(c)	Fructose-1, 6-bisphosphate	Dihydroxyacetone phosphate	Glyceraldehyde -3- phosphate	Oxaloacetate
(d)	Fructose-1,3-bisphosphate	Glyceraldehyde-3-phosphate	Dihydroxy acetone phosphate	Oxaloacetate

TOPIC 7 ~ *Respiratory Quotient*

103 The Respiratory Quotient (RQ) or respiratory ratio is

(a) $RQ = \frac{\text{Volume of } O_2 \text{ evolved}}{\text{Volume of } CO_2 \text{ consumed}}$

(b) $RQ = \frac{\text{Volume of } O_2 \text{ consumed}}{\text{Volume of } CO_2 \text{ evolved}}$

(c) $RQ = \frac{\text{Volume of } CO_2 \text{ consumed}}{\text{Volume of } O_2 \text{ evolved}}$

(d) $RQ = \frac{\text{Volume of } CO_2 \text{ evolved}}{\text{Volume of } O_2 \text{ consumed}}$

104 The respiratory quotient during cellular respiration would depend on the

(a) nature of enzymes involved
(b) nature of the substrate
(c) amount of carbon dioxide released
(d) amount of oxygen utilised

105 The Respiratory Quotient (RQ) of some of the compounds are 4, 1 and 0.7. These compounds are identified respectively as

(a) malic acid, palmitic acid and tripalmitin
(b) oxalic acid, carbohydrate and tripalmitin
(c) tripalmitin, malic acid and carbohydrate
(d) palmitic acid, carbohydrate and oxalic acid

106 In succulent plants like *Opuntia*, the RQ value will be

(a) less than one (b) more than one
(c) infinite (d) zero

107 What is the RQ of glucose? ***JIPMER 2018***

(a) One (b) Less than one
(c) More than one (d) Infinite

108 RQ value of 0.9 may be expected for the complete oxidation of which one of the following biomolecule?

(a) Glucose (b) Malic acid
(c) Proteins (d) Tartaric acid

109 If RQ is less than 1.0 in a respiratory metabolism, it would mean that

(a) carbohydrates are used as respiratory substrate
(b) organic acids are used as respiratory substrate
(c) the oxidation of the respiratory substrate consumed more oxygen than the amount of CO_2 released
(d) the oxidation of the respiratory substrate consumed less oxygen than the amount of CO_2 released

110 Respiratory quotient in anaerobic respiration is

(a) 0.7 (b) 0.9
(c) unity (d) infinity

111 Refer the given equation.

$$2(C_{51}H_{98}O_6) + 145\ O_2 \rightarrow 102\ CO_2 + 98\ H_2O + \text{Energy}$$

The respiratory quotient in this case is

(a) 1 (b) 0.7 (c) 1.45 (d) 1.62

112 Maximum amount of energy per molecule is liberated on oxidation of

(a) fats (b) proteins
(c) starch (d) vitamins

113 More carbon dioxide is evolved than the volume of oxygen consumed when the respiratory substrate is

(a) fat
(b) sucrose
(c) glucose
(d) organic acid

114 The Respiratory Quotient (RQ) of a germinating castor seed is

(a) equal to one (b) greater than one
(c) less than one (d) equal to zero

NEET

SPECIAL TYPES QUESTIONS

I. Assertion and Reason

■ **Direction** (Q. No. 115-122) *In each of the following questions, a statement of Assertion (A) is given followed by corresponding statement of Reason (R).*
Of the statements, mark the correct answer as

(a) If both A and R are true and R is the correct explanation of A
(b) If both A and R are true, but R is not the correct explanation of A
(c) If A is true, but R is false
(d) If A is false, but R is true

115 **Assertion** (A) The conversion of glyceraldehyde -3-phosphate into 1,3- bisphosphoglycerate is an oxidation reaction.

Reason (R) The reaction in which 1,3-bisphosphoglycerate is formed from glyceraldehyde-3-phosphate utilises NAD^+.

116 **Assertion** (A) To make ATP from ADP and inorganic phosphate requires 30.6 kJ of energy per mole.

Reason (R) ATP is found in every cells.

117 **Assertion** (A) Carbohydrates are used first by most cells in respiration.

Reason (R) Lipids are never used in respiration.

118 **Assertion** (A) ATP formation during respiration is an exergonic reaction.

Reason (R) ATP formation requires input of energy.

119 **Assertion** (A) Two turns of Krebs' cycle occur per glucose molecule used. ***AIIMS 2018***

Reason (R) Each turn of Krebs' cycle produces 3 NADH, 1 $FADH_2$ and 1 ATP molecule.

120 **Assertion** (A) Aerobic respiration is bioenergetically more efficient than anaerobic glycolysis.

Reason (R) Aerobic respiration occurs in the presence of oxygen, while fermentation occurs in the absence of oxygen.

121 **Assertion** (A) Yeast cells show alcoholic fermentation.

Reason (R) Fermentation in an aerobic process.

122 **Assertion** (A) Respiratory pathway is considered as an amphibolic pathway.

