Chapter: Breathing And Exchange of Gases

Exercise

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

Answer: The maximum volume of air that can be exhaled after a maximum inspiration is referred to as vital capacity. The human body contains between 3.5 and 4.5 litres of water. It encourages the act of supplying fresh air and expelling stale air, thereby increasing gaseous exchange between tissues and the environment.

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

Answer: The amount of air that remains in the lungs after a normal expiration is referred to as functional residual capacity (FRC). It includes the expiratory reserve volume (ERV) as well as the residual volume (RV). The maximum amount of air that can be exhaled after a normal expiration is referred to as the ERV. It ranges from 1000 mL to 1500 mL. The volume of air remaining in the lungs after maximum expiration is referred to as RV. It ranges from 1100 mL to 1500 mL.

$\therefore \text{FRC} = \text{ERV} + \text{RV}$

$\cong 1500 + 1500$

$\cong 3000\,\text{mL}$

The functional residual capacity of the human lungs ranges between 2500 and 3000 mL.

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

Answer:

Each alveolus is made up of permeable squamous epithelial cells in thin layers. In the same way, squamous epithelial cells line blood capillaries. Through the nose, oxygen-rich air enters the body and reaches the alveoli. The veins transport deoxygenated (high in carbon dioxide) blood from the body to the heart. It is sent to the lungs for oxygenation by the heart. The exchange of oxygen and carbon dioxide occurs between the blood capillaries surrounding the alveoli and the gases present in the alveoli.

As a result, the alveoli function as gas exchange sites. Because of pressure or concentration differences, gases exchange via simple diffusion. Because the barrier between the alveoli and the capillaries is thin, gas diffusion occurs from higher partial pressure to lower partial pressure. Venous blood has a lower oxygen partial pressure and a higher carbon dioxide partial pressure than alveolar air. As a result, oxygen is introduced into the bloodstream. At the same time, carbon dioxide diffuses from the blood into the alveoli.

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

Answer: Carbon dioxide is transported by plasma and red blood cells. This is due to their high water solubility.

(1) Through plasma: About 7% of CO_2 is moved in a dissolved state through plasma. Carbonic acid is produced by the reaction of carbon dioxide and water.

$$CO_2 + H_2O \rightarrow \underset{\text{(carbonic acid)}}{H_2CO_3}$$

Since carbonic acid formation is a slow process, a little amount of carbon dioxide is transmitted this way.

(2) Through RBCs:
Red blood cells transmit approximately $20 - 25\%$ of CO_2 as carbaminohemoglobin. Carbon dioxide binds to the amino groups on the polypeptide chains of haemoglobin, resulting in carbaminohemoglobin.

(3) Using sodium bicarbonate:
Sodium bicarbonate transmits approximately 70% of CO_2 In the presence of the enzyme carbonic anhydrase, a large amount of carbon dioxide diffuses into blood plasma and combines with water to form carbonic acid. Carbonic anhydrase is a zinc enzyme that is used to accelerate the formation of Carbonic acid. This carbonic acid dissociates into its ions that is, bicarbonate (HCO_3^-) and hydrogen ions (H^+)

$$CO_2 + H_2O \xrightarrow{\text{carbonic anhydrase}} H_2CO_3 \text{ (carbonic acid)}$$

$$H_2CO_3 \xrightarrow{\text{carbonic anhydrase}} HCO_3^- + H^+$$

Question 5. What will be the P_{O_2} and P_{CO_2} in the atmospheric air compared to those in the alveolar air?

(i) P_{O_2} lesser, P_{CO_2} higher

(ii) P_{O_2} higher, P_{CO_2} lesser

(iii) P_{O_2} higher, P_{CO_2} higher

(iv) P_{O_2} lesser, P_{CO_2} lesser

Answer: (ii) P_{O_2} higher, P_{CO_2} lesser

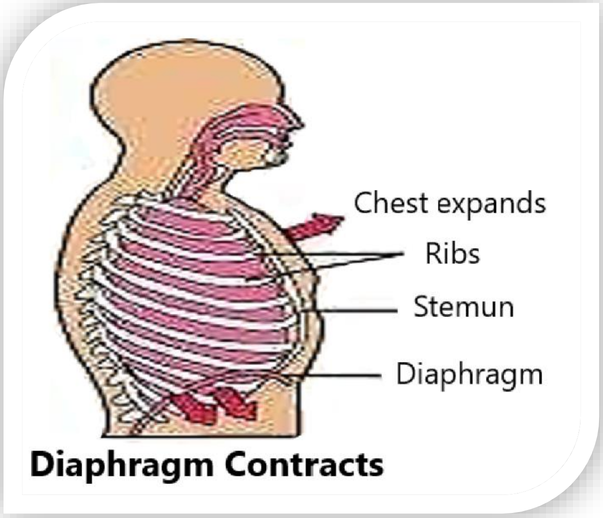
The partial pressure of oxygen in atmospheric air is greater than the partial pressure of oxygen in alveolar air. P_{O_2} in atmospheric air is approximately $159\,mm$ Hg. It is approximately $104\,mmHg$ in alveolar air. Carbon dioxide partial pressure in atmospheric air is lower than carbon dioxide partial pressure in alveolar air. P_{CO_2} in atmospheric air is approximately 0.3 mmHg. It is approximately 40 mm Hg in alveolar air.

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

Answer:

The process of bringing air from outside the body into the lungs is known as inspiration or inhalation. It is accomplished by establishing a pressure gradient between the lungs and the surrounding environment. When air enters the lungs, the diaphragm expands toward the abdominal cavity, creating more space in the thoracic cavity for the inhaled air.

