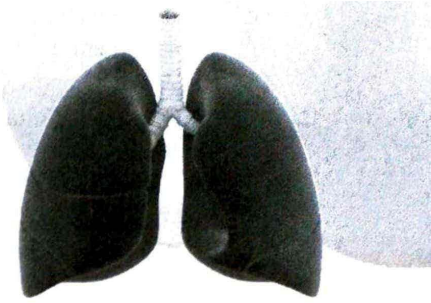
CHAPTER

14 Breathing and Exchange of Gases



14.1. Respiratory Organs

1. Which of the following is not the function of conducting part of respiratory system?

(A) Inhaled air is humidified.

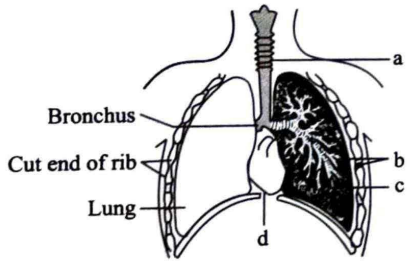
(B) Temperature of inhaled air is brought to body temperature.

(C) Provides surface for diffusion of O_2 and CO_2.

(D) It clears inhaled air from foreign particles.

[NEET 2022]

2. The figure shows a diagrammatic view of human respiratory system with labels a, b, c and d. Select the option, which gives correct identification and main function and/or characteristic.



(A) a-Trachea-long tube supported by complete cartilaginous rings for conducting inspired air.

(B) b-Pleural membrane-surround ribs on both sides to provide cushion against rubbing.

(C) c-Alveoli-thin walled vascular bag-like structures for exchange of gases.

(D) d-Lower end of lungs-diaphragm pulls it down during inspiration. **[NEET 2013]**

14.2. Mechanism of Breathing

3. Match List-I with List-II:

List-I	List-II
(a) Residual Volume	(i) Maximum volume of air that can be breathed in after forced expiration
(b) Vital Capacity	(ii) Volume of air inspired or expired during normal respiration
(c) Expiratory Capacity	(iii) Volume of air remaining in lungs after forcible expiration
(d) Tidal Volume	(iv) Total volume of air expired after normal inspiration

Choose the correct answer from the options given below:

	(a)	(b)	(c)	(d)
(A)	(iv)	(iii)	(ii)	(i)
(B)	(ii)	(iv)	(i)	(iii)
(C)	(iii)	(i)	(iv)	(ii)
(D)	(i)	(ii)	(iii)	(ii)

[Re-NEET 2024]

4. Match List I with List II:

List I	List II
(a) Expiratory capacity	(i) Expiratory reserve volume + Tidal volume + Inspiratory reserve volume
(b) Functional residual capacity	(ii) Tidal volume + Expiratory reserve volume
(c) Vital capacity	(iii) Tidal volume + Inspiratory reserve volume
(d) Inspiratory capacity	(iv) Expiratory reserve volume + Residual volume

Choose the correct answer from the options given below:

	(a)	(b)	(c)	(d)
(A)	(iii)	(ii)	(iv)	(i)
(B)	(ii)	(i)	(iv)	(iii)
(C)	(i)	(iii)	(ii)	(iv)
(D)	(ii)	(iv)	(i)	(iii)

[NEET 2024]

5. Vital capacity of lung is ..... .

(A) IRV + ERV + TV – RV

(B) IRV + ERV + TV

(C) IRV + ERV

(D) IRV + ERV + TV + RV **[NEET 2023]**

6. The Total Lung Capacity (TLC) is the total volume of air accommodated in the lungs at the end of a forced inspiration. This includes:

(A) RV, IC (Inspiratory Capacity), EC (Expiratory Capacity) and ERV.
(B) RV, ERV, IC and EC.
(C) RV, ERV, VC (Vital Capacity) and FRC (Functional Residual Capacity).
(D) RV (Residual Volume), ERV (Expiratory Reserve Volume), TV (Tidal Volume) and IRV (Inspiratory Reserve Volume). **[NEET Oct. 2020]**