Reason (R) It involves both anabolism and catabolism. ***AIIMS 2019***

II. Statement Based Questions

123 Which statement is wrong for Krebs' cycle? ***NEET 2017***

(a) There are three points in the cycle where NAD^+ is reduced to $NADH + H^+$
(b) There is one point in the cycle where FAD^+ is reduced to $FADH_2$
(c) During conversion of succinyl Co-A to succinic acid, a molecule of GTP is synthesised
(d) The cycle starts with condensation of acetyl group (acetyl Co-A) with pyruvic acid to yield citric acid

124 Which of the following statements regarding mitochondria is incorrect? ***NEET 2019***

(a) Enzymes of electron transport are embedded in outer membrane
(b) Inner membrane is convoluted with infoldings
(c) Mitochondrial matrix contains single circular DNA molecule and ribosomes
(d) Outer membrane is permeable to monomers of carbohydrates, fats and proteins

125 Which one of these statements is incorrect?

NEET 2018

(a) Glycolysis operates as long as it is supplied with NAD that can pick up hydrogen atoms
(b) Glycolysis occurs in cytosol
(c) Enzymes of TCA cycle are present in mitochondrial matrix
(d) Oxidative phosphorylation takes place in outer mitochondrial membrane

126 Choose the incorrect statement.

(a) Flow of electrons in ETS is $Fe^{+3} \rightarrow Fe^{+2} \rightarrow Fe^{+3}$
(b) In ETS electrons move from high negative to high positive redox potential
(c) Cyt-a_3 has Fe and Cu
(d) Cytochrome are non-proteinaceous, but ubiquinone is proteinaceous

127 Calculation of ATP gain for every glucose is made on certain assumptions. Choose the correct option in accordance with the statement given above.

(a) The pathway functioning is sequential and orderly
(b) One substrate forms the reactant for the others
(c) TCA cycle and ETS pathway follow one after another
(d) All of the above

128 Choose the correct statement for the given options.

(a) Intermediates in the pathway are utilised to synthesise other compounds
(b) No alternative substrates other than glucose is allowed to enter the pathway at intermediate stages
(c) None of the substrate is respired in the pathway at intermediary stages
(d) Pathway functioning is insequential

129 Select the wrong statement.

(a) When tripalmitin is used as a substrate in respiration, the RQ is 0.7
(b) The intermediate compound, which links glycolysis with Krebs' cycle is malic acid
(c) One glucose molecule yield a net gain of 36 ATP molecules during aerobic respiration
(d) One glucose molecule yields a net gain of 2 ATP molecules during fermentation

130 Glycolysis

I. causes partial oxidation of glucose (one molecule) to form 2 molecules of pyruvic acid and 2 ATP as net gain.
II. takes place in all living cells.
III. uses 2 ATP at every step.
IV. scheme was given by Gustav Embden, Otto Meyerhof and J Parnas.

Choose the option containing correct statements from above.

(a) I, II and III (b) I, II, III and IV
(c) I, II and IV (d) Only I

131 Which of the following is true regarding glycolysis?

I. Takes place in cytosol.
II. Produces no ATP.
III. Has no connection with electron transport chain.
IV. Reduces two molecules of NAD^+ for every glucose molecule processed.

(a) Only I (b) I, II and III
(c) I and II (d) None of these

132 Consider the following statements.

I. Fermentation can be performed by eukaryotes.
II. Electron transport chain can occur without the presence of oxygen.
III. Complete oxidation of glucose does not require the presence of oxygen.

Which one of the following options contain the correct statements.

(a) Only III (b) I and III (c) I and II (d) Only I

133 Consider the following statements.

I. The role of oxygen in ETS is limited.
II. Oxygen acts as the final hydrogen acceptor.

(a) I is true and II is false (b) I is false and II is true
(c) Both I and II are true (d) Both I and II are false

134 Read the following statements about an overview of Electron Transport System (ETS).

I. Ubiquinone receives reducing equivalents *via* $FADH_2$ (complex-II) that is generated during oxidation of succinate in the TCA cycle.
II. Cytochrome-*c* is a small protein attached to the outer surface of the inner membrane acts as mobile carrier for transfer of electrons between complex-III and IV.
III. Complex-IV refers to cytochrome-*c* oxidase complex containg cytochromes-*a* and a_3 and two copper centres.
IV. As the electrons moves down the system, energy is used up to form ADP from ATP.
V. 2 ATP are formed for every pairs of electrons that enters by way of NADH and 3 ATP are formed for every pair of electrons that enters by way of $FADH_2$.

Choose the option containing incorrect statements.

(a) I and II (b) III and IV
(c) IV and V (d) I and III

135 Study the following statements regarding chemiosmotic hypothesis in mitochondria.

I. F_1 head-piece contains the site for the synthesis of ATP from ADP + Pi.
II. F_0 part forms the channel through which protons cross the inner membrane.
III. The passage of protons through the channel is coupled to the catalytic site of the F_1 component for the ATP production.

IV. For each ATP produced, $2H^+$ pass through F_0 from the intermembrane space to the matrix against the electrochemical process gradient.

Select the option depicting the correct statements.

(a) I and II
(b) I, II and III
(c) I and III
(d) I, II, III and IV

III. Matching Type Questions

136 Match the following columns for the location of the steps of aerobic respiration.

	Column I (Respiratory pathways)		Column II (Location)
A.	Glycolysis	1.	Inner mitochondrial membrane
B.	TCA cycle	2.	Mitochondrial matrix
C.	ETS	3.	Cytoplasm

Codes

	A	B	C		A	B	C
(a)	3	1	2	(b)	3	2	1
(c)	1	2	3	(d)	2	1	3

137 Match the following columns.

	Column I (Compounds)		Column II (Examples)
A.	4 C compound	1.	Acetyl CO-A
B.	2 C compound	2.	Pyruvate
C.	5 C compound	3.	Citric acid
D.	3 C compound	4.	α-ketoglutaric acid
		5.	Malic acid

