NCERT Solutions for Class-XI Biology

Chapter-17

1. Define vital capacity. What is its significance?

1. Vital capacity is defined as the maximum volume of air a person can breathe in after a forced expiration or the maximum volume of air a person can breathe out after a forced inspiration. It represents the maximum amount of air one can renew in the respiratory system in a single respiration. Thus, greater the vital capacity more is the energy available to the body.

2. State the volume of air remaining in the lungs after a normal breathing.

2. The volume of air remaining in the lungs after a normal expiration is known as functional residual capacity (FRC). It includes expiratory reserve volume (ERV) and residual volume (RV). ERV is the maximum volume of air that can be exhaled after a normal expiration.

It is about 1000 mL to 1500 mL. RV is the volume of air remaining in the lungs after maximum expiration. It is about 1100 mL to 1500 mL.

$\therefore$ FRC = ERV + RV

$\cong$ 1500 + 1500

$\cong$ 3000 mL

Functional residual capacity of the human lungs is about 2500 – 3000 mL.

3. Diffusion of gases occurs in the alveolar region only and not in the other parts of respiratory system. Why?

3. For efficient exchange of gases, respi: atory surface must have certain characteristics such as (i) it must be thin, me ist and permeable to respiratory gases (ii) it must have large surface area, (iii) it must be highly vascular. Only alveolar region has these characteristics. Thus, diffusion of gases occurs in this region only.

4. What are the major transport mechanisms for CO_2? Explain.

4. Plasma and red blood cells transport carbon dioxide. This is because they are readily soluble in water.

(1) Through plasma:

About 7% of CO2 is carried in a dissolved state through plasma. Carbon dioxide combines with water and forms carbonic acid.

$$CO_2 + H_2O \longrightarrow \underset{\text{(Carbonic acid)}}{H_2CO_3}$$

Since the process of forming carbonic acid is slow, only a small amount of carbon dioxide is carried this way.

(2) Through RBCs:

About 20 – 25% of CO_2 is transported by the red blood cells as carbaminohaemoglobin. Carbon dioxide binds to the amino groups on the polypeptide chains of haemoglobin and forms a compound known as carbaminohaemoglobin.

(3) Through sodium bicarbonate:

About 70% of carbon dioxide is transported as sodium bicarbonate. As CO_2 diffuses into the blood plasma, a large part of it combines with water to form carbonic acid in the presence of the enzyme carbonic anhydrase. Carbonic anhydrase is a zinc enzyme that speeds up the formation of carbonic acid. This carbonic acid dissociates into bicarbonate $\left(HCO_3^-\right)$ and hydrogen ions (H^+).

$$CO_2 + H_2O \xrightarrow{\text{Carbonic anhydrase}} H_2CO_3$$

$$H_2CO_3 \xrightarrow[\text{anhydrase}]{\text{Carbonic}} HCO_3^- + H^+$$

5. What will be the pO_2 and pCO_2 in the atmospheric air compared to those in the alveolar air?

(i) pO_2 lesser, pCO_2 higher

(ii) pO_2 higher, pCO_2 lesser

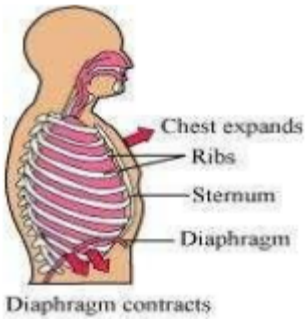
(iii) pO_2 higher, pCO_2 higher

(iv) pO_2 lesser, pCO_2 lesser

5. (ii) Air that has entered the alveoli through the bronchioles is called alveolar air. It has the same partial pressure of CO_2 and O_2 as is in the atmospheric air. Then, there occurs gaseous exchange between the adjacent blood capillaries and the alveoli. CO_2 diffuses from blood into the alveolar air and O_2 diffuses from alveolar air to the blood. As a result, new alveolar air has higher pCO_2 and lesser pO_2, than the atmospheric air.

6. Explain the process of inspiration under normal conditions.

6. Inspiration or inhalation is the process of bringing air from outside the body into the lungs. It is carried out by creating a pressure gradient between the lungs and the atmosphere. When air enters the lungs, the diaphragm expands toward the abdominal cavity, thereby increasing the space in the thoracic cavity for accommodating the inhaled air.



The volume of the thoracic chamber in the anteroposterior axis increases with the simultaneous contraction of the external intercostal muscles. This causes the ribs and the sternum to move out, thereby increasing the volume of the thoracic chamber in the dorsoventral axis. The overall increase in the thoracic volume leads to a similar increase in the pulmonary volume. Now, as a result of this increase, the intra-pulmonary

pressure becomes lesser than the atmospheric pressure. This causes the air from outside the body to move into the lungs.

7. How is respiration regulated?

7. Respiration is under both nervous and chemical regulation.

The respiratory centre in brain is composed of groups of neurons located in the medulla oblongata and pons varolii. The respiratory centre regulates the rate and depth of the breathing.

Dorsal respiratory group of neurons are located in the dorsal portion of the medulla oblongata. This group of neurons mainly causes inspiration.

Ventral group of neurons are located in the ventrolateral part of the medulla oblongata. These can cause either inspiration or expiration.

Pneumotaxic centre is located in the dorsal part of pons varolii. It sends signals to all the neurons of dorsal respiratory group and only to inspiratory neurons of ventral respiratory group. Its job is primarily to limit inspiration. Chemically, respiration is regulated by the large numbers of chemoreceptors located in the carotid bodies and in the aortic bodies. Excess carbon dioxide or hydrogen ions mainly stimulate the respiratory centre of the brain and increases the inspiratory and expiratory-signals to the respiratory muscles. Increased CO_2 lowers the pH resulting in acidosis. The role of oxygen in the regulation of respiratory rhythm is quite insignificant.

