Breathing and Exchange of Gases

CHAPTER 17

EXAM DRILL

ANSWERS

1. **(b) :** The bronchial lining swells and produces excess mucus in bronchitis. Hypoxic hypoxia causes altitude sickness. Anaemic hypoxia occurs due to anaemia or CO poisoning. Tuberculosis is caused by *Mycobacterium tuberculosis*.

2. **(c)** **3.** **(c)**

4. **(c) :** Insects, Centipedes, Millipedes, ticks, *Peripatus* respire through trachea.

5. **(c) :** 'X' is oxygen – Hb dissociation curve which shifted to left as pH increases, CO_2 and temperature decreases. Y is oxygen – Hb dissociation curve which shifted to right as pH decreases and CO_2 and temperature increases. All the factors which shift the oxygen – Hb dissociation curve to the right increases the Bohr effect.

6. Cutaneous respiration is exchange of gases through skin, *e.g.*, in earthworm. Pulmonary respiration occurs through lungs as in humans.

OR

Cartilaginous rings support the wall of trachea and prevents its collapse during inspiration.

7. Birds respire through lungs.

8. During vigorous exercise, skeletal muscles do not immediately get as much oxygen as it is required for work. Lactic acid is produced from glucose. This accumulated lactic acid result in muscular pain.

9. Respiratory Quotient (RQ) is ratio of volume of carbon dioxide produced to the volume of oxygen consumed over a period of time in respiration.

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

For glucose; $RQ = \frac{6CO_2}{6O_2} = 1$

10. Lungs are surrounded by two membranes called pleurae. The outer membrane is parietal pleura and an inner membrane is visceral pleura. A narrow space exists between two pleurae, called pleural cavity that contains pleural fluid. Pleural fluid lubricates pleurae so that they may slide over each other without friction during breathing.

11. **(a)** **12.** **(b)**

13. **(c) :** Exchange of gases (*i.e.*, oxygen and CO_2) between lung alveoli and pulmonary capillaries is called external respiration.

14. **(d) :** Inspiration is caused by contraction of external intercostal muscles and relaxation of abdominal muscles. The elevation of ribs increases the volume of thoracic cavity, air pressure in lungs decreases and air is drawn into lungs.

15. **(i) (a) :** Larynx (A) is a sound producing organ, thus it is also called voice box. Labelled parts 'B', 'C' and 'D' respectively represents trachea (windpipe), bronchus and alveoli.

(ii) **(b) :** The wall of the alveoli has an extensive network of blood capillaries interspersed with elastic and reticular connective tissue fibres. Due to very intimate contact of blood capillaries with the alveoli, the exchange of gases takes place easily.

(iii) **(c) :** Trachea 'B' and bronchi 'C', (*sing*; bronchus) have cartilaginous rings.

(iv) **(b) :** Trachea or windpipe (B) bears rings of hyaline cartilage which are incomplete posteriorly.

16. **(i) (a) :** Emphysema 'B' is a respiratory disorder which causes the inflation or abnormal distension of the bronchioles or alveolar sacs resulting in the loss of their elasticity. It is caused by cigarette smoking and chronic bronchitis.

(ii) **(d) :** Bronchitis 'C' is caused by cigratte smoking and exposure to air pollutants like carbon monoxide.

(iii) **(a) :** Asthma 'A' is caused due to an allergic reactions which stimulate the release of histamine from the mast cells. Histamine cause bronchiolar smooth muscle to contract.

(iv) **(d) :** Pneumonia 'D' is caused mainly by bacteria *Streptococcus pneumoniae*.

(v) In emphysema 'B', the surface area for gas exchange is greatly reduced as the alveolar septa collapse. There is loss of elasticity in the walls of bronchioles or alveolar sacs. As a result, the alveolar sacs remain filled with air even after expiration. The exhalation becomes more difficult. The lungs remain inflated.

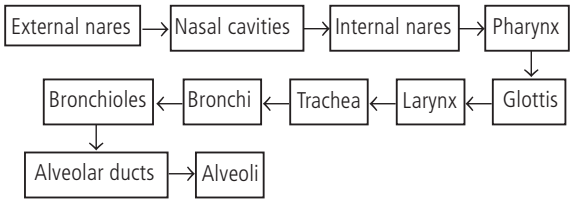
17. (i) Haemoglobin (ii) Gills
(iii) Carbaminohaemoglobin (iv) Hypoxia

18. Differences between right lung and left lung are:

S.No.	Right lung	Left lung
(i)	It consists of three lobes and two fissures.	It consists of two lobes and one fissures.
(ii)	Cardiac notch is absent.	Cardiac notch is present along with the inner border of lung.
(iii)	It is broader, larger and heavier.	It is narrower and lighter than the right lung.