Codes

	A	B	C	D
(a)	2	5	3	1
(b)	3	1	4	2
(c)	5	1	4	2
(d)	5	3	1	2

138 Match the following columns.

	Column I (Stages of aerobic respiration of a glucose molecule)		Column II (ATP produced through ETS)
A.	Glycolysis	1.	6
B.	Formation of acetyl Co-A	2.	3
C.	Krebs' cycle	3.	22

Codes

	A	B	C		A	B	C
(a)	1	1	3	(b)	2	1	3
(c)	3	2	1	(d)	3	1	2

139 Match the following columns.

	Column I		Column II
A.	RQ	1.	Chemiosmotic ATP synthesis
B.	Peter Mitchel	2.	Muscle fatigue
C.	Cytochromes	3.	Inner mitochondrial membrane
D.	Lactic acid	4.	Alcoholic fermentation
E.	Yeast	5.	Respirometer

Codes

	A	B	C	D	E
(a)	5	1	3	4	2
(b)	5	1	3	2	4
(c)	1	5	2	3	4
(d)	5	2	4	3	1

140 Match the columns about ETS.

	Column I (ETS complexes)		Column II (Names)
A.	Complex-I	1.	NADH dehydrogenase
B.	Complex-II	2.	Succinate dehydrogenase
C.	Complex-III	3.	Cytochrome-bc_1 complex
D.	Complex-IV	4.	Cytochrome-*c* oxidase complex
E.	Complex-V	5.	ATP synthase

Codes

	A	B	C	D	E
(a)	5	4	3	2	1
(b)	1	2	3	4	5
(c)	2	3	1	4	5
(d)	3	4	1	2	5

141 Match the following columns.

	Column I		Column II
A.	Peripheral membrane protein of ATP synthase	1.	Complex-III
B.	Pyruvate dehydrogenase	2.	F_0
C.	Integral membrane protein of ATP synthase	3.	F_1
D.	Cytochrome-bc_1	4.	Mitochondrial matrix

Codes

	A	B	C	D		A	B	C	D
(a)	3	2	1	4	(b)	1	2	4	3
(c)	1	2	3	4	(d)	3	4	2	1

142 Match the following columns.

	Column I		Column II
A.	Double aminated compound	1.	Glycogen
B.	Storage form of glucose	2.	Asparagine
C.	Fats made of three fatty acid chain attached to glycerol	3.	Citric acid
D.	Tricarboxylic acid	4.	Triglyceride

Codes

	A	B	C	D		A	B	C	D
(a)	2	3	4	1	(b)	1	4	2	3
(c)	2	1	4	3	(d)	1	3	4	2

NCERT Exemplar

MULTIPLE CHOICE QUESTIONS

143 The ultimate electron acceptor of respiration in an aerobic organism is
(a) cytochrome (b) oxygen (c) hydrogen (d) glucose

144 Phosphorylation of glucose during glycolysis is catalysed by
(a) phosphoglucomutase (b) phosphoglucoisomerase
(c) hexokinase (d) phosphorylase

145 The end product of oxidative phosphorylation is
(a) NADH (b) oxygen (c) ADP (d) ATP + H_2O

146 Pyruvic acid, the key product of glycolysis can have many metabolic fates. Under aerobic condition, it forms
(a) lactic acid (b) $CO_2 + H_2O$
(c) acetyl Co-A + CO_2 (d) ethanol + CO_2

147 Electron Transport System (ETS) is located in mitochondrial ***NEET (Odisha) 2019***
(a) outer membrane (b) intermembrane space
(c) inner membrane (d) matrix

148 Which of the following exhibits the highest rate of respiration?
(a) Growing shoot apex (b) Germinating seed
(c) Root tip (d) Leaf bud

149 Mitochondria are called powerhouses of the cell. Which of the following observations supports this statement?
(a) Mitochondria synthesise ATP
(b) Mitochondria have a double membrane
(c) The enzymes of the Krebs' cycle and the cytochromes are found in mitochondria
(d) Mitochondria are found in almost all plants and animal cells

150 Match the following columns.

	Column I		Column II
A.	Molecular oxygen	1.	α-ketoglutaric acid
B.	Electron acceptor	2.	Hydrogen acceptor
C.	Pyruvate dehydrogenase	3.	Cytochrome-*c*
D.	Decarboxylation	4.	Acetyl Co-A

Codes

	A	B	C	D
(a)	2	3	4	1
(b)	3	4	2	1
(c)	2	1	3	4
(d)	4	3	1	2

Answers

› *Mastering NCERT with MCQs*

1 (c)	2 (b)	3 (a)	4 (a)	5 (a)	6 (b)	7 (c)	8 (d)	9 (d)	10 (a)
11 (d)	12 (b)	13 (a)	14 (a)	15 (d)	16 (a)	17 (a)	18 (d)	19 (a)	20 (d)
21 (d)	22 (b)	23 (a)	24 (c)	25 (a)	26 (a)	27 (b)	28 (a)	29 (d)	30 (d)
31 (d)	32 (d)	33 (d)	34 (a)	35 (b)	36 (b)	37 (a)	38 (d)	39 (d)	40 (d)
41 (c)	42 (a)	43 (c)	44 (c)	45 (d)	46 (a)	47 (b)	48 (c)	49 (b)	50 (c)
51 (b)	52 (b)	53 (a)	54 (a)	55 (c)	56 (b)	57 (a)	58 (b)	59 (d)	60 (c)
61 (a)	62 (c)	63 (b)	64 (a)	65 (b)	66 (a)	67 (d)	68 (a)	69 (c)	70 (d)
71 (b)	72 (b)	73 (c)	74 (c)	75 (c)	76 (b)	77 (a)	78 (a)	79 (b)	80 (a)
81 (b)	82 (c)	83 (d)	84 (a)	85 (d)	86 (a)	87 (a)	88 (c)	89 (d)	90 (c)
91 (a)	92 (d)	93 (a)	94 (c)	95 (c)	96 (b)	97 (c)	98 (a)	99 (c)	100 (c)
101 (b)	102 (b)	103 (d)	104 (b)	105 (b)	106 (d)	107 (a)	108 (c)	109 (c)	110 (d)
111 (b)	112 (a)	113 (d)	114 (c)						

