17

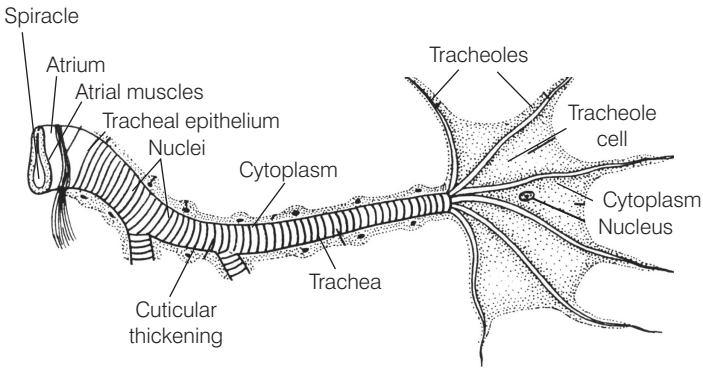
Breathing and Exchange of Gases

Multiple Choice Questions (MCQs)

Q. 1 Respiration in insects is called direct because

(a) the cells exchange O_2 /CO_2 directly with the air in the tubes
(b) the tissues exchange O_2 /CO_2 directly with coelomic fluid
(c) the tissues exchange O_2 /CO_2 directly with the air outside through body surface
(d) tracheal tubes exchange O_2 /CO_2 directly with the haemocoel which then exchange with tissues

Ans. *(a)* Insects have a network of tubes (tracheal tubes) to transport atmospheric air within the body. These openings lead to trachae. The cells exchange O_2/CO_2 directly with the air in the spiracles present on insects body.



Trachea and tracheoles in insects

Q. 2 Which of the following does not occur during breathing?

(a) Brings the air to body temperature (b) Warms up the air
(c) Diffusion of gases (d) Cleans up the air

Ans. *(c)* Diffusion of gases is a physical phenomenon that takes place between the tissue and blood vessels, and does not occur during breathing whereas bringing air to the body temperature, its cleaning and warming occurs during the process of breathing.

Q. 3 A person suffers punctures in his chest cavity in an accident, without any damage to the lungs its effect could be

(a) reduced breathing rate (b) rapid increase in breathing rate
(c) no change in respiration (d) cessation of breathing

Ans. *(d)* The movement of air into and out of the lungs is carried out by creating a pressure gradient between the lungs and the atmosphere. The pressure within the lungs is less than the atmospheric pressure so there is a negative pressure in the lungs with respect to atmospheric pressure.

The puncture in the chest affects this pressure gradient maintained by the lungs and thus may cause cessation of breathing.

Q. 4 It is known that exposure to carbon monoxide is harmful to animals because

(a) it reduces CO_2 transport (b) it reduces O_2 transport
(c) it increases CO_2 transport (d) it increases O_2 transport

Thinking Process

The reaction between haemoglobin and CO_2 is reversible, whereas it is irreversible in case of CO.

Ans. *(b)* Haemoglobin consist of a protein globin and pigment here. The four portion of iron in name combine with molecule of oxygen. It is an easy reversible reaction to form oxyhaemoglobin

$$Hb + O_2 \rightleftharpoons HbO_2$$

Whereas, the complex formed by the reaction of carbon monooxide and haemoglobin is incredibly strong

$$\underset{\text{(Haemoglobin)}}{Hb + CO} \longrightarrow \underset{\substack{\text{(Carboxy}\\ \text{haemoglobin)}}}{HbCO}$$

As a result of this strong between the haemoglobin and carbon monooxide the haemoglobin looses its affinity to oxygen thus may lead to choking or even death.

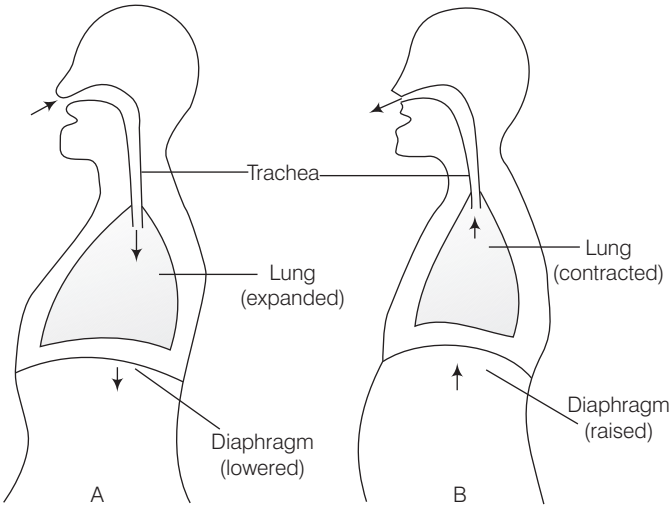
Q. 5 Mark the true statement among the following with reference to normal breathing

