7. What are the assumptions made during the calculation of net gain of ATP?
Solution: It is possible to make calculations of the net gain of ATP for every glucose molecule oxidised; but in reality this can remain only a theoretical exercise. These calculations can be made only on certain assumptions that:

- There is a sequential, orderly pathway functioning, with one substrate forming the next and with glycolysis, TCA cycle and ETS pathway following one after another.
  transferred into the mitochondria and undergoes oxidative phosphorylation.
- None of the intermediates in the pathway are utilised to synthesise any other compound.
- Only glucose is being respired - no other alternative substrates are entering in the pathway at any of the intermediary stages.

But these kind of assumptions are not really valid in a living system; all pathway work simultaneously and do not take place one after another; substrates enter the pathways and are withdrawn from it as and when necessary; ATP is utilised as and when needed; enzymatic rates are controlled by multiple means. Hence, there can be a net gain of 36 ATP molecules during aerobic respiration of one molecule of glucose.

8. Distinguish between the following:
(a) Aerobic respiration and Anaerobic respiration.
(b) Glycolysis and Fermentation.
(c) Glycolysis and Citric acid cycle.
Solution: (a) Differences between aerobic and anaerobic respiration are as follows:

Aerobic respiration	Anaerobic respiration
Aerobic respiration is a type of respiration in which foodstuffs (usually carbohydrates) are completely oxidised to carbon dioxide and water, with the release of chemical energy, in a process requiring atmospheric oxygen. The reaction can be summarized by the equation: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{energy}$	Anaerobic respiration is a type of respiration in which foodstuffs (usually carbohydrates) are partially oxidised, with the release of chemical energy, in a process not involving atmospheric oxygen. Since the substrate is never completely oxidised the energy yield of this type of respiration is lower than that of aerobic respiration. It occurs in some yeasts and bacteria and in muscle tissue when oxygen is absent.

(b) Differences between glycolysis and fermentation are as follows:

	Glycolysis	Fermentation
(i)	It is the first step of respiration which occurs without requirement of oxygen and is common to both aerobic and anaerobic modes of respiration.	It is anaerobic respiration or respiration which does not require oxygen.
(ii)	Glycolysis produces pyruvic acid.	Fermentation produces different products. The common ones are ethanol (and CO_2) and lactic acid.
(iii)	It produces two molecules of NADH per glucose molecule.	It generally utilises NADH produced during glycolysis.
(iv)	It forms 2 ATP molecules per glucose molecule.	It does not produce ATP.

9. Discuss "The respiratory pathway is an amphibolic pathway".
Solution: Amphibolic pathway is the one which is used for both breakdown (catabolism) and build-up (anabolism) reactions.
Respiratory pathway is mainly a catabolic process which serves to

run the living system by providing energy. The pathway produces a number of intermediates. Many of them are raw materials for building up both primary and secondary metabolites. Acetyl CoA is helpful not only in Krebs' cycle but is also raw material for synthesis of fatty acids, steroids, terpenes, aromatic compounds and carotenoids, a-ketoglutarate is organic acid which forms glutamate (an important amino acid) on amination. OAA (Oxaloacetic acid) on amination produces asparate. Both aspartate and glutamate are components of proteins. Pyrimidines and alkaloids are other products. Succinyl CoA forms cytochromes and chlorophyll.
Hence, fatty acids would be broken down to acetyl CoA before entering the respiratory pathway when it is used as a substrate. But when the organism needs to synthesise fatty acids, acetyl CoA would be withdrawn from the respiratory pathway for it. Hence, the respiratory pathway comes into the picture both during breakdown and synthesis of fatty acids. Similarly, during breakdown and synthesis of proteins too, respiratory intermediates form the link. Breaking down processes within the living organism is catabolism, and synthesis is anabolism. Because the respiratory pathway is involved in both anabolism and catabolism, it would hence be better to consider the respiratory pathway as an amphibolic pathway rather than as a catabolic one.

10. Define RQ. What is its value for fats?
Solution: Respiratory quotient (RQ) is the ratio of the volume of carbon dioxide produced to the volume of oxygen consumed in respiration over a period of time. Its value can be one, zero, more than 1 or less than one.

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

Volume of C02 evolved Volume of 02 consumed
RQ is less than one when the respiratory substrate is either fat or protein.
$C_{57} H_{104}O_6 + 80\ O_2 \rightarrow 57\ CO_2 + 52H_2O$
$RQ = 57CO_2/80O_2 = 0.71$
RQ is about 0.7 for most of the common fats.

11. What is oxidative phosphorylation?
Solution: Oxidative phosphorylation is the synthesis of energy rich ATP molecules with the help of energy liberated during oxidation of reduced co-enzymes (NADH, $FADH_2$) produced in respiration. The enzyme required for this synthesis is called ATP synthase. It is considered to be the fifth complex of electron transport chain. ATP synthase is located in FT or head piece of F_0 -F_1 or elementary particles. The particles are present in the inner mitochondrial membrane. ATP synthase becomes active in ATP formation only where there is a proton gradient having higher concentration of H^+ or protons on the F_0 side as compared to F x side (chemiosmotic hypothesis of Peter Mitchell).
Increased proton concentration is produced in the outer chamber or outer surface of inner mitochondrial membrane by the pushing of proton with the help of energy liberated by passage of electrons from one carrier to another. Transport of the electrons from NADH over ETC helps in pushing three pairs of protons to the outer chamber while two pairs of protons are sent outwardly during electron flow from $FADH_{2.}$ The flow of protons through the F_0 channel induces F_1 particle to function as ATP-synthase. The energy of the proton gradient is used in attaching a phosphate radical to ADP by high energy bond. This produces ATP. Oxidation of one molecule of $NADH_2$ produces 3 ATP molecules while a similar

oxidation of $FADH_2$ forms 2 ATP molecules.

12. What is the significance of step-wise release of energy in respiration?
Solution: The utility of step-wise release of energy in respiration are given as follows:

1. There is a step-wise release of chemical bond energy which is very easily trapped in forming ATP molecules.
2. Cellular temperature is not allowed to rise.
3. Wastage of energy is reduced.
4. There are several intermediates which can be used in production of a number of biochemicals.
5. Through their metabolic intermediates different substances can undergo respiratory catabolism.
6. Each step of respiration is controlled by its own enzyme. The activity of different enzymes can be enhanced or inhibited by specific compounds.

This helps in controlling the rate of respiration and the amount of energy liberated by it.

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