7. Select the correct events that occur during inspiration.
(I) Contraction of diaphragm.
(II) Contraction of external intercostal muscles.
(III) Pulmonary volume decreases.
(IV) Intrapulmonary pressure increases.
Options:
(A) (II) and (IV) (B) (I), (II) and (IV)
(C) Only (IV) (D) (I) and (II)
[NEET Sept. 2020]

8. Tidal Volume and Expiratory Reserve Volume of an athlete is 500 mL and 1000 mL, respectively. What will be his Expiratory Capacity if the Residual Volume is 1200 mL?
(A) 1700 mL (B) 2200 mL
(C) 2700 mL (D) 1500 mL
[NEET National 2019]

9. Select the correct statement.
(A) Expiration occurs due to external intercostal muscles.
(B) Intrapulmonary pressure is lower than the atmospheric pressure during inspiration.
(C) Inspiration occurs when atmospheric pressure is less then intrapulmonary pressure.
(D) Expiration is initiated due to contraction of diaphragm. **[NEET Odisha 2019]**

10. The maximum volume of air a person can breathe in after a forced expiration is known as:
(A) expiratory capacity (B) vital capacity
(C) inspiratory capacity (D) total lung capacity.
[NEET Odisha 2019]

11. Match the items given in Column I with those in Column II and select the correct option given below.

Column I	Column II
(a) Tidal volume	(i) 2500 – 3000 mL
(b) Inspiratory reserve volume	(ii) 1100 – 1200 mL
(c) Expiratory reserve volume	(iii) 500 – 550 mL
(d) Residual volume	(iv) 1000 – 1100 mL

Select the correct option from the following.

	(a)	(b)	(c)	(d)
(A)	(i)	(iv)	(ii)	(iii)
(B)	(iii)	(i)	(iv)	(ii)
(C)	(iii)	(ii)	(i)	(iv)
(D)	(iv)	(iii)	(ii)	(i)

[NEET 2018]

12. Lungs are made up of air-filled sacs, the alveoli. They do not collapse even after forceful expiration, because of:
(A) Residual Volume (RV)
(B) Inspiratory Reserve Volume (IRV)
(C) Tidal Volume (TV)
(D) Expiratory Reserve Volume (ERV). **[NEET 2017]**

13. What is vital capacity of our lungs?
(A) Inspiratory reserve volume plus tidal volume.
(B) Total lung capacity minus expiratory reserve volume.
(C) Inspiratory reserve volume plus expiratory reserve volume.
(D) Total lung capacity minus residual volume.
[AIPMT Screening 2008]

14. Which one of the following statements is incorrect?
(A) The principle of countercurrent flow facilitates efficient respiration in gills of fishes.
(B) The residual air in lungs slightly decreases the efficiency of respiration in mammals.
(C) The presence of non-respiratory air sacs, increases the efficiency of respiration in birds.
(D) In insects, circulating body fluids serve to distribute oxygen to tissues. **[AIPMT 2006]**

15. When 1500 mL of air is in the lungs, it is called the ..... .
(A) residual volume
(B) inspiratory reserve volume
(C) vital capacity
(D) tidal volume **[AIPMT 1996]**

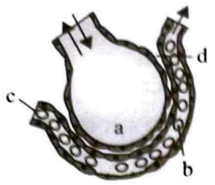
16. The ventilation movements of the lungs in mammals are governed by:
(A) muscular walls of lung
(B) diaphragm
(C) costal muscles
(D) both (B) and (C). **[AIPMT 1995]**

14.3. Exchange of Gases

17. The partial pressures (in mm Hg) of oxygen (O_2) and carbon dioxide (CO_2) at alveoli (the site of diffusion) are:
(A) $pO_2 = 104$ and $pCO_2 = 40$
(B) $pO_2 = 40$ and $pCO_2 = 45$
(C) $pO_2 = 95$ and $pCO_2 = 40$
(D) $pO_2 = 159$ and $pCO_2 = 0.3$ **[NEET 2021]**

18. The partial pressure of oxygen in the alveoli of the lungs is:
(A) equal to that in the blood.
(B) more than that in the blood.
(C) less than that in the blood.
(D) less than that of carbon dioxide.
[NEET Phase-II 2016]

19. The figure given below shows a small part of human lung where exchange of gases takes place. In which one of the options given below, the one part a, b, c or d is correctly identified along with its function?