(a) inspiration is a passive process whereas expiration is active
(b) inspiration is a active process whereas expiration is passive
(c) inspiration and expiration are active processes
(d) inspiration and expiration are passive processes

Ans. *(b)* Inspiration is a active process whereas expiration is a passive process. Inspiration occur when the muscles of diaphragm contrac to increase the overall volume of thoracic cavity.

Thus the pressure within the lungs (intra-pulmonary pressure) is less in comparison to the atmospheric pressure, *i.e.,* there is a negative pressure in the lungs with respect to atmospheric pressure. As the muscles use energy for contraction inspiration is called active process.

Whereas, during the expiration diaphragm muscles relax without the use of energy intra-pulmonary pressure becomes higher than the atmospheric pressure and air noshes out. Thus, it is a passive process.



Mechanism of breathing **A. Inspiration** (chest cavity enlarged)
B. Expiration (chest cavity reduced)

Q. 6 A person breathes in some volume of air by forced inspiration after having a forced expiration. This quantity of air taken in is

(a) total lung capacity
(b) tidal volume
(c) vital capacity
(d) inspiratory capacity

Ans. *(c)* The maximum volume of air that a person can breathe in after forced expiration or the maximum volume of air that a person can breathe out after forced inspiration is called vital capacity

$$\underset{\text{(Inspiratory reserve volume)}}{VC = IRV} + \underset{\text{(Expiratory reserve volume)}}{ERV} + \underset{\text{(Tidal volume)}}{TV}$$

The value of vital capacity varies from 3400 mL to 4800 mL.

On the other hand, tidal volume is the air inspired or expired during normal breathing. Total lung capacity is the volume of air present in lungs and respiratory passage after maximum inspiration. Whereas, inspiratory capacity is total volume of air that a person can inspire after normal inspiration.

Q. 7 Mark the incorrect statement in context to O_2 binding to Hb

(a) higher pH
(b) lower temperature
(c) lower pCO_2
(d) higher pO_2

Ans. *(d)* There are various factors which affect the binding of O_2 with Hb.

These factors are

(i) Low temperature
(ii) Low H^+ concentration (low pH).
(iii) Low diphosphoglyceraldehy

So, higher pO_2 is the in correct statement.

Q. 8 Mark the correct pair of muscles involved in the normal breathing in humans.

(a) External and internal intercostal muscles
(b) Diaphragm and abdominal muscles
(c) Diaphragm and external intercostal muscles
(d) Diaphragm and intercostal muscles

Ans. *(d)* The diaphragm and a specialised set of muscles, called **external muscles** present between the ribs are involved in the normal breathing in humans. They are involved in generating pressure gradient of air between the lungs and the atmosphere, so as to faeilitate the intake of air.

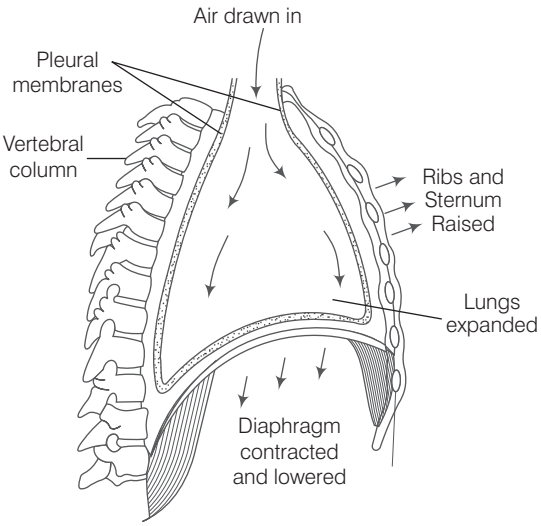


Diagram illustrating part of muscles in lungs involved in the process of inspiration

Q. 9 Incidence of emphysema a respiratory disorder is high in cigarette smokers. In such cases

(a) the bronchioles are found damaged
(b) the alveolar walls are found damaged
(c) the plasma membrane is found damaged
(d) the respiratory muscles are found damaged

Ans. *(b)* **Emphysema** is a chronic disorder in which alveolar walls are damaged due to the infacation or obsomal distersion. It is a respiratory disorder caused by ciggrette smoking and inhalation of other smoke or toixic substences over a period of time.

