

CHAPTER 14

BREATHING AND EXCHANGE OF GASES



CLASS 11TH

NCERT EXERCISE AND SOLUTIONS - BIOLOGY

Q. 1. Define vital capacity. What is its significance?

ANSWER:-

Vital capacity refers to the maximum volume of air a person can inhale after a forced exhalation.

Significance of vital capacity:

- It represents the maximum volume of air that can be exchanged or replenished in the respiratory system during a single breath.
- The extra inhaled air indicates the maximum oxygen available for glucose oxidation, thereby providing more energy for the body.

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

ANSWER:-

The functional residual capacity (FRC) refers to the volume of air remaining in the lungs after a normal exhalation. It is the sum of the expiratory reserve volume (ERV) and the residual volume (RV).

The expiratory reserve volume (ERV) is the maximum amount of air that can be exhaled after a normal expiration, typically ranging from 1000 ml to 1500 ml. The residual volume (RV) is the amount of air left in the lungs after maximum exhalation, generally between 1100 ml and 1500 ml. Thus,

$$\begin{aligned} \text{FRC} &= \text{ERV} + \text{RV} \\ &\cong 1500 + 1500 = 3000 \text{ ml} \end{aligned}$$

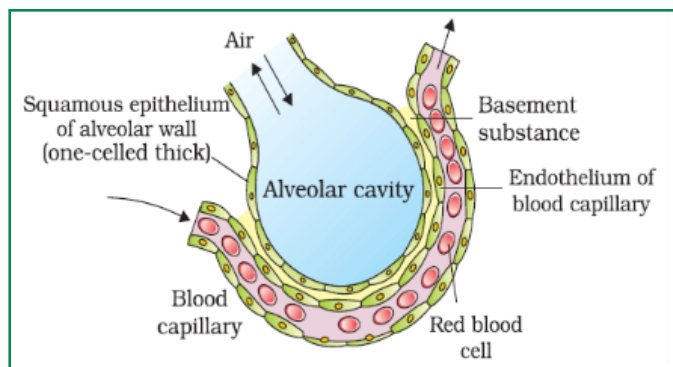
Therefore, the functional residual capacity of human lungs is approximately 2500 ml to 3000 ml.

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

ANSWER:-

Alveoli are small air sacs in the lungs designed for efficient gas exchange. These structures are specially adapted for this process. The alveolar membrane is less than a millimetre thick, and its outer surface is closely associated with blood capillaries.





The endothelial membrane of these capillaries and the alveolar membrane are separated by a thin basement membrane, which facilitates the easy diffusion of gases. The air in the alveoli has higher levels of pO_2 and lower levels of pCO_2 , promoting the diffusion of gases. These unique structural features are not found in any other part of the respiratory system, which is why gas diffusion occurs exclusively in the alveoli.

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

ANSWER:-

Carbon dioxide is released by actively metabolizing tissues into the blood. On average, approximately 3.7 ml of CO_2 is absorbed by every 100 ml of blood from tissues.

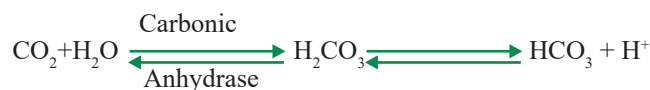
In the blood, carbon dioxide is transported in three forms:

1. Carbon dioxide as a simple solution

About 5-10% of the total carbon dioxide in the blood is dissolved directly in the plasma and transported as a simple physical solution.

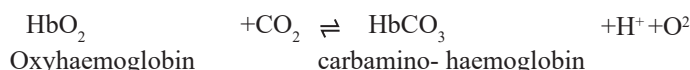
2. Carbon dioxide as bicarbonate ions

Due to the high partial pressure of carbon dioxide at tissue sites from catabolic processes, CO_2 diffuses into the blood and reacts with water to form carbonic acid. This reaction occurs in the presence of the enzyme carbonic anhydrase. The carbonic acid then dissociates into hydrogen ions (H^+) and bicarbonate ions (HCO_3^-). Some bicarbonate ions help maintain the blood's pH, while the remaining bicarbonate is transported by plasma.