› *NEET Special Types Questions*

115 (a)	116 (d)	117 (c)	118 (d)	119 (b)	120 (b)	121 (c)	122 (a)	123 (d)	124 (a)
125 (d)	126 (d)	127 (d)	128 (a)	129 (b)	130 (c)	131 (a)	132 (d)	133 (c)	134 (c)
135 (b)	136 (b)	137 (c)	138 (a)	139 (b)	140 (b)	141 (d)	142 (c)		

› *NCERT Exemplar Questions*

143 (b)	144 (c)	145 (d)	146 (c)	147 (c)	148 (b)	149 (a)	150 (a)		

Answers & Explanations

5 (*a*) In the process of respiration, certain compounds get oxidised in order to produce energy. The compounds that are oxidised during this process, are known as respiratory substrates.

7 (*c*) The energy released by oxidation during respiration is not directly used, but is stored as ATP, which is broken down whenever energy is needed.

8 (*d*) Usually carbohydrates are oxidised to release energy, but proteins, fats and even organic acids can be used as respiratory substrates under certain conditions.

9 (*d*) Option (d) is true. Plants unlike animals possess no special organs for gaseous exchange. But, plants do possess stomata and lenticels through which exchange of gases takes place.

Thus, there is no such breathing mechanism occurring in the plant, but gaseous exchange do occur.

10 (*a*) During respiration, glucose is broken down by oxidation within the cell and CO_2, water and energy is released. Therefore, the suitable equation is

$$C_6H_{12}O_6 + 6O_2 \rightarrow + 6CO_2 + 6H_2O + \text{Energy}$$

13 (*a*) Glycolysis is also called EMP pathway because it was given by three scientists, Gustav Embden, Otto Meyerhof and J Parnas. It is the common pathway to both anaerobic and aerobic metabolism.

14 (*a*) Glycolysis is a series of reactions that take place in the cytoplasm of all prokaryotes and eukaryotes (i.e. all living cells).

The role of glycolysis is to produce energy (both directly and by supplying substrate for the citric acid cycle and oxidative phosphorylation) and various intermediate compounds, for biosynthetic pathway.

16 (*a*) Sucrose (a disaccharide) is converted into monosaccharides, i.e. glucose and fructose by the activity of the enzyme invertase. This step initiates the glycolytic pathway.

17 (*a*) Conversion of glucose to glucose-6-phosphate during glycolysis is catalysed by the enzyme hexokinase. During this step, glucose is phosphorylated to glucose-6-phosphate by ATP. It is the first step of activation phase of glycolysis.

20 (*d*) Each reaction in glycolysis is catalysed by its own specific enzyme. Glycolysis is a series of reactions that extract energy from glucose by splitting it into three carbon molecules called pyruvate.

21 (*d*) ATP is utilised in two steps of glycolysis, first in the conversion of glucose into glucose-6-phosphate and second in the conversion of fructose-6- phosphate to fructose-1, 6- bisphosphate.

22 (*b*) In glycolytic pathway, glyceraldehyde-3-phosphate is converted into 1, 3-bisphosphoglyceric acid by an oxidation and phosphorylation reaction, which occurs in the presence of H_3PO_4 and coenzyme NAD.

23 (*a*) Out of all the ten reactions taking place in glycolytic cycle, $NADH + H^+$ is formed only during conversion of PGAL to BPGA.

24 (*c*) ATP synthesis occurs in two steps of glycolysis which are

(i) Conversion of BPGA to PGA

(ii) Conversion of phosphoenol pyruvate to pyruvic acid.

27 (*b*) The correct sequence in glycolysis would be

Glucose-6-phosphate (G-6-P)
↓
3-Phosphoglyceraldehyde (3 PGAL)
↓
1,3-bisphosphoglyceric acid (3 PGA)
↓
Phosphoenol Pyruvate (PEP)

28 (*a*) Oxidative phosphorylation or ATP synthesis from NADH occurs only under aerobic condition and this results in the production of 6ATP molecules from 2 NADH.

29 (*d*) In glycolysis, 2 molecules of ATP are consumed initially in converting glucose to fructose-1, 6-bisphosphate. 2 triose phosphate molecules are formed from one glucose molecule. 4 molecules of ATP are produced at substrate level phosphorylation. Therefore, net gain of ATP is $2 \times 2ATP - 2ATP = 2$

30 (*d*) Pyruvic acid is the key product of glycolysis. Its metabolic fate depends on the cellular need. There are three major ways in which different cells handle pyruvic acid produced by glycolysis. These are lactic acid fermentation, alcoholic fermentation and aerobic respiration.

32 (*d*) Fermentation does not produce H_2O (water). Since, during respiration in the presence of oxygen, the electrons that are removed from glucose are eventually passed to oxygen by e^- carriers; therefore glucose is oxidised and oxygen is reduced to water. But when oxygen is not present, i.e. anaerobic respiration or fermentation occurs. It does not produce water.