Q. 10 Respiratory process is regulated by certain specialised centres in the brain. One of the following listed centres can reduce the inspiratory duration upon stimulation.

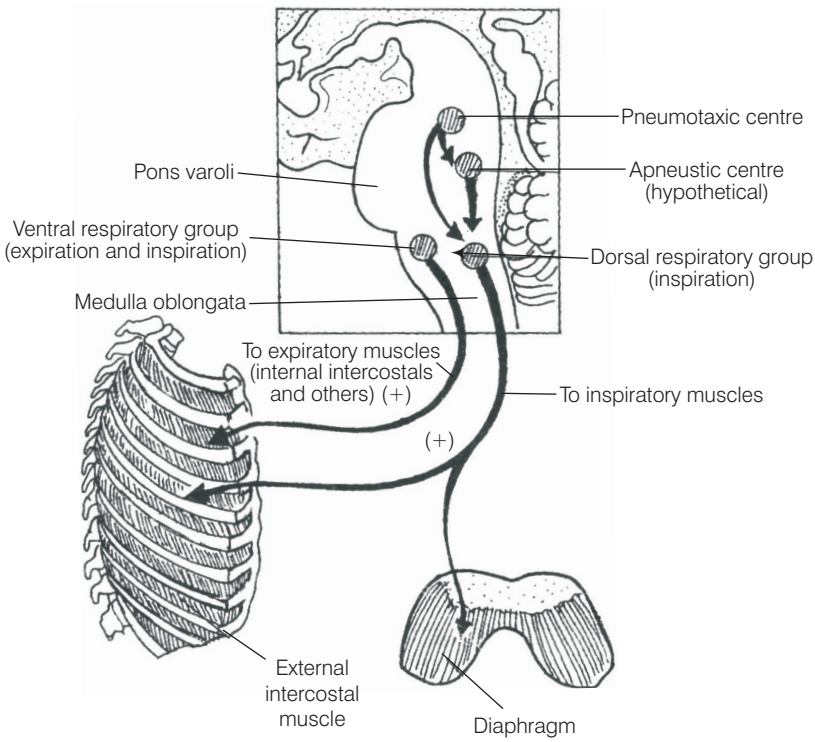
(a) Medullary inspiratory centre
(b) Pneumotaxic centre
(c) Apneustic centre
(d) Chemosensitive centre

Ans. *(b)* **Pneumotaxic Centre** Located in the dorsal part of pons varoli of the brain can reduce the duration of inspiration and thus alter the respiratory rate.

Apneustic Centre Whereas is located in the lower part of pons varoli is responsible for promoting inspiration process.

Chemosensitive Centre is situated adjacent to the rhythm centre which is highly sensitive to CO_2 and hydrogen ions. Increase in CO_2 and H^+ in body and activates this centre for the elimination of CO_2 and H

Medullary Inspiratory Centre is a specialised region present in medulla of the brain. and is primarily responsible for regulating the respiratory rhythm.



Respiratory centre in human brain

Q. 11 CO_2 dissociates from carbamino haemoglobin when

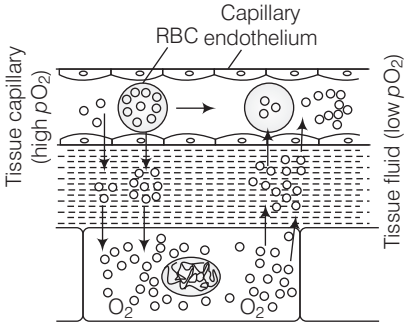
(a) pCO_2 is high and pO_2 is low
(b) pO_2 is high and pCO_2 is low
(c) pCO_2 and pO_2 are equal
(d) None of the above

Thinking Process

CO_2 is carried by haemoglobin as carbamino haemoglobin. This binding is related to the partial pressure of CO_2.

Ans. *(b)* When, the pCO_2 is low and pO_2 is high as in the lung alveoli, dissociation of CO_2 from carbamino-haemoglobin takes place, CO_2 which is bound to haemoglobin from the tissue is delivered at the alveoli, to maintain the concentration of CO_2 thus increasing pCO_2 .

Exchange of gases takes place between tissue capillary and tissue cells. Capillary cells with high pO_2 causes diffusion of O_2 into tissue cells *via* tissue fluid on the other hand high pCO_2 in the tissue cells causes diffusion of CO_2 into tissue capillary *via* tissue fluid.