(A) a — Alveolar cavity — main site of exchange of respiratory gases.

(B) d — Capillary wall — exchange of O_2 and CO_2 takes place here.

(C) b — Red blood cell — transport of CO_2 mainly.

(D) c — Arterial capillary — passes oxygen to tissues.

[AIPMT Screening 2011]

20. The exchange of gases in the alveoli of the lungs takes place by:

(A) simple diffusion (B) osmosis

(C) active transport (D) passive transport.

[AIPMT 1998]

21. In the lungs, the air is separated from the venous blood through:

(A) Squamous epithelium + tunica media blood vessel

(B) Squamous epithelium + endothelium of blood vessel

(C) Transitional epithelium + tunica externa of blood vessel

(D) None of the above. **[AIPMT 1997]**

14.4. Transport of Gases

22. Given below are two statements: One is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): During the transportation of gases about 20-25 percent of CO_2 is carried by Haemoglobin as carbamino-haemoglobin.

Reason (R): This binding is related to high pCO_2 and low pO_2 in tissues.

In the light of the above statements, choose the correct answer from the options given below.

(A) A is true but R is false.

(B) A is false but R is true.

(C) Both A and R are true and R is the correct explanation of A.

(D) Both A and R are true but R is NOT the correct explanation of A. **[Re-NEET 2024]**

23. Which of the following factors are favourable for the formation of oxyhaemoglobin in alveoli?

(A) High pO_2 and Lesser H^+ concentration.

(B) Low pCO_2 and High H^+ concentration.

(C) Low pCO_2 and High temperature.

(D) High pO_2 and High pCO_2. **[NEET 2024]**

24. Under normal physiological conditions in human being every 100 mL of oxygenated blood can deliver ..... mL of O_2 to the tissues.

(A) 5 mL (B) 4 mL

(C) 10 mL (D) 2 mL **[NEET 2022]**

25. Select the favourable conditions required for the formation of oxyhaemoglobin at the alveoli.

(A) High pO_2, low pCO_2, less H^+, lower temperature

(B) Low pO_2, high pCO_2, more H^+, higher temperature

(C) High pO_2, high pCO_2, less H^+, higher temperature

(D) Low pO_2, low pCO_2, more H^+, higher temperature

[NEET 2021]

26. Identify the wrong statement with reference to transport of oxygen.

(A) Partial pressure of CO_2 can interfere with O_2 binding with haemoglobin.

(B) Higher H^+ concentration in alveoli, favours the formation of oxyhaemoglobin.

(C) Low pCO_2 in alveoli, favours the formation of oxyhaemoglobin.

(D) Binding of oxygen with haemoglobin is mainly related to partial pressure of O_2. **[NEET Sept. 2020]**

27. Approximately seventy percent of carbon dioxide absorbed by the blood will be transported to the lungs:

(A) as bicarbonate ions.

(B) in the form of dissolved gas molecules.

(C) by binding to RBC.

(D) as carbamino-haemoglobin. **[AIPMT 2014]**

28. A large proportion of oxygen is left unused in the human blood even after its uptake by the body tissues. This O_2:

(A) raises the pCO_2 of blood to 75 mm of Hg.

(B) is enough to keep oxyhaemoglobin saturation at 96%.

(C) helps in releasing more O_2 to the epithelial tissues.

(D) acts as a reserve during muscular exercise.

[AIPMT Screening 2011]

29. What is true about RBCs in humans?

(A) They carry about 20-25 percent of CO_2.

(B) They transport 99.5 percent of O_2.

(C) They transport about 80 percent oxygen only and the rest 20 percent of it is transported in dissolved state in blood plasma.

(D) They do not carry CO_2 at all.

[AIPMT Screening 2010]

30. When CO_2 concentration in blood increases breathing becomes:

(A) shallower and slow.