36 *(b)* When oxygen is not available, yeast or some other microbes respire anaerobically. In case of anaerobic respiration, the following reaction occurs

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \longrightarrow 3\ \underset{\text{Ethanol}}{C_2H_5OH} + 2CO_2 + \text{Energy}$$

Thus, the end products of anaerobic respiration are CO_2, ethanol and energy.

38 *(d)* In the production of ethanol, pyruvic acid is first converted to acetaldehyde by enzyme pyruvate decarboxylase. The reaction is given below

$$\underset{\text{Pyruvic acid}}{2CH_3COCOOH} \xrightarrow[TPP,\ Mg^{2+}]{\text{Pyruvate decarboxylase}} \underset{\text{Acetaldehyde}}{2CH_3CHO} + 2CO_2$$

39 (*d*) In alcoholic fermentation, the oxidation of glyceraldehyde-3-phosphate (triose phosphate) occurs, which produces NADH. This NADH donates an electron and then the acetaldehyde gets reduced to ethanol and NAD^+ is regenerated. Thus, triose phosphate is the electron donor and acetaldehyde is the electron acceptor.

41 (*c*) During anaerobic respiration of yeast, two ATP produced from a single glucose molecule. Hence, 38 ATP will be produce from 19 glucose molecules. Anaerobic respiration occurs in the absence of oxygen. It is found in deep-seated tissues of plants and animals, germinating seeds, yeasts and bacteria.

43 (*c*) Due to the excessive contraction of muscles (e.g. leg muscles in hurdle race), the metabolic products of glycolysis, i.e. pyruvate is converted into lactic acid/lactate.

This gets accumulated in the muscles and leads to muscle fatigue. Due to this, pain is experienced in the fatigued muscle.

45 (*d*) In lactate fermentation, CO_2 is not released. Lactic acid fermentation is a process by which glucose, fructose and sucrose are converted into energy and lactic acid. The reaction for lactic acid fermentation is

$$\underset{\text{2 Pyruvic acid}}{\overset{2\,(NADH + H^+)}{\xrightarrow[FMN,\ Zn^{2+}]{\text{lactate dehydrogenase}}}} \underset{\text{2 Lactic acid}}{2\,NAD^+}$$

46 (*a*) During fermentation, the pyruvic acid is transformed to ethyl alcohol and 4 ATP molecules are produced. This pyruvic acid comes from breakdown of glucose by glycolysis.

47 (*b*) Glycolysis, which is also called EMP pathway is the common pathway to both anaerobic and aerobic metabolism. (A) Pyruvic acid is formed during glycolysis in the cytosol, which then enters into the mitochondrial matrix. If O_2 is available, it gets converted into (B) CO_2 and water, while in the absence of O_2 in bacteria, it forms (C) lactic acid and in yeast, it forms (D) ethyl alcohol and CO_2.

48 (*c*) Enolase works on 2-phosphoglyceric acid (3C-compound), aconitase on citric acid (6C-compound), fumarase on fumaric acid (4C-compound) and alcohol dehydrogenase on acetaldehyde (2C-compound).

50 (*c*) In a cellular respiration, energy stored in a glucose molecule, which enters into cytoplasm is called glycolysis.

Then its product enters into Krebs' cycle, which is also called Tricarboxylic Acid (TCA) cycle. Finally electron transport chain occurs that results in the formation of ATP.

Therefore, the correct sequence is Glycolysis → Krebs' cycle → Electron transport chain.

51 (*b*) Glycolysis is an essential and first path of respiration. It is common in both aerobic and anaerobic respiration and occurs in the cytoplasm of all living cells of prokaryotes as well as eukaryotes.

53 (*a*) CO_2 and H_2O are the end products of aerobic respiration. Ethyl alcohol and lactic acid are formed as a result of anaerobic respiration (fermentation), while pyruvic acid is produced during both aerobic and anaerobic respiration.

54 (*a*) Option (a) is correct as the first event, i.e. complete oxidation of pyruvate by the stepwise removal of all the hydrogen atoms, leaving three molecules of CO_2 occurs in the matrix of mitochondria.

The enzymes for this process occurs here. This process include oxidative decarboxylation and tricarboxylic acid cycle.

The second event, i.e. the passing on of the electrons removed as part of the hydrogen atoms to molecules of O_2 with simultaneous synthesis of ATP occurs in inner membrane of mitochondria. This process is called electron transport system.

55 (*c*) The conversion of glycolysis product, i.e. pyruvate into acetyl Co-A that enters the next step in Krebs' cycle is called pyruvate oxidation. It is also called the link reaction as it links glycolysis with Krebs' cycle.

56 (*b*) Pyruvic acid synthesised in glycolysis must enter inside the mitochondrion where oxidative decarboxylation occurs in the presence of NAD^+, pyruvic acid (pyruvate) dehydrogenase complex and coenzyme-A (Co-A).

$$\text{Pyruvic acid} + \text{Co-A} + NAD^+ \xrightarrow[\text{Pyruvate dehydrogenase}]{Mg^{2+}} \text{Acetyl Co-A} + CO_2 + NADH + H^+$$

Thus, pyruvate dehydrogenase enzyme serves as the link enzyme.

58 (*b*) NAD^+ functions as an electron carrier in cellular respiration. NAD is an oxidising agent which accepts electrons and then transfers them to the Electron Transport System (ETS) for the formation of 3ATP molecules.

59 (*d*) Acetyl Co-A is common to respiration-mediated breakdown of fats, carbohydrates and proteins which is formed from pyruvic acid.