Tissue cell showing low pO_2 high pCO_2

Q. 12 In breathing movements, air volume can be estimated by

(a) stethoscope (b) hygrometer
(c) sphygmomanometer (d) spirometer

Ans. ***(d)*** **Spirometer** is the device used to measure the volume of air involved in breathing movements and it also helps in clinical assessment of pulmonary functions.

Stethoscope is a medical device used for listening the internal sounds of an animal or human body.

Hygrometer is a device used for measuring the moisture content in the atmosphere, *i.e.,* humidity.

Sphygmomanometer is a device that is used to measure **blood pressure**.

Q. 13 From the following relationships between respiratory volume and capacities, mark the correct option.

(i) Inspiratory Capacity (IC) = Tidal Volume + Residual Volume
(ii) Vital Capacity (VC) = Tidal Volume (TV) + Inspiratory Reserve Volume (IRV) + Expiratory Reserve Volume (ERV).
(iii) Residual Volume (RV) = Vital Capacity (VC) – Inspiratory Reserve Volume (IRV)
(iv) Tidal Volume (TV) = Inspiratory Capacity (IC) – Inspiratory Reserve Volume (IRV)

Codes

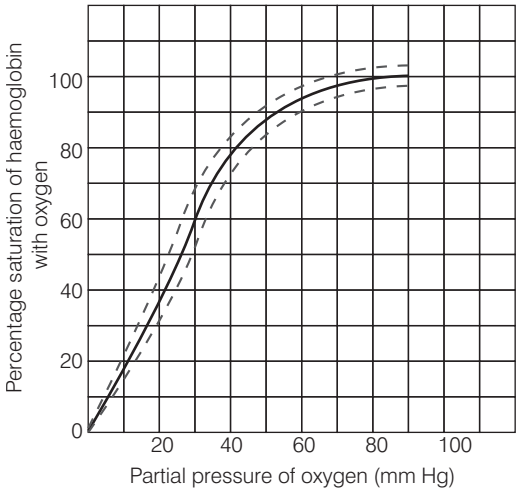
(a) (i) Incorrect, (ii) Incorrect, (iii) Incorrect, (iv) Correct
(b) (i) Incorrect, (ii) Correct, (iii) Incorrect, (iv) Correct
(c) (i) Correct, (ii) Correct, (iii) Incorrect, (iv) Correct
(d) (i) Correct, (ii) Incorrect, (iii) Correct, (iv) Incorrect

Ans. ***(b)***
(i) **Inspiratory Capacity** (IC) = Tidal Volume + Inspiratory Reserve Volume (TV + IRV).
(ii) **Vital Capacity** (VC) Tidal Volume + Inspiratory Reserve Volume + Expiratory Reserve Volume. (TV + ERV + IRV)
(iii) **Residual Volume** (RV) Volume of air remaining in the lungs after a forcible expiration.
(iv) **Tidal Volume** (TV) Volume of air inspired or expired during a normal respiration.

Q. 14 The oxygen-haemoglobin dissociation curve will show a right shift in case of

(a) high pCO_2 (b) high pO_2
(c) low pCO_2 (d) less H^+ concentration

Ans. *(a)* A **sigmoid curve** obtained when percentage saturation of haemogblobin with O_2 is plotted against the pO_2.



Oxygen dissociation curve

The oxygen haemoglobin dissociation curve is shifted to right under following condition.

(i) Decrease in partial pressure of oxygen.
(ii) Increase in partial pressure of carbonoxide.
(iii) Increase in hydrogen concentration.
(iv) Decrease in pH activity.
(v) Increased body temperature.

Q. 15 Match the following columns.

Column I	Coulmn II
A. Earthworm	1. Moist cuticle
B. Aquatic arthropods	2. Gills
C. Fishes	3. Lungs
D. Birds/Reptiles	4. Trachea

Codes

	A	B	C	D
(a)	2	1	4	3
(c)	1	3	2	4

	A	B	C	D
(b)	1	4	2	3
(d)	1	2	4	3

Ans. *(b)* Earthworm respire through their moist cuticle and aquatic arthropods, respire through trachea.

Fishes respire through **gills,** and birds/reptiles respire through **lungs**.

Very Short Answer Type Questions

Q. 1 Define the following terms?

(a) Tidal volume (b) Residual volume

(c) Asthma

Thinking Process

The quantity of air that lung can receive, hold or expel under different condition is called pulmonary volume. Combination of two or more pulmonary volume is called pulmonary capacities.