The volume of the thoracic chamber in the anteroposterior axis increases when the external intercostal muscles are simultaneously contracted. The ribs and sternum move outward, increasing the volume of the thoracic chamber in the dorsoventral axis. The overall increase in thoracic volume causes a corresponding increase in pulmonary volume. As a result of this increase, the intra-pulmonary pressure now falls below that of the atmospheric pressure. This causes air to enter the lungs from outside the body.



Question 7. How is respiration regulated?

Answer:
The respiratory rhythm centre, located in the medulla region of the brain, is primarily in charge of respiration regulation. By signalling to reduce the inspiration rate, the pneumatic centre can alter the function performed by the respiratory rhythm centre.
Carbon dioxide and hydrogen ions are sensitive to the chemosensitive region located near the respiratory centre. This region then indicates that the rate of expiration for removing the compounds should be changed.
Carbon dioxide and hydrogen ion levels in the blood are detected by receptors found in the carotid artery and aorta. As the carbon dioxide level rises, the respiratory centre sends nerve impulses to effect the necessary changes.

Question 8. What is the effect of P_{CO_2} on oxygen transport?

Answer: P_{CO_2} is essential for the transportation of oxygen. The low P_{CO_2} and high P_{O_2} at the alveolus promote the formation of haemoglobin. The high P_{CO_2} and low P_{O_2} in the tissues promote oxygen dissociation from oxyhaemoglobin. As a result, the decrease in P_{CO_2} the blood increases haemoglobin's affinity for oxygen. As a result, oxygen is transported in the blood as oxyhaemoglobin and dissociates from it in the tissues.

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

Answer: The oxygen level in the atmosphere decreases as altitude increases. As a result, as a man climbs a hill, he takes in less oxygen with each breath. As a result, the amount of oxygen in the blood decreases. In response to a decrease in blood oxygen content, the respiratory rate increases. Simultaneously, the heart rate increases to increase the supply of oxygen to the blood.

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

Answer: Gaseous exchange occurs in insects via a network of tubes known as the tracheal system. Spiracles are small openings on the sides of an insect's body. The spiracles allow oxygen-rich air to enter. The spiracles are linked to the tube network. The tracheae receive oxygen from the spiracles. From here, oxygen diffuses into the body's cells.
Carbon dioxide moves in the opposite direction. CO_2 from the body's cells enter the tracheae before exiting the body via the spiracles.

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

Answer: The oxygen dissociation curve is a graph that depicts the percentage saturation of oxyhaemoglobin at various oxygen partial pressures.
At various partial pressures, the curve depicts the equilibrium of oxyhaemoglobin and haemoglobin.
The partial pressure of oxygen in the lungs is very high. As a result, haemoglobin binds to oxygen to form oxyhaemoglobin.
The oxygen concentration in tissues is low. As a result, oxyhaemoglobin releases oxygen in the tissues to form haemoglobin.
The binding of oxygen to haemoglobin causes the dissociation curve to have a sigmoid shape. As the first oxygen molecule binds to haemoglobin, the affinity for the second oxygen molecule to bind increases. As a result, haemoglobin attracts more oxygen.

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

Answer:
Hypoxia is characterized by an insufficient or decreased supply of oxygen to the lungs. It is caused by several extrinsic factors, including a decrease in pO2, insufficient oxygen, and so on. The various types of hypoxia are discussed further below.
Hypoxemic hypoxia
As a result of the low partial pressure of oxygen in the arterial blood, the oxygen content of the blood decreases in this condition.
Anaemic Hypoxia
The concentration of haemoglobin is reduced in this condition.
Stagnant or ischemic Hypoxia
Because of poor blood circulation, there is a deficiency in the oxygen content of the blood in this condition.
Histotoxic hypoxia
Tissues are unable to use oxygen in this condition. This occurs as a result of carbon monoxide or cyanide poisoning.

Question 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

Inspiratory reserve volume (IRV)	Expiratory reserve volume (ERV)
1. It is the maximum amount of air that can be inhaled following a normal inspiration.	1. It is the maximum amount of air that can be exhaled following a normal expiration.
2. In human lungs, 2500–3500 mL is present.	2. In human lungs, 1000–1100 mL is present.

(b) Inspiratory capacity and Expiratory capacity

Inspiratory capacity	Expiratory capacity
1. It refers to the amount of air that can be inhaled just after a normal expiration.	1. It refers to the amount of air that can be exhaled just after a normal expiration.
2. It incorporates tidal volume as well as inspiratory reserve volume. IC = TV + IRV	2. It incorporates tidal volume as well as expiratory reserve volume. EC = TV + ERV

(c) Vital capacity and Total lung capacity

Vital capacity	Total lung capacity
1. It is the highest amount of exhalation after taking the maximum amount of ingestion.	1. It is the amount of air remaining in the lungs after maximum inspiration.
2. It consists of IC and ERV. Also, it is approximately 4000 mL in the human lungs.	2. It consists of IC, ERV, and residual volume. In human lungs, it is about 5000–6000 mL.

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

Answer:

The volume of air inspired or expired during normal respiration is referred to as tidal volume. It is between 6000 and 8000 mL of air per minute.

The hourly tidal volume of a healthy human is calculated as follows:

Tidal volume $= 6000 \text{ to } 8000\,\text{mL}/\text{ minute}$

Tidal volume in an hour $= 6000 \text{ to } 8000\,\text{mL} \times (60\,\text{min})$

$$= 3.6 \times 10^5 \text{ mL to } 4.8 \times 10^5 \text{ mL}$$