61 (*a*) One of the three carbon atoms of pyruvic acid is oxidised to carbon dioxide. The combination of the remaining two carbon acetate unit is readily accepted by a sulphur containing compound coenzyme-A (Co-A) to form acetyl Co-A. This is called oxidative decarboxylation reaction, which is the connecting link between glycolysis and Krebs' cycle.

62 (*c*) In eukaryotes, all the reactions of Tricarboxylic Acid (TCA) cycle or Krebs' cycle take place in the matrix of mitochondria because all enzymes of this cycle are found in the matrix of mitochondria except succinic dehydrogenase, which is located in the inner membrane of mitochondria.
In prokaryotes, Krebs' cycle occurs in cytoplasm.

63 (*b*) Option (b) is incorrect for Krebs' cycle and can be corrected as

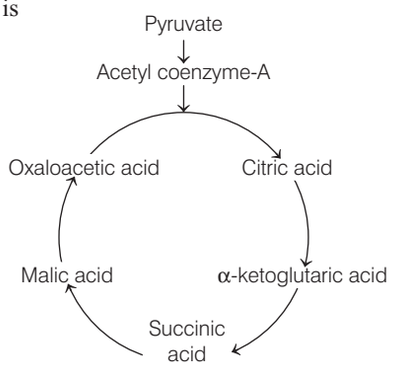
Acetyl Co-A is the intermediate compound between glycolysis and Krebs' cycle. Rest are correct.

64 (*a*) In the first reaction of citric acid cycle, one molecule of acetyl Co-A combines with the 4 carbon compound Oxaloacetic Acid (OAA) to form 6 carbon citric acid and Co-A is released.

65 (*b*) TCA cycle starts with the condensation of acetyl group with Oxaloacetic Acid (OAA) and water to yield citric acid. Thus, reaction is catalysed by the enzyme citrate synthase.

66 *(a)* Option (a) is correct.
- α-ketoglutarate is a 5C compound
- Citric acid is a 6C compound
- Malate is a 4C compound
- Pyruvic acid is a 3C compound.

67 (*d*) All are wrong as the corrrect sequence of Krebs' cycle is



68 (*a*) Option (a) is correct.
- Oxaloacetic acid is a 4C compound.
- Phosphoglyceric acid is a 3C compound.
- Ribulose bisphosphate is a 5C compound.
- Phosphoenol pyruvate is a 3C compound.

69 (*c*) During the conversion of succinyl Co-A to succinic acid, a molecule of GTP is synthesised. This is a substrate level phosphorylation.
In a coupled reaction, GTP is converted to GDP with the simultaneous synthesis of ATP from ADP.

70 (*d*) During the step of Krebs' cycle, where succinic acid undergoes oxidation or dehydrogenation to form fumaric acid, FAD is reduced to $FADH_2$ and enzyme involved in this step is succinic acid dehydrogenase. Conversion of isocitric acid to α-ketoglutaric acid, malic acid to oxaloacetic acid and pyruvic acid to acetyl Co-A, all involve reduction of NAD to NADH + H^+.

75 (*c*) Krebs' cycle produces 2GTP (or 2 ATP) through substrate level phosphorylation along with six molecules of $NADH_2$ and 2 molecules of $FADH_2$ for every two molecules of acetyl Co-A oxidised.

76 (*b*) The number of glucose molecules produced in each reaction involved in complete glucose oxidation are
ETC produces - 34 ATP

Glycolysis produces - 2 ATP

Krebs' cycle produces - 2 ATP

Pyruvic acid to acetyl Co-A conversion produces no ATP

Thus, the highest number of ATP molecules are obtained through ETC.

77 (*a*) The main purpose of ETC (Electron Transport Chain) is to release and utilise the energy stored in NADH + H^+ and $FADH_2$. This is accomplished when these are oxidised through the electron transport system and the electrons are passed on to O_2, resulting in the formation of H_2O.

89 (*d*) All the given mechanisms in the options lead to ATP formation. This type of method used depends on the type of organisms and their energy transfer mechanisms.
- **Photophosphorylation** is the enzymatic formation of ATP from ADP coupled to the light dependent transfer of electrons in photosynthetic cells.
- **Substrate level phosphorylation** is the phosphorylation of ADP or some other nucleoside 5-diphosphate coupled to the dehydrogenation of an organic substrate, independent of the electron transfer chain.
- **Oxidative phosphorylation** is the enzymatic phosphorylation of ADP to ATP coupled to electron transfer from a substrate to molecular oxygen.

92 *(d)* Six carbon dioxide molecules are released by complete oxidation of one glucose molecule. Two carbon dioxide molecules are released during oxidative decarboxylation reaction and four carbon dioxide molecules are released in Krebs' cycle or tricarboxylic acid cycle.

94 *(c)* Net gain of 36 to 38 ATP molecules is obtained through aerobic respiration as 2ATP molecules are produced through glycolysis and Kreb's cycle each and

32 to 34 ATP molecules are produced through electron transport chain.

95 (*c*) 34 molecules of ATP (30 through NADH and 4 through $FADH_2$) are obtained as a result of oxidative phosphorylation. Rest 4 molecules are obtained as a result of direct phosphorylation.

96 *(b)* The net yield of ATP molecules in aerobic respiration during Krebs' cycle per glucose molecules is 2 ATP + 3NADH. These 3 NADH further convert to $3 \times 2 = 6$ ATP in ETS. Thus, net yield will be $2 + 6 = 8$ ATP.

98 *(a)* Oxidation of one molecule of NADH gives rise to 3 molecules of ATP, while that of one molecule of $FADH_2$ produces 2 molecules of ATP.