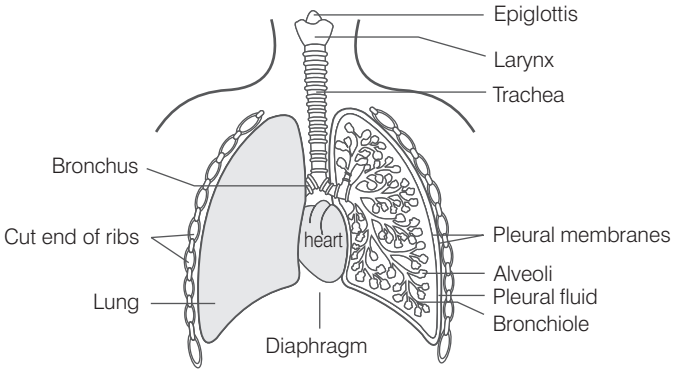
Ans. (a) **Tidal Volume** (TV) is the volume of air inspired or expired during normal breath. This is about 500 mL, *i.e.*, a healthy man inspire or expire about 6000 to 8000 mL of air per minute.

(b) **Residual Volume** (RV) is the volume of air remaining in the lungs even after a forcible expiration. It is about 1100 mL to 1200 mL.

(c) **Asthma** It is a disease caused due to an allergic reaction to foreign substances. The major symptoms are difficulty in breathing causing wheezing and coughing. Due to the inflammation of bronchi.

Q. 2 A fluid filled double membranous layer surrounds the lungs. Name it and mention its important function.

Ans. A fluid filled double membranous layer that surrounds the lungs is called **pleura**, and fluid is pleural fluid in between them. The outer pleural membrane is in close contact with the thoracic lining whereas, the inner pleural membrane is in contact with the lung surface. These collectively reduce friction on lung's surface.

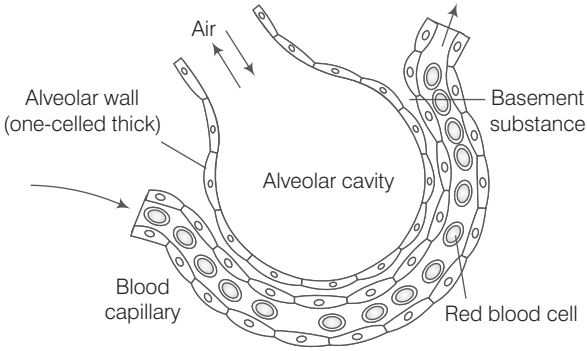


Diagrammatic view of human respiratory system of man

Q. 3 Name the primary site of exchange of gases in our body?

Ans. The primary site for the exchange of gases in our body is **alveoli**. There are 300 millions of alveoli collectively in both the lungs. These alveoli have very thin wall consisting of squamous epithelium. With extensive network of blood capillaries.

The presence of blood capillaries in the alveoli, result in easy exchange of gases. Each alveolus is also called as miniature lung.



A diagram of a section of an alveolus with a pulmonary capillary

Q. 4 Cigarette smoking causes emphysema. Give reason.

Ans. Emphysema is a chronic disorder of respiratory system, where inflation or abnormal distension of alveolar wall occurs. Cigarette smoking and the inhalation of other smoke or toxic substances over a period of time causes the damaging of septa between the alveoli, and of its elastic tissue is replaced by the connective tissue in lungs.

Hence, the respiratory surface decreases, thus causing the **emphysema**. It causes shortness of breath, production of sputum, chronic bronchitis, etc.

Q. 5 What is the amount of O_2 supplied to tissues through every 100 mL of oxygenated blood under normal physiological conditions?

Ans. Every 100 mL of oxygenated blood can deliver around 5 mL of O_2 to the tissue under normal **physiological conditions**.

Q. 6 A major percentage (97%) of O_2 is transported by RBCs in the blood. How does the remaining percentage (3%) of O_2 transported?

Ans. About 97% of O_2 is transported by RBCs in the blood. The remaining 3% of O_2 is carried in a dissolved state through the **plasma**.

Q. 7 Arrange the following terms based on their volumes in an ascending order.

(a) Tidal Volume (TV)
(b) Residual Volume (RV)
(c) Inspiratory Reserve Volume (IRV)
(d) Expiratory Capacity (EC)

Ans. (d) **Expiratory Capacity** (EC) Approximate volume is 1000 mL.
(b) **Residual Volume** (RV) Approximate volume is 1200 mL.
(c) **Inspiratory Reserve Volume** (IRV) Approximate volume is 2500 to 3000mL.