OR

The flow chart showing the pathway of fresh air into the lungs :



19. Ventilation, also known as breathing, is the movement of air through the conducting passage between the atmosphere and the lungs. Breathing movements has two phases – expiration and inspiration. It occurs with the help of intercostal muscles (external and internal) and diaphragm. Inspiration is an active process as it occurs due to muscle contraction and expiration is a passive process and is caused due to muscle relaxation. The downward and upward movement of the diaphragm increases and decreases the diametre of thoracic cavity during inspiration and expiration respectively. The elevation and depression of the ribs, during inspiration and expiration lengthens and shortens the thoracic cavity.

20. Emphysema is a chronic respiratory disease in which alveolar walls are damaged and much of the elastic tissue of lungs is replaced by connective tissue due to which respiratory surface is reduced for the exchange of oxygen and carbon dioxide. There is loss of elasticity in the walls of bronchioles or alveolar sacs. As a result, the alveolar sacs remain filled with air even after exhalation. The exhalation becomes more difficult and the lungs remain inflated. Symptoms include breathlessness, lips or fingernails turn blue or gray, frequent coughing and wheezing, tightness felt in chest.

21. **(a)** O_2 will diffuse from blood into the tissue, as the gases diffuse from area of higher concentration to lower concentration.

(b) Two factors that result in association of O_2 to haemoglobin are : low temperature and high pH.

22. The surface at which gaseous exchange takes place is known as respiratory surface. This surface must have the following characteristics:

(i) It must be thin for easy diffusion of gases.

(ii) It should have a large surface area for adequate exchange of gases.

(iii) It must be permeable to respiratory gases (*i.e.*, oxygen and carbon dioxide).

23. Differences between bronchial asthma and occupational respiratory disorder are :

S.No.	Bronchial asthma	Occupational respiratory disorder
(i)	It is an allergy attack of breathlessness associated with bronchial obstruction characterised by expiratory wheeze.	It occurs in people who work in mining industries, so, these are due to occupation of an individual and cause proliferation of fibrous connective tissue of upper part of lungs.
(ii)	It is due to allergic reaction to foreign substances which stimulate release of histamine from mast cells. Histamine cause contraction of bronchiolar smooth muscle.	It is due to the exposure of harmful substances, dust, gas fumes, etc.

24. The respiratory bronchioles terminate into extremely thin walled, lobulated structures called the alveoli. Oxygen diffuses from the alveoli into blood and carbon dioxide from the blood into the alveoli. The walls of alveoli have extensive network of blood capillaries interspersed with elastic and reticular connective tissue. The diffusion of gases occur in the alveolar capillaries. So, due to very intimate contact of blood capillaries with alveoli, the gaseous exchange takes place easily and diffusion of gases occur.

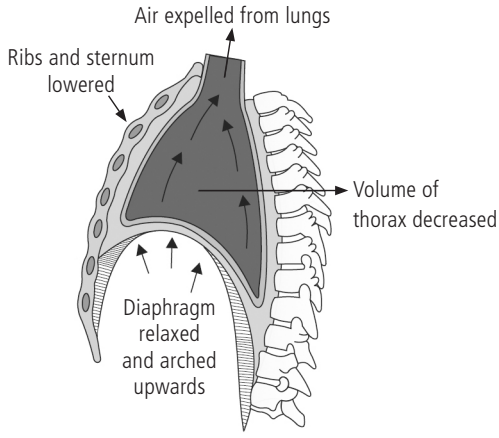
25. Inspiration and expiration both are affected by contraction and relaxation of muscles of diaphragm and intercostal muscles. Inspiration is caused by contraction of external intercostal muscles, it pulls ribs and sternum upward and outward, increasing the volume of thoracic cavity and forcing the air to move into lungs.

Expiration is caused by contraction of internal intercostal muscles, as it pulls ribs downward and inward, decreasing the size of thoracic cavity and thus forcing the air out of lungs.

26. Expiration (exhalation) takes place when the intrapulmonary pressure is higher than the atmospheric pressure. Relaxation of the diaphragm makes it convex and

the intercostal muscles pull the ribs downward and inwards and reducing the thoracic volume and thereby the pulmonary volume. This leads to an increase in intra-pulmonary pressure, which is slightly above the atmospheric pressure, causing the expulsion of air from the lungs, *i.e.*, expiration.