(B) there is no effect on breathing.

(C) slow and deep.

(D) faster and deeper. **[AIPMT 2004]**

31. The process of migration of chloride ions from plasma to RBC and of carbonate ions from RBC to plasma is:

(A) chloride shift (B) ionic shift

(C) atomic shift (D) Na^+ pump. **[AIPMT 1999]**

32. Haemoglobin is a type of:

(A) carbohydrate (B) respiratory pigment

(C) vitamin (D) skin pigment.

[AIPMT 1999]

33. Which one of the following statements about blood constituents and transport of respiratory gases is most accurate?

(A) RBCs transport oxygen whereas WBCs transport CO_2.

(B) RBCs transport oxygen whereas plasma transport only CO_2.

(C) RBCs as well as WBCs transport both oxygen and CO_2.

(D) RBCs as well as plasma transport both oxygen and CO_2. **[AIPMT 1996]**

34. Although much CO_2 is carried in blood, yet blood does not become acidic, because:

(A) it is absorbed by leucocytes.

(B) blood buffers play an important role in CO_2 transport.

(C) it combines with water to form H_2CO_3 which is neutralised by Na_2CO_3.

(D) it is continuously diffused through tissues and is not allowed to accumulate. **[AIPMT 1995]**

35. Oxygen dissociation curve of haemoglobin is:

(A) sigmoid (B) hyperbolic

(C) linear (D) hypobolic. **[AIPMT 1994]**

36. Carbon dioxide is transported from tissues to respiratory surface by only:

(A) plasma and erythrocytes

(B) plasma

(C) erythrocytes

(D) erythrocytes and leucocytes. **[AIPMT 1993]**

37. Carbonic andydrase occurs in:

(A) lymphocytes (B) blood plasma

(C) RBC (D) leucocytes.

[AIPMT 1991]

14.5. Regulation of Respiration

38. Match the following columns and select the correct option from the codes given below.

Column I	Column II
(a) Pneumotaxic centre	(i) Alveoli
(b) O_2 dissociation curve	(ii) Pons region of brain
(c) Carbonic anhydrase	(iii) Haemoglobin
(d) Primary site of gaseous exchange	(iv) RBC

Select the correct option:

	(a)	(b)	(c)	(d)
(A)	(i)	(iii)	(ii)	(iv)
(B)	(ii)	(iii)	(iv)	(i)
(C)	(iii)	(ii)	(iv)	(i)
(D)	(iv)	(i)	(iii)	(ii)

[NEET Oct. 2020]

39. When you hold your breath which of the following gas changes in blood would first lead to the urge to breathe?

(A) Falling O_2 concentration

(B) Rising CO_2 concentration

(C) Falling CO_2 concentration

(D) Rising CO_2 and falling O_2 concentration

[AIPMT Cancelled 2015]

40. The respiratory centre which regulates respiration is located in:

(A) cerebellum (B) medulla oblongata

(C) cerebral peduncle (D) the vagus nerve.

[AIPMT 1994]

14.6. Disorders of Respiratory System

41. Which one of the following options correctly represents the lung conditions in asthma and emphysema, respectively?

(A) Increased respiratory surface; Inflammation of bronchioles.

(B) Increased number of bronchioles; Increased respiratory surface.

(C) Inflammation of bronchioles; Decreased respiratory surface.

(D) Decreased respiratory surface; Inflammation of bronchioles. **[NEET 2018]**

42. Which of the following is an occupational respiratory disorder?

(A) Botulism (B) Silicosis

(C) Anthracis (D) Emphysema **[NEET 2018]**

43. Asthma may be attributed to:

(A) allergic reaction of the mast cells in the lungs.

(B) inflammation of the trachea.

(C) accumulation of fluid in the lungs.

(D) bacterial infection of the lungs.

[NEET Phase-I 2016]

44. Which one of the following is the correct statement for respiration in humans?

(A) Cigarette smoking may lead to inflammation of bronchi.

(B) Neural signals from pneumotaxic centre in pons region of brain can increase the duration of inspiration.