(a) **Tidal Volume**(TV) Approximate volume is 6000 to 8000 mL.

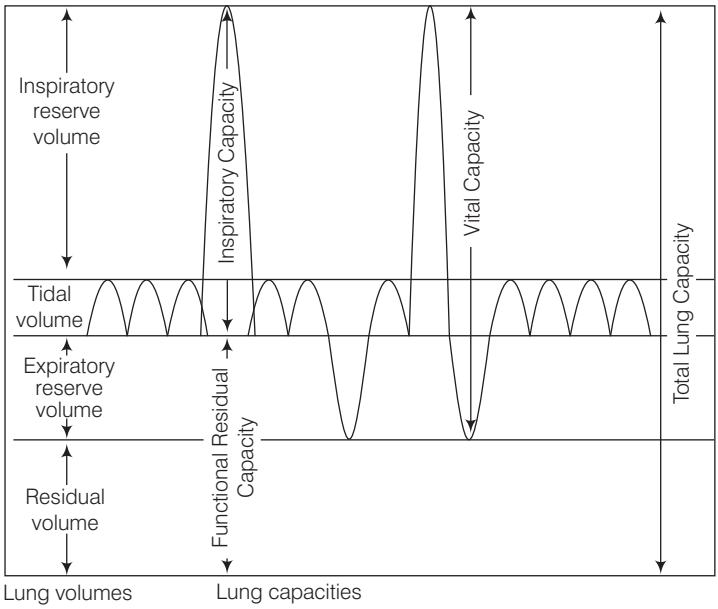


Diagram depicting pulmonary volumes and pulmonary capacities

Q. 8 Complete the missing terms

(a) Inspiratory Capacity (IC) = ... + IRV

(b) ... = TV + ERV

(c) Functional Residual Capacity (FRC) = ERV + ...

Ans. **(a)** Inspiratory Capacity (IC) = (TV) + (IRV) Tidal Volume. Inspiratory Reserve Volume

(b) Expiratory Capacity (EC) = (TV + ERV) Tidal Volume. Expiratory Reserve Volume

(c) Functional Residual Capacity (FRC) = (ERV) Expiratory + (RV) Reserve Volume. Residual Volume

Q. 9 Name the organs of respiration in the following organisms.

(a) Flatworm .....

(b) Birds .....

(c) Frog .....

(d) Cockroach .....

Thinking Process

Mechanism of breathing vary among different groups of animals depending on their habitats and levels of organisation.

Ans. (a) **Flatworm** General body surface

(b) **Birds** Lungs

(c) **Frog** Lungs and moist skin

(d) **Cockroach** Tracheal tubes

Q. 10 Name the important parts involved in creating a pressure gradient between lungs and the atmosphere during normal respiration.

Ans. The diaphragm and a specialised set of **external** and **intercostals muscles** between the ribs, help in the generation of pressure gradient during normal respiration.

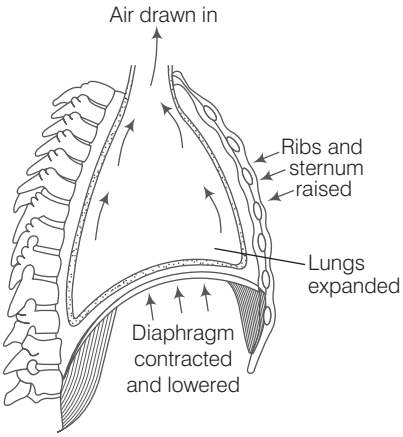


Diagram depicting expiration process *via* diaphragm and intercostal muscles in lungs

Short Answer Type Questions

Q. 1 State the different modes of CO_2 transport in blood.

Ans. *Carbon dioxide is carried by the blood in three forms*

(i) **In Dissolved State** Under normal temperature and pressure, about 7% of CO_2 is carried by physical solution.

(ii) **As Carbamino Compounds** CO_2 binds directly with Hb to form an unstable compound carbaminocompounds (CO_2 Hb) About 23% CO_2 is transported in this form. When pCO_2 is high and pO_2 is low as in the tissues, more binding of carbon-dioxide occurs whereas, when pCO_2 is low and pO_2 is high as in alveol as tissue dissociation of CO_2 from carbamino-haemoglobin takes place.

$$HbO_2 + CO_2 \rightleftharpoons HbCO_2 + H^+ + O_2$$

(iii) **As Bicarbonate Ions** CO_2 reacts with water to form carbonic acid (H_2CO_3) in the presence of carbonic anhydrase in RBC. H_2CO_3 dissociates into hydrogen and bicarbonate ions (HCO_3^-).