99 *(c)* The NADH synthesised in glycolysis is transferred into the mitochondria and undergoes oxidative phosphorylation.

101 (*b*) Pathway *A* is glycolysis, pathway *B* is the Krebs' cycle and pathway *C* is oxidative phosphorylation.

Arrow 1	—	ADP or NAD^+
Arrow 2	—	Pyruvate
Arrow 3	—	NADH
Arrow 4	—	ATP
Arrow 5	—	ADP, NAD^+ or FAD
Arrow 6 and 7	—	$FADH_2$ and NADH (either one can be 6 or 7)
Arrow 8	—	ATP or CO_2
Arrow 9 and 10	—	O_2 and ADP (either one can be 9 or 10)
Arrow 11 and 12	—	H_2O and ATP (either one can be 11 or 12)

106 *(d)* In succulent plants like *Opuntia*, carbohydrates are incompletely oxidised to organic acid in dark without the evolution of CO_2. Hence, the value of RQ remains zero.

107 (*a*) The RQ (Respiratory Quotient) of glucose is 1.

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6\,CO_2 + 6\,H_2O$$

$$RQ = \frac{6CO_2}{6O_2} = 1$$

109 *(c)* Respiratory quotient is the ratio of volume of CO_2 evolved to the volume of O_2 consumed. Thus, if

RQ is less than 1.0 in respiratory metabolism, means that respiratory substrates consume more oxygen than the amount of CO_2 released.

110 *(d)* In anaerobic respiration, CO_2 is evolved, but oxygen is not used. So, value of O_2 becomes zero. Therefore, in such case respiratory quotient will be infinite, e.g.

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \xrightarrow{\text{Zymase}} 2\,C_2H_5OH + 2\,CO_2 + \text{Energy}$$

$$\text{Where, respiratory quotient} = \frac{\text{Evolved } CO_2}{\text{Consumed } O_2}$$

$$= \frac{2\,CO_2}{0\,O_2} = \infty \text{ (Infinity)}$$

111 *(b)* The respiratory quotient of the equation can be calculated in the following volume of way

$$\text{Respiratory quotient} = \frac{\text{Evolved } CO_2}{\text{Consumed } O_2} = \frac{102\ CO_2}{145\ O_2} = 0.7$$

113 *(d)* Organic acid evolves more carbon dioxide than volume of oxygen it consumes when broken down as respiratory substrate under aerobic conditions. Thus, its RQ is more than unity.

114 (*c*) The Respiratory Quotient (RQ) of a germinating castor seed is less than one. This can be explained as castor seeds are rich in fats (oil) and respiratory quotient of fats is less than one (mostly 0.7). During germination of seed aerobic respiration occurs and oxygen is consumed. Since, breakdown of fat required more oxygen, their RQ is less than one.

115 (*a*) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.

The conversion of glyceraldehyde-3-phosphate to 1, 3-bisphosphoglycerate is an oxidation reaction.

This oxidation reaction occurs due to the use of NAD^+ which gets converted to NADH by accepting a hydrogen molecule and this reaction is catalysed by the enzyme glyceraldehyde-3-phosphate dehydrogenase.

116 (*d*) Assertion is false, but Reason is true and Assertion can be corrected as

The breaking of ATP into ADP and inorganic phosphate releases 30.6 kJ of energy per mole (not the making of ATP from ADP).

This energy is released from breaking of high energy phosphate bonds in ATP. All cells of the body have ATP molecules in them.

117 (*c*) Assertion is true, but Reason is false and it can be corrected as

Carbohydrates are used first by most cells in respiration. Lipids (fats or oils) are used mainly when carbohydrate reserves have been exhausted. As proteins have other essential functions, these are used only when all the carbohydrate and lipid reserves have been used up.

118 (*d*) Assertion is false, but Reason is true and Assertion can be corrected as

ATP formation during respiration is an endergonic process. This is because ATP formation requires input of energy.

119 (*b*) Both Assertion and Reason are true, but Reason is not the correct explanation for Assertion.

Glucose is converted into two molecules of pyruvic acid due to which two Krebs' cycle occur for glucose molecule. Each turn of Krebs' cycle produces 3 NADH, 1 $FADH_2$ and 1 ATP molecules. On oxidation, 1 NADH produces 3 ATP molecules and 1$FADH_2$ produces 2 ATP molecules. In each turn of Krebs' cycle, 12 ATP molecules are produced.

120 (*b*) Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion.

The correct explanation is aerobic respiration yields a total of 36 or 38 ATP molecules for one molecule of glucose.

Fermentation yields a total of 2 ATP molecules for each molecule of glucose degraded. So, aerobic respiration is bioenergetically more efficient than anaerobic glycolysis.

121 (*c*) Assertion is true, but Reason is false and it can be corrected as

Alcoholic fermentation is an anaerobic process. It involves conversion of pyruvic acid into ethanol with the release of carbon dioxide.

$$\text{Pyruvate} \xrightarrow[\text{Fermentation}]{\text{Alcoholic}} \text{Ethanol} + CO_2$$

122 (*a*) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.

Respiratory pathway is considered as an amphibolic pathway as it involves both anabolic and catabolic reactions. For example, fatty acids are broken down to acetyl Co-A before entering respiratory pathway and many other carbonic acids are synthesised as an intermediate compound.

123 (*d*) The statement in option (d) is incorrect and can be corrected as

Krebs' cycle starts with the condensation of acetyl group with oxaloacetic acid and water to yield citric acid.

Rest of the statements are correct.