(C) Workers in grinding and stone breaking industries may suffer, from lung fibrosis.

(D) About 90% of carbon dioxide (CO_2) is carried by haemoglobin as carbamino-haemoglobin.

[AIPMT Screening 2012]

45. Blood analysis of a patient reveals an unusually high quantity of carboxyhaemoglobin content. Which of the following conclusions is most likely to be correct?

The patient has been inhaling polluted air containing unusually high content of:

(A) carbon disulfide (B) chloroform

(C) carbon dioxide (D) carbon monoxide.

[AIPMT 2004]

SOLUTIONS

1. (C) The conducting part of the respiratory system includes all of the structures that allow air to enter and exit the lungs. The nasal cavity, pharynx, trachea, bronchi, and most bronchioles are part of it, while the alveoli and their ducts are part of the respiratory or exchange system. The primary functions of conducting part include transporting atmospheric air to the alveoli, clearing it of foreign particles, humidifying, and bringing the air to body temperature. While, the exchange part of the respiratory system is considered as the actual site for O_2 and CO_2 diffusion. These gases are exchanged between the alveoli and a network of tiny blood vessels called capillaries that are located in the alveolar walls.

⚠ Caution

➥ *To avoid confusion, students should remember that the function of the conducting part of respiratory system is associated with its name only. This part serves to conduct, clean, warm, and moisten air. On the other hand, the respiratory part includes the alveoli, which facilitates the gaseous exchange.*

2. (C) (a) Trachea or windpipe is an air conducting tube which is supported by incomplete cartilaginous rings. Through this conducting tube transport of gases take place.

(b) Pleural membrane surrounds the lungs. It is a double membrane, which helps in the reduction of friction in the lung membranes.

(c) Alveoli are thin walled vascular bag-like structures for exchange of gases.

(d) Diaphragm is involved in the inspiration and expiration process.

Related Theory

➥ *The cartilaginous rings in the trachea and bronchi prevents collapsing of air passage and also hold the passage open so that oxygen can be breathed in with a minimum of effort by the diaphragm. The C-shaped cartilaginous ring prevents collapsing of trachea. It allows the trachea to collapse slightly at its opening, so food can pass down the oesophagus after swallowing.*

3. (C) Residual volume is the volume of air remaining in the lungs after forcible expiration. This is typically about 1200 mL. Vital capacity is the maximum volume of air that can be breathed in after forced expiration. This is typically around 4800 mL. Expiratory capacity is the total volume of air expired after normal inspiration. This is typically around 1700 mL. Tidal volume is the amount of air that is inhaled or exhaled during normal breathing. This is typically about 500 mL.

4. (D) Expiratory capacity (EC) is the total volume of air a person can expire after a normal inspiration. This includes tidal volume (TV) and expiratory reserve volume (TV+ERV). Functional residual capacity (FRC) is the volume of air that will remain in the lungs after a normal expiration. This includes ERV+RV. Vital capacity (VC) is the maximum volume of air a person can breathe in after a forced expiration. This includes ERV, TV and IRV. Inspiratory capacity (IC) is the total volume of air a person can inspire after a normal expiration. This includes tidal volume and inspiratory reserve volume (TV+IRV).

5. (B) The vital capacity of the lung is the maximum amount of air that can be forcefully exhaled after taking a deep breath. It is the sum of the inspiratory reserve volume (IRV), expiratory reserve volume (ERV), and tidal volume (TV).

6. (D) The Total Lung Capacity (TLC) is the maximum volume of air the lungs can accommodate or sum of all volume compartments or volume of air in lungs after maximum inspiration. The normal value is about 6,000 mL (4–6 L). TLC is calculated by summation of the four primary lung volumes (TV, IRV, ERV, and RV).