The whole reaction proceeds as follows

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

$$\underset{\text{Carbonic acid}}{H_2CO_3} \rightleftharpoons \underset{\text{Hydrogen ion}}{H^+} + \underset{\text{Bicarbonate ion}}{HCO_3^-}$$

The carbonic anhydrase reaction mainly occur in RBC as it contain high concentration of enzyme carbonic anhydrase and minute quantity of it is present in plasma too.

Q. 2 Compared to O_2, diffusion rate of CO_2 through the diffusion membrane per unit difference in partial pressure is much higher. Explain.

Thinking Process

Diffusing capacity can be defined as the volume of gas, that diffuses through the membrane per minute for a pressure difference of 1 mm Hg. It is further dependent on the solubility of the diffusing gases.

Ans. As, the solubility rate of CO_2 is 20-25 times higher than that of the O_2, the amount of CO_2 that can diffuse through the diffusion membrane per unit difference in partial pressure is much higher compared to that of O_2.

Q. 3 For completion of respiration process, write the given steps in sequential manner.

(a) Diffusion of gases (O_2 and CO_2) across alveolar membrane.
(b) Transport of gases by blood.
(c) Utilisation of O_2 by the cells for catabolic reactions and resultant release of CO_2.
(d) Pulmonary ventilation by which atmospheric air is drawn in and CO_2 rich alveolar air is released out.
(e) Diffusion of O_2 and CO_2 between blood and tissues.

Ans. **(d)** Pulmonary ventilation by which atmospheric air is drawn in and CO_2 rich alveolar air is released out.
(a) Diffusion of gases (O_2 and CO_2) across alveolar membrane.
(b) Transport of gases by blood.
(c) Diffusion of O_2 and CO_2 between blood and tissues.
(e) Utilisation of O_2 by the cells for catabolic reactions and resultant release of CO_2.

Q. 4 Differentiate between

(a) Inspiratory and expiratory reserve volume
(b) Vital capacity and total lung capacity.
(c) Emphysema and occupational respiratory disorder.

Ans. *Difference between these are as follows*

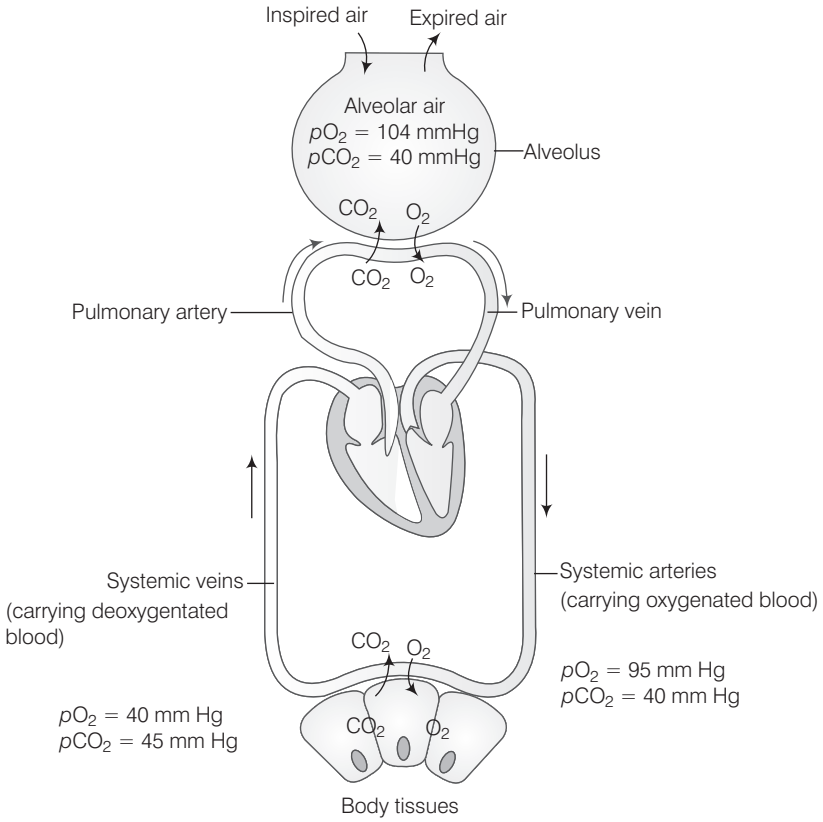
(a)	**Inspiratory Reserve Volume**	**Expiratory Reserve Volume**
	It is the additional volume of air, a person can inspire by a forcible inspiration. It ranges between 2500 mL to 3000 mL.	It is the additional volume of air a person can expire by a forcible expiration. It ranges between 1000 mL to 1100 mL.
(b)	**Vital Capacity**	**Total Lung Capacity**
	Vital capacity is the maximum volume of air that a person can breathe in after a forced expiration. This includes ERV, TV and IRV or the maximum volume of air a person can breathe out after a forced inspiration. *i.e.,* Vc = ERV + IRV + TV	Total using capacity is the total volume of air accommodated in the lungs at the end of a forced inspiration. This includes RV, ERV, TV and IRV or vital capacity + residual volume. *i.e.,* TLC = RV +(ERV +IRV +TV) or VC +RV