The well labelled diagram of mechanism of breathing showing expiration is :



OR

The quantities of air the lungs can receive, hold or expel under different conditions are said to be respiratory volumes. A combination of two or more pulmonary (respiratory) volumes are called pulmonary capacities.

(i) Residual volume : It is the volume of air that always remains in the lungs after forcible expiration. It enables the lungs to continue exchange of gases even after maximum exhalation or on holding the breath. It is about 1100-1200 mL.

(ii) Inspiratory capacity (IC): It is the total volume of air that can be inhaled after a normal expiration. It is about 3000-3500 mL and includes tidal volume (TV) and inspiratory reserve volume (IRV), IC = TV + IRV.

27. **(a)** The causative agent of this disease is *Mycobacterium tuberculosis* that spreads from a person to person through microscopic droplets released into the air. Symptoms include fatigue, weight loss, lethargy, anorexia, a low grade fever, night sweats, cough, dyspnea and chest pain.

(b) The thyroid cartilage is the largest cartilage of the larynx. It has a V-shaped depression called thyroid notch. It supports the larynx on the front and sides. Thyroid cartilage is made up of hyaline cartilage. It forms a subcutaneous projection called Adam's apple.

28. Tourists visiting high altitude areas such as Rohtang Pass or Mansarovar, experience altitude sickness. Its symptoms include nausea, fatigue and heart palpitations. This is because in the low atmospheric pressure of high altitudes, the body does not get enough oxygen. But gradually the body gets acclimatised and stops experiencing altitude sickness. The body compensates low oxygen availability by increasing red blood cell production, decreasing the binding affinity of haemoglobin to make haemoglobin bound oxygen more available to body tissues and increasing the breathing rate.

29. (i) In the given figure, the labelled parts 'A' and 'B' represent inspiratory reserve volume and tidal volume, respectively. Inspiratory reserve volume (A) is the additional volume of air a person can inspire forcibly after normal inspiration. This averages 2500-3000 mL.

Tidal volume (B) is the volume of air inspired or expired during a normal respiration. It is about 500 mL for a healthy adult.

(ii) The part 'E' represents total lung capacity (TLC). It is the total amount of air present in the lungs and the respiratory passage after a maximum inspiration. It is the sum total of vital capacity and the residual volume (TLC = VC + RV) or (TLC = TV + IRV + ERV + RV). It is about 4900 - 5900 mL.

(iii) In the given figure, labelled part 'C' and 'D' are residual volume (RV) and vital capacity (VC) respectively.

Differences between 'C' (RV) and 'D' (VC) are as follows :

S.No.	Residual volume	Vital capacity
(i)	It is the volume of air that always remains in the lungs after forcible expiration and enables the lungs to continue the gaseous exchange even after maximum exhalation or on holding the breath.	It is the maximum volume of air a person can breathe in after a forced expiration or breathe out after a forced inspiration.
(ii)	It varies from 1100-1200 mL.	It varies from 3400-4800 mL.

30. The lungs are soft, spongy and elastic organs and are pinkish in colour. The upper most portion of each lung is called the apex and the inferior most portion is called the base. The costal surfaces of the lungs are so named because they lie next to the ribs. The median surfaces of the lungs lie next to the mediastinum. The left lung is smaller than the right and has a concavity, the cardiac notch, where the heart lies. The left lung has two lobes, superior lobe and inferior lobe, that are divided by the oblique fissure. The right lung has three lobes: superior lobe, middle lobe and inferior lobe which are divided by the horizontal fissure and oblique fissure.

31. (a) In the given figure showing a section of an alveolus with a pulmonary capillary, the labelled parts A, B, C, and D represents alveolar cavity, red blood cell, pulmonary blood capillary and basement membrane respectively.

(b) The process by which respiratory gases move between blood and alveolus is known as diffusion. Gases always diffuse from region of higher concentration to a region of lower concentration.

(c) Diffusing capacity is the volume of gas that diffuses through membrane per minute for a pressure difference of 1 mmHg. It further depends on solubility of the diffusing gases.

OR

Transport of O_2 : Blood carries oxygen from the alveoli to various body tissues. About 3% of O_2 is carried in a dissolved state through the plasma. About 97% of O_2 is transported in combination with haemoglobin of the RBCs as oxyhaemoglobin.