Related Theory

Tidal volume is the amount of air that can be inhaled or exhaled during one respiratory cycle. This depicts the functions of the respiratory centres, respiratory muscles and the mechanics of the lung and chest wall. Inspiratory Reserve Volume (IRV) is the amount of air that can be forcibly inhaled after a normal tidal volume. IRV is usually kept in reserve, but is used during deep breathing. The normal adult value is 1900-3300 mL. Expiratory Reserve Volume (ERV) is the volume of air that can be exhaled forcibly after exhalation of normal tidal volume. The normal adult value is 700-1200 mL. ERV is reduced with obesity, ascites or after upper abdominal surgery. Residual Volume (RV) is the volume of air remaining in the lungs after maximal exhalation. Normal adult value is averaged at 1200 mL (20-25 mL/kg). It is indirectly measured from the summation of FRC and ERV and cannot be measured by spirometry.

Caution

Lung volumes and Lung capacities must be memorised well. Students usually make mistakes in the questions related to such topics.

7. (D) During inspiration, the contraction of diaphragm occurs, which pulls it downwards, and external intercostal muscles contract and lift up the ribs and sternum. This increases the size of thoracic cavity and hence, the pulmonary volume. Due to this, there is a decrease in the pressure (intrapulmonary pressure) to less than the atmospheric pressure. As a result, air rushes inside the lungs.

8. (D) Expiratory Capacity = Tidal Volume + Expiratory Reserve Volume

Tidal Volume (TV) = 500 mL

Expiratory Reserve Volume (ERV) = 1000 mL

Therefore,

Expiratory Capacity = 500 mL + 1000 mL = 1500 mL

Related Theory

The total lung capacity (TLC) is the maximum amount of air that can fill the lungs (TLC = TV + IRV + ERV + RV). The vital capacity (VC), about is the total amount of air that can be expired after fully inhaling (VC = TV + IRV + ERV). The inspiratory capacity (IC) is the maximum amount of air that can be inspired (IC = TV + IRV). The functional residual capacity (FRC) is the amount of air remaining in the lungs after a normal expiration (FRC = RV + ERV).

Mnemonics

The respiratory volumes and capacities can be learned by this simple and easy trick:

TIER

T - ***TV (Tidal Volume)***

I - ***IRV (Inspiratory Reserve Volume)***

E - ***ERV (Expiratory Reserve Volume)***

R - ***RV (Residual Volume)***

Always remember,

TV + IRV = IC (Inspiratory Capacity)

ERV + RV = FRC (Functional Residual Capacity)

TV + ERV = EC (Expiratory Capacity)

ERV + TV + IRV = VC (Vital Capacity)

RV + ERV + TV + IRV = TLC (Total Lung Capacity)

9. (B) Intrapulmonary pressure is lower than the atmospheric pressure during inspiration. Due to this low pressure, air rushes into the lungs. Inspiration occurs due to external intercostal muscles, while expiration occurs due to internal intercostal muscles. Expiration occurs when atmospheric pressure is less than intrapulmonary pressure. Inspiration is initiated due to contraction of diaphragm, while expiration is initiated due to relaxation of diaphragm.

10. (B) Vital Capacity (VC) is the maximum volume of air a person can breathe in after a forced expiration. It is equal to the sum of inspiratory reserve volume, tidal volume, and expiratory reserve volume with an average value of 4800 mL.

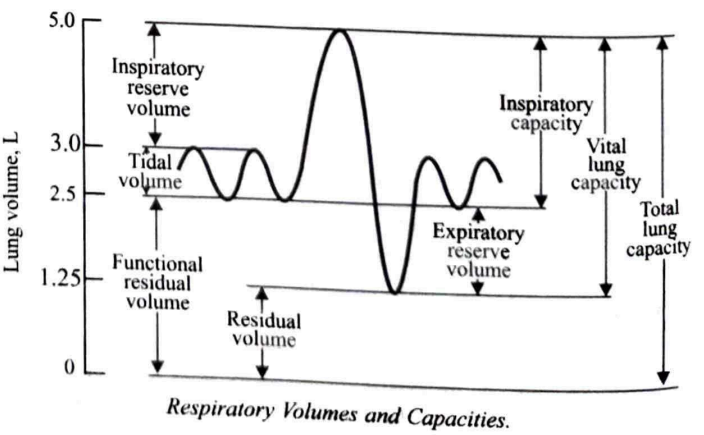
11. (B) Tidal Volume (TV) is the amount of air that moves in or out of the lungs with each normal or resting respiratory cycle. It is about 500-550 mL. Inspiratory Reserve Volume (IRV) is the amount of air that can be forcibly inhaled after a normal tidal volume. It is about 2500-3000 mL. Expiratory Reserve Volume (ERV) is the amount of air that can be forcibly exhaled beyond a tidal exhalation. It is about 1000-1100 mL. Residual Volume (RV) is the volume of air remaining in the lungs even after a forcible expiration. This averages 1100 mL to 1200 mL.