(c)	Emphysema	Occupational Respiratory Disorder
	Emphysema is a chronic disorder of respiratory system, in which alveolar cells are damaged due to which regulatory respiratory surface is decreased. Cause of emphysema is cigarette smoking.	It is caused due to the long exposure of dust produced by stone grinding or breaking and give rise to inflammation leading to fibrosis and thus causing serious lung damage. Protective masks are provided for the workers in such industries.

Long Answer Type Questions

Q. 1 Explain the transport of O_2 and CO_2 between alveoli and tissue with diagram.

Ans. *Representing the transport of O_2 and CO_2 between alveoli and tisue with diagram*

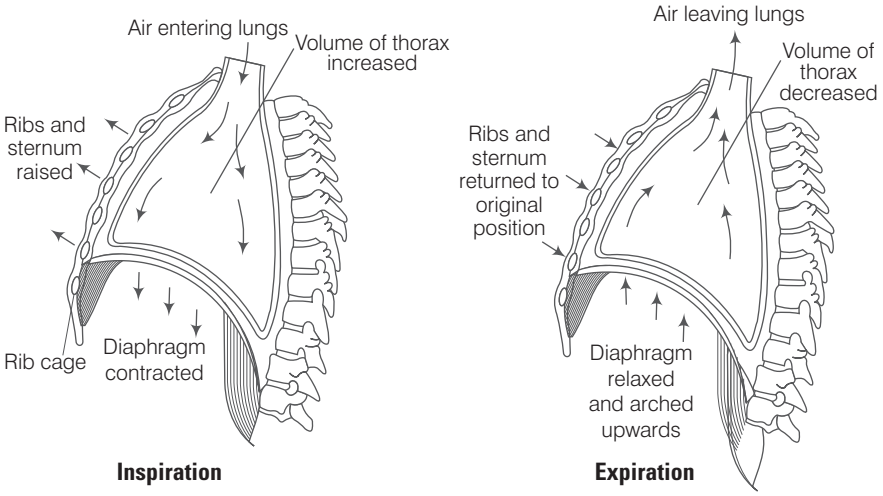


Diagrammatic representation of exchange of gases at the alveolus and the body tissue with blood and transport of oxygen and carbon dioxide

Q. 2 Explain the mechanism of breathing with neat labelled sketches.

Ans. **Mechanism of Breathing** Breathing involves two stages, inspiration during which atmospheric air is drawn in and expiration by which the alveolar air is released out.

The movement of air into and out of the lungs is carried out by creating a pressure gradient between the lungs and the atmosphere, the help of diaphragm and inter costal muscles.



Q. 3 Explain the role of neural system in regulation of respiration.

Ans. Human beings have a significant ability to maintain and moderate the respiratory rhythm to suit the demands of the body tissue. This is done by the neural system.

Respiration regulated by neural system in following ways/ manress

(i) A specialised centre present in the medulla region of the brain called respiratory rhythm centre is primarily responsible in regulating respiration process. Another centre present in the pons region of the brain called pneumotaxic centre, can moderate the functions of the respiratory rhythm centre. Neural signal from this centre, can reduce the duration of inspiration and thereby alter the respiratory rate.

(ii) A chemosensitive area is situated adjacent to the rhythm centre which is highly sensitive to CO_2 and hydrogen ions. Increase in these substances activates this centre, which in turn signals the rhythm centre to make necessary adjustments in the respiratory process by which these substances can be eliminated.

(iii) Receptors associated with aortic arch and carotid artery also recognise changes in CO_2 and H^+ concentration and send necessary signals to the rhythm centre for remedial action because the role of oxygen in the regulation of respiratory rhythm is quite insignificant.