Partial pressure of O_2 is high in the alveoli as compared to pulmonary blood capillaries, therefore O_2 diffuses from alveoli into the pulmonary capillaries and combines with Hb to form oxyhaemoglobin. When this oxygenated blood reaches the different tissues having low partial pressure of O_2, the bonds holding O_2 to Hb become unstable. As a result, O_2 is released from the blood capillaries into the tissues.

$$Hb + O_2 \underset{\text{In tissues}}{\overset{\text{In lungs}}{\rightleftharpoons}} \underset{\text{Oxyhaemoglobin}}{HbO_2}$$

Transport of CO_2 : Blood carries CO_2 from various body tissues to the alveoli. About 7% of CO_2 gets dissolved in the blood plasma and is carried in solution. About 70% of CO_2 is transported by plasma as bicarbonate ions. From the tissues (which have high pCO_2), CO_2 diffuses into the blood capillaries (which have low pCO_2). In the RBCs, CO_2 combines with water, to form carbonic acid (H_2CO_3). H_2CO_3 is unstable and quickly dissociates into hydrogen ions and bicarbonate ions.

$$CO_2 + H_2O \underset{\text{anhydrase}}{\overset{\text{Carbonic}}{\rightleftharpoons}} H_2CO_3$$

$$\underset{\text{anhydrase}}{\overset{\text{Carbonic}}{\rightleftharpoons}} H^+ + \underset{\text{(Bicarbonate ion)}}{HCO_3^-}$$

The above reaction is thousand times faster in RBCs as compared to plasma because RBCs contain carbonic anhydrase enzyme that reversibly catalyses the conversion of CO_2 and water to H_2CO_3. About 20-25% of CO_2 is carried by Hb as carbaminohaemoglobin.

$$CO_2 + Hb \rightleftharpoons \underset{\text{(Carbaminohaemoglobin)}}{HbCO_2}$$

The blood carries CO_2 in these three different forms towards the alveoli. CO_2 is less soluble in arterial blood than in venous blood. Therefore, some CO_2 diffuses from the plasma of the pulmonary capillaries into the alveoli. For the release of CO_2 from the bicarbonate, a series of reverse reactions takes place and CO_2 is released into the alveoli of the lungs. High pO_2 in the pulmonary capillaries due to oxygenation of Hb favours separation of CO_2 from carbaminohaemoglobin.

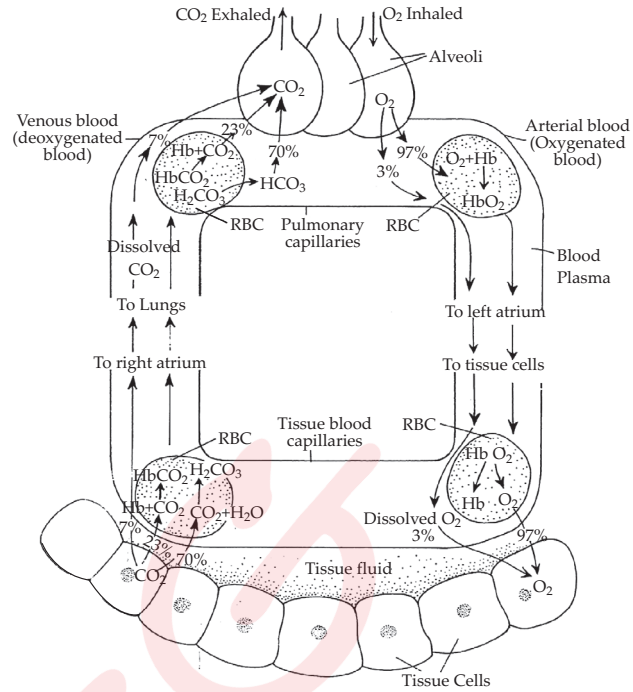
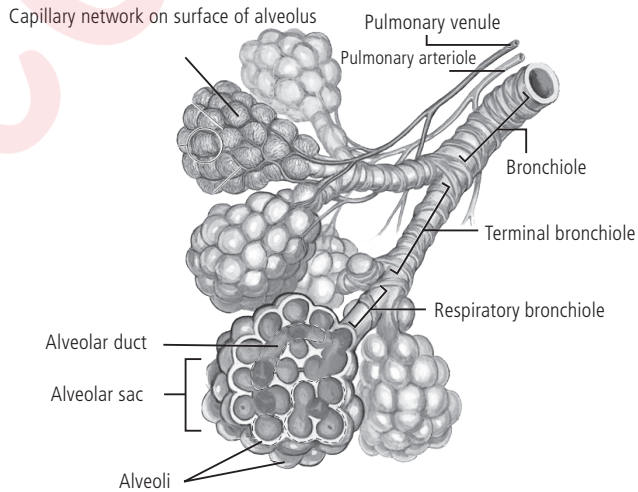


Fig.: Transport of oxygen and carbon dioxide

32. (a) Diagrammatic representation of respiratory portion of lungs is as follows :



(b) The parts starting with external nostrils upto the terminal bronchioles comprise the conducting portion of human respiratory system. It includes nose, pharynx, larynx, trachea, bronchi, bronchioles and terminal bronchioles. The parts starting with external nostrils upto the terminal bronchioles constitute the conducting parts of human respiratory system. It includes nose, pharynx, larynx, trachea, bronchi, bronchioles and terminal bronchioles.