124 (*a*) The statement in option (a) is incorrect. The correct form of the statement is

Enzymes of electron transport are embedded in the inner membrane of mitochondria.

Rest of the statements are correct.

125 (*d*) The statement in option (d) is incorrect. It can be corrected as

Oxidative phosphorylation occurs in the inner mitochondrial membrane because of its less permeability, presence of ETC proteins and ATP synthase.

It is the process of ATP formation due to the transfer of electrons from NADH or $FADH_2$ to oxygen molecule (O_2) by a series of electron carriers.

The remaining three statements are correct.

126 (*d*) The statement in option (d) is incorrect. It can be corrected as

Cytochromes are proteinaceous, but ubiquinone is a non-proteinaceous, organic molecule.

Ubiquinone is a lipophilic metabolite.

Rest of the statements are correct.

128 (*a*) The statement in option (a) is correct.

Other statements are incorrect and can be corrected as

- Alternative substrates other than glucose are allowed to enter the pathway at intermediate stages, e.g. glycerol (a product of fats breakdown) can enter the pathway after being converted to PGAL.
- Substrate can be respired in the pathway at intermediate stages like when organism need fatty acids, acetyl Co-A would be withdrawn from the pathway.
- Respiratory pathway functioning is sequentional, i.e. Glycolysis → Krebs' cycle → ETS not Krebs' cycle to glycolysis.

129 *(b)* The statement in option (b) is incorrect and can be corrected as

The intermediate compound between the glycolysis with Krebs' cycle is acetyl Co-A

Rest of the statements are correct.

130 (*c*) Statements I, II and IV are correct only statement III is incorrect and can be corrected as

Glycolysis utilises 1 ATP molecule each at 2 steps, i.e. in the conversion of glucose to glucose-6-phosphate and in the conversion of fructose-6-phosphate to fructose-1, 6-bisphosphate.

131 (*a*) Only statement I is correct. Rest of the statements are incorrect and can be corrected as

- Glycolysis produces 4 molecules of ATP.
- In glycolysis one molecule of NAD^+ is reduced for each glucose molecule processed.
- The energy stored with the NADH is released in the electron transport chain.

132 (*d*) The statement I is correct. Statements II and III are incorrect and can be corrected as

- Electron transport chain can occur only in the presence of oxygen.
- Complete oxidation of glucose into CO_2 and H_2O requires the presence of oxygen.

133 (*c*) Both statements I and II are true.

The role of oxygen is limited to the terminal stage of ETS. Yet, the presence of oxygen is vital since it drives the whole process by removing hydrogen from the system. Oxygen acts as the final hydrogen acceptor.

134 (*c*) Statements IV and V are incorrect and can be corrected as

- When the electrons pass from one carrier to another *via* complex-I to IV in ETS, they are coupled to ATP synthase complex-V for the production of ATP from ADP and inorganic phosphate.
- Oxidation of one molecule of NADH gives rise to 3 ATP, while that of one molecule of $FADH_2$ produces 2 molecules of ATP.

Rest of the statement are correct.

135 (*b*) Statements I, II and III are correct. Statement IV is incorrect and can be corrected as

For each ATP produced, $2H^+$ pass through F_0 from the intermembrane space to the matrix down the electrochemical process gradient.

138 (*a*) The option (a) shows the correct matching. During aerobic respiration of a single glucose various stages produces ATP, NADH, $FADH_2$ and GTP. Out of these NADH and FADH goes to ETS for conversion into

ATP. Thus, during glycolysis 2NADH produced which formed 6ATP by ETC. Acetyl Co-A production from pyruvate forms 2NADH, i.e. 6 ATP, Krebs' cycle produces 6NADH and 2$FADH_2$, i.e. 22 ATP.

143 (*b*) Oxygen is the ultimate electron acceptor in aerobic respiration because at the end of electron transport chain it accepts a pair of electrons and combines with hydrogen atom to form water molecule.

144 (*c*) Hexokinase catalyses the conversion of glucose into glucose-6-phosphate by the use of ATP molecule, through phosphorylation reaction. This reaction is the first step of glycolysis.

145 (*d*) Oxidative phosphorylation involves complete oxidation of glucose molecule that produces 38 ATP molecules, water (H_2O) and carbon dioxide with the help of energy released during oxidation of reduced coenzymes. Thus, option (d) is correct.

146 (*c*) Option (c) is correct as

Pyruvate, the product obtained through glycolysis, under aerobic condition forms acetyl Co-A and CO_2. It can be represented as

$$\text{Pyruvic acid} + \text{Co-A} + NAD^+ \xrightarrow[\text{Pyruvate dehydrogenase}]{Mg^{2+}} \text{Acetyl Co-A} + CO_2 + NADH + H^+$$

Other options are explained as

- Lactic acid is formed in muscles under anaerobic conditions.
- Ethanol and CO_2 are products of anaerobic respiration in yeast cells.
- CO_2 and H_2O are final products released at the end of cellular respiration.

147 (*c*) Electron transport system is present in the inner mitochondrial membrane, which has groups of several proton (H^+) and electron (e^-) acceptors.

148 (*b*) Germinating seeds have the highest rate of respiration. As soon as the water is imbibed by seeds, hydrolytic enzymes (amylase) come into action and mobilise the reserve food materials, so the seeds show high metabolic activity and germinate into a tiny plant.

All these activities require energy, which is derived from increased rate of aerobic respiration.

149 (*a*) Mitochondria are double membrane bound structures and are the site of ATP production, which is the energy currency of the cell.

The rest of the statements, are also correct, but do not verify and support the fact that mitochondria are the powerhouse of the cell.