3. Carbon dioxide as carbamino-haemoglobin

At tissue sites where the partial pressure of oxygen is low and the partial pressure of carbon dioxide is high, CO_2 loosely binds with the globin portion of deoxygenated haemoglobin, forming carbamino-haemoglobin. In the alveoli, where the partial pressure of oxygen is high and carbon dioxide is low, CO_2 dissociates from carbamino haemoglobin, releasing carbon dioxide into the alveolar air.



Q. 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

ANSWER:-

The pO_2 and pCO_2 levels in atmospheric air, when compared to those in alveolar air, will be:

- (ii) pO_2 is higher, pCO_2 is lower

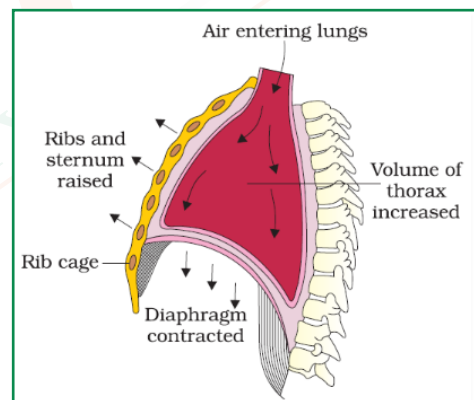
In a gas mixture, each gas contributes to the overall pressure, known as partial pressure. Gases always diffuse along the pressure gradient. Oxygen easily diffuses into the lungs when the pO_2 level is higher in the atmosphere, while carbon dioxide can diffuse out of the body more readily when the pCO_2 level is lower in the atmosphere.

Q. 6. Explain the process of inspiration under normal conditions.

ANSWER:-

Inspiration is the process by which fresh air enters the lungs. It occurs when the intrapulmonary pressure (the pressure inside the lungs) is lower than the atmospheric pressure. The muscles involved in inspiration, such as the diaphragm, external intercostal muscles, and abdominal muscles, are collectively referred to as the inspiratory muscles.

When the diaphragm contracts, it moves downward into the abdominal cavity, flattening out. This increases the thoracic cavity's volume in the anteroposterior direction. Simultaneously, the external intercostal muscles contract, lifting the ribs and sternum, which expands the thoracic chamber in the dorso-ventral direction.



The overall increase in thoracic volume results in an increase in pulmonary volume, which lowers the pressure inside the lungs. This creates a pressure difference, causing air to flow from the atmosphere into the lungs. As the abdominal muscles relax, the compression of abdominal organs is relieved, allowing for a stronger inspiration.

Q. 7. How is respiration regulated?

ANSWER:-

The medulla region of the brain, which contains the respiratory rhythm center, plays a key role in regulating respiration. The respiratory rhythm center's function can be modified by the pneumotaxic center, which sends signals to decrease the rate of inspiration. The chemosensitive area near the respiratory center is responsive to hydrogen ions and carbon dioxide. This region sends signals to adjust the rate of expiration to help eliminate these compounds.

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Receptors in the carotid artery and aorta detect the levels of carbon dioxide and hydrogen ions in the blood. When carbon dioxide levels rise, the respiratory center sends nerve impulses to initiate the necessary adjustments in respiration.

Q. 8. What is the effect of $p\text{CO}_2$ on oxygen transport?

ANSWER:-

$p\text{CO}_2$ plays a critical role in oxygen transport. In the alveoli, where $p\text{CO}_2$ levels are low, oxygen binds with haemoglobin to form oxyhaemoglobin. In contrast, higher $p\text{CO}_2$ levels and lower $p\text{O}_2$ levels in the tissues facilitate the release of oxygen from oxyhaemoglobin. Thus, oxygen binds to haemoglobin at the lungs, where $p\text{CO}_2$ is low, and dissociates at the tissues, where $p\text{CO}_2$ is high.

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

ANSWER:-

As altitude increases, the concentration of atmospheric oxygen decreases, resulting in a lower partial pressure of oxygen. This reduced oxygen availability creates a need for more oxygen. To compensate, the body begins to breathe faster, which in turn raises the heart rate to meet the increased oxygen demand.