The main functions of the conducting parts of the respiratory tract are:

(i) Transport atmospheric air to alveoli.

(ii) They filter the air from dust and foreign particles.

(iii) These humidify and bring air to body temperature.

OR

(i) Differences between bronchioles and tracheoles are as follows :

S.No.	Bronchioles	Tracheoles
(i)	They are found in mammals.	They are found in insects, millipedes, centipedes and ticks.
(ii)	They open into alveolar duct.	They are closed at the tip.
(iii)	They are the branches of tertiary bronchi.	They are the branches of trachea.
(iv)	They are not filled with any fluid.	They are filled with a tissue fluid.
(v)	They do not penetrate body cells.	They penetrate body cells.

(ii) Following are the differences between Bohr and Haldane effects :

S.No.	Bohr effect	Haldane effect
(i)	In this effect, an increase in CO_2 in blood cause dissociation of O_2 from haemoglobin.	In this effect, binding of oxygen with haemoglobin displaces CO_2 from the blood.
(ii)	In tissues, addition of CO_2 to the blood facilitates unloading of oxygen.	O_2 uploading favours CO_2 uptake.
(iii)	It promotes oxygen transport.	It promotes carbon dioxide transport.

(iii) Differences between external and internal respiration are as follows :

External respiration	Internal respiration
It is simply the intake of O_2 from the surrounding medium (air or water) and giving out of CO_2 into the surrounding medium.	It involves mainly three steps: (a) Uptake of O_2 by tissue cells (b) Oxidation of food inside the cells by oxidising enzymes and (c) Elimination of CO_2 from the tissues.

(iv) Differences between inspiratory and expiratory muscles are as follows :

S.No.	Inspiratory muscles	Expiratory muscles
(i)	Contraction of these muscles brings about inspiration.	Contraction of these muscles brings about expiration.
(ii)	Examples : Diaphragm and external intercostal muscles.	Examples : Abdominal muscles and internal intercostal muscles.

33. The various parts of human respiratory system are:

(i) Nostrils : These are paired openings, and leads into nasal chamber through nasal passage, through which air enters.

(ii) Pharynx : The nasal chamber opens into nasopharynx, a portion of pharynx. It is common passage of both food and air. Nasopharynx opens through glottis of larynx region into the trachea.

(iii) Larynx : It is a cartilaginous box, that helps in producing sound.

(iv) Trachea (wind pipe) : It is lined with incomplete rings of hyaline cartilage, to prevent its collapse during inspiration. It is lined by pseudostratified ciliated columnar epithelium. It is divided into a pair of primary bronchi that enter the right and left lungs.

(v) Lungs: A pair of lungs present in thoracic cavity are enclosed by double membranes called pleurae. The space between pleurae is filled with pleural fluid to avoid friction during breathing.

(vi) Bronchioles: Primary bronchus enters each lung and divide into secondary and tertiary bronchioles and further divides to form respiratory bronchioles.

(vii) Alveoli: Respiratory bronchioles finally lead into alveolar sacs, that open into alveoli. The wall of alveoli are thin, have extensive network of blood capillaries and are actual site of gaseous exchange.

OR

Neural system plays a significant role in maintaining and moderating the respiratory rhythm. Medulla oblongata has a specialised centre called respiratory rhythm centre, that regulates the respiration. The functions of the respiratory rhythm centre are controlled by another centre present in the pons varolii, called pneumotaxic centre. Neural signals from this centre can reduce the duration of inspiration and thereby alter the respiratory rate. Adjacent to the rhythm centre is situated a chemosensitive area which is highly sensitive to CO_2 and H^+ ions. Increase in these substances can activate this centre, which in turn can signal the rhythm centre to make necessary adjustments in the respiratory process by which these substances can be eliminated. Receptors present on aortic arch and carotid artery also can recognise changes in CO_2 and H^+ concentration and send necessary signals to the rhythm centre for remedial actions.

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