8. What is the effect of pCO_2 on oxygen transport?

8. pCO_2 plays an important role in the transportation of oxygen. At the alveolus, the low pCO_2 and high pO_2 favours the formation of haemoglobin. At the tissues, the high pCO_2 and low pO_2 favours the dissociation of oxygen from oxyhaemoglobin. Hence, the affinity of haemoglobin for oxygen is enhanced by the decrease of pCO_2 in blood. Therefore, oxygen is transported in blood as oxyhaemoglobin and oxygen dissociates from it at the tissues.

9. What happens to the respiratory process in a man going up a hill?

9. Rate of breathing will increase in order to supply sufficient oxygen to blood because air in mountainous region is deficient in oxygen.

10. What is the site of gaseous exchange in an insect?

10. In insects, gaseous exchange occurs through a network of tubes collectively known as the tracheal system. The small openings on the sides of an insect's body are known as spiracles. Oxygen-rich air enters through the spiracles. The spiracles are connected to the network of tubes. From the spiracles, oxygen enters the tracheae. From here, oxygen diffuses into the cells of the body. The movement of carbon dioxide follows the reverse path. The CO_2 from the cells of the body first enters the tracheae and then leaves the body through the spiracles.

11. Define oxygen dissociation curve. Can you suggest any reason for its sigmoidal pattern?

11. The relationship between the partial pressure of oxygen (pO_2) and percentage saturation of the haemoglobin with oxygen (O_2)is graphically illustrated by a curve called oxygen haemoglobin dissociation curve (also called oxygen dissociation curve).
The sigmoidal pattern of oxygen haemoglobin dissociation curve is the result of two properties which play significant role in the transport of oxygen. These two properties are:
(i) Minimal loss of oxygen from haemoglobin occurs above pO_2 of 70-80 mm Hg despite significant changes in tension of oxygen beyond this. This is depicted by relatively flat portion of the curve.
(ii) Any further decline in pO_2 from 40 mm Hg causes a disproportionately greater release of oxygen from the haemoglobin. It results in the steeper portion of the curve and causes the curve to be sigmoid.

12. Have you heard about hypoxia? Try to gather information about it, and discuss with your friends.

12. Hypoxia is a condition characterised by an inadequate or decreased supply of oxygen to the lungs. It is caused by several extrinsic factors such as reduction in pO_2, inadequate oxygen, etc. The different types of hypoxia are discussed below.
Hypoxemic hypoxia
In this condition, there is a reduction in the oxygen content of blood as a result of the low partial pressure of oxygen in the arterial blood.
Anaemic hypoxia
In this condition, there is a reduction in the concentration of haemoglobin.
Stagnant or ischemic hypoxia
In this condition, there is a deficiency in the oxygen content of blood because of poor blood circulation. It occurs when a person is exposed to cold temperature for a prolonged period of time.
Histotoxic hypoxia
In this condition, tissues are unable to use oxygen. This occurs during carbon monoxide or cyanide poisoning.

13. Distinguish between
(a) IRV and ERV
(b) Inspiratory capacity and Expiratory capacity
(c) Vital capacity and Total lung capacity

13. (a) Differences between IRV and ERV are as follows:

Inspiratory reserve volume(IRV)	**Expiratory reserve volume(ERV)**
It is the maximum amount of air that can be inhaled after a normal inhalation.	It is the maximum amount of air that can be exhaled out after a normal exhalation.
About 2500-3500 ml of air can be inhaled after a normal inhalation.	About 1000-1500 ml of air can be exhaled after the normal exhalation.

(b) Difference between Inspiratory capacity and Expiratory capacity:
Inspiratory capacity: It is the volume of air that can be inhaled after a normal expiration.

- IC = TV + IRV

Expiratory capacity: It is the volume of air that can be exhaled after a normal inspiration.

- EC = TV + ERV

(c) Differences between vital capacity and total lung capacity are as follows:

Vital lung capacity	Total lung capacity
Vital capacity (VC) is the maximum amount of air a person can breathe in after a forced breathe out.	Total lung capacity (TLC) is the volume of air in the lungs after a forced inspiration.
It includes IC and ERV.	It includes IC, ERV, and residual volume.
It is about 4000 milliliters in the human lungs.	It is about 5000-6000 milliliters in the human lungs.
Vital lung capacity is calculated by summing tidal volume(VT), inspiratory reserve volume (IRV), and expiratory reserve volume (ERV). Therefore, VC = TV+IRV+ERV.	Total lung capacity is calculated by summing tidal volume (TV), inspiratory reserve volume (IRV), expiratory reserve volume (ERV), and residual volume(RV). Therefore, TLC = TV+IRV+ERV+RV

14. What is Tidal volume? Find out the Tidal volume (approximate value) for a healthy human in an hour.

14. Tidal volume is the volume of air inspired or expired during normal respiration.

It is about 6000 to 8000 mL of air per minute.

The hourly tidal volume for a healthy human can be calculated as:

Tidal volume = 6000 to 8000 mL/minute

Tidal volume in an hour = 6000 to 8000 mL × (60 min)

$= 3.6 \times 10^5$ mL to 4.8×10^5 mL

Therefore, the hourly tidal volume for a healthy human is approximately 3.6×10^5 mL to 4.8×10^5 mL.