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

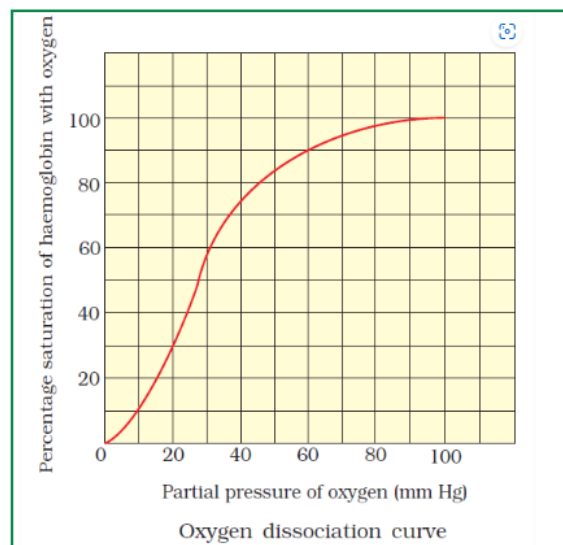
ANSWER:-

Insects possess respiratory organs called tracheae, which have openings known as spiracles that allow air to enter. These spiracles are located on both sides of the insect's abdomen, with a pair on each abdominal segment. The trachea further divides into smaller tubes that extend to the tissue level. Oxygen entering the trachea is diffused into the tissues, while carbon dioxide from the tissues is expelled through the trachea.

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

ANSWER:-

A graph created by plotting the percentage saturation of haemoglobin with oxygen against the partial pressure of oxygen is known as the oxygen dissociation curve. The binding of the first oxygen molecule to haemoglobin increases the affinity of the second oxygen molecule, which explains the rapid formation of oxyhaemoglobin, represented by the steep slope of the S-curve. Once the formation of oxyhaemoglobin slows down or when haemoglobin molecules are fully saturated and no longer available for binding, the curve reaches a plateau phase.



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

ANSWER:-

Hypoxia is a condition where the body or part of it lacks sufficient oxygen. It has various types:

1. **Cytotoxic hypoxia:** due to cyanide poisoning
2. **Anaemic hypoxia:** caused by low haemoglobin
3. **Hypoxic hypoxia:** caused by low oxygen in the atmosphere
4. **Stagnant hypoxia:** from heart failure or reduced heart activity
5. **Carbon monoxide poisoning:** due to CO binding with haemoglobin

Symptoms include shortness of breath, rapid heart rate, anxiety, confusion, and fatigue.

Hypoxia can be caused by:

- Low oxygen at high altitudes
- Respiratory disorders like bronchitis or asthma
- Anaemia
- Heart problems such as tachycardia

Q. 13. Distinguish between

- (a) IRV and ERV
- (b) Inspiratory capacity and Expiratory capacity.
- (c) Vital capacity and Total lung capacity.

ANSWER:-

(a) IRV and ERV

IRV (Inspiratory Reserve Volume)	ERV (Expiratory Reserve Volume)
The volume of air that can be inhaled additionally after a normal inspiration	The volume of air that can be exhaled forcefully after a normal expiration
In a healthy individual, IRV is approximately 2500–3000 ml	In a healthy individual, ERV is approximately 1000–1100 ml

(b) Inspiratory capacity and Expiratory capacity.

Inspiratory Capacity (IC)	Expiratory Capacity (EC)
Inspiratory capacity is the volume of air that can be inhaled after a normal expiration	Expiratory capacity is the volume of air that can be exhaled after a normal inspiration
It is the sum of tidal volume and inspiratory reserve volume, i.e., $IC = TV + IRV$	It is the sum of tidal volume and expiratory reserve volume, i.e., $EC = TV + ERV$

(c) Vital capacity and Total lung capacity.

Vital Capacity (VC)	Total Lung Capacity (TLC)
After maximum inhalation, it is the maximum volume of air that can be exhaled. It includes IC and ERV.	After maximum inhalation, it is the total volume of air in the lungs. It includes ERV, IC, and residual volume.
The vital capacity in humans is approximately 4000 ml.	The total lung capacity in humans is around 5000 ml to 6000 ml.



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

ANSWER:-

Tidal volume (TV) refers to the volume of air inhaled or exhaled during normal respiration. For a healthy individual, the tidal volume is around 500 ml. On average, a healthy person can inhale or exhale approximately 6000-8000 ml of air per minute, or about 12-16 breaths per minute.

Therefore, the tidal volume for a healthy person over the course of an hour is roughly between 360,000 ml and 480,000 ml.

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