12. (A) In lungs, even after the most forceful expiration, some of the volume of air remains. This volume is termed as Residual Volume (RV). Due to this, lungs do not collapse even after the most forceful expiration. RV is about 1100 mL to 1200 mL.

13. (D) Vital Capacity (VC) is the maximum amount of air a person can expel from the lungs after a maximum inhalation. It is equal to the sum of inspiratory reserve volume, tidal volume, and expiratory reserve volume or total lung capacity minus residual volume.

Vital Capacity = IRV + ERV + TV = TLC - RV

Related Theory



Respiratory Volumes and Capacities.

14. (B) Residual air is the air that remains in the lungs after the most forceful expiration. It is about 1200 mL. As the residual air remains in the lungs, it has no effect on respiration efficiency.

15. (A) The amount of air that remains in the lungs after a forceful expiration is referred to as residual volume. It holds approximately 1500 mL. It allows the lungs to continue gaseous exchange even after complete exhalation or holding one's breath. On the other hand, Inspiratory Reserve Volume (IRV) is the additional volume of air, a person can inspire by a forcible inspiration. This averages 2500 mL to 3000 mL. Vital Capacity (VC) is the maximum volume of air a person can breathe in after a forced expiration. Tidal Volume (TV) is the volume of air inspired or expired during a normal respiration. It is approximately 500 mL.

16. (D) The ventilation movements of the lungs that facilitate respiration are caused by the relaxation and contraction of the diaphragm and the movement of the costal muscles present in an individual's thorax.

The method is as follows:

During inspiration: Contraction of diaphragm occurs, which increases the volume of thoracic chamber in the antero-posterior axis. Due to this, contraction of external intercostal muscles takes place, which lifts up the ribs and the sternum causing an increase in the volume of the thoracic chamber in the dorso-ventral axis. The overall increase in the thoracic volume causes a similar increase in pulmonary volume.

During expiration: The sternum and diaphragm return to their usual places when the intercostal muscles and diaphragm are relaxed, which also lowers the thoracic volume and, consequently, the pulmonary volume.

17. (A) Partial pressure of oxygen pO_2 = 104 mm Hg and partical pressure of carbon dioxide pCO_2 = 40 mm Hg is observed in human lung alveoli.

Related Theory

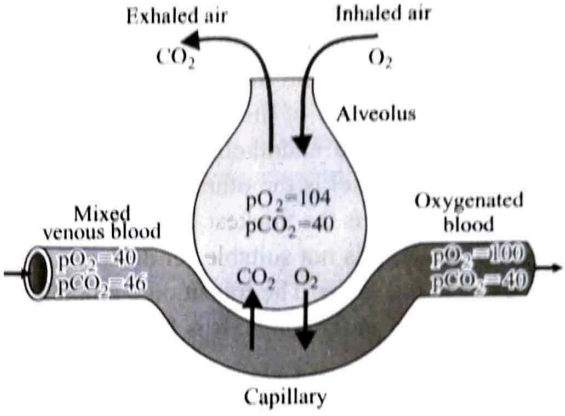
Partial pressures (in mm Hg) of oxygen and carbon dioxide in different parts involved in diffusion in comparison to those in atmosphere:

Respiratory gas	O_2	CO_2
Atmospheric air	159	0.3
Alveoli	104	40
Blood (deoxygenated)	40	45
Blood (oxygenated)	95	40
Tissues	40	45

18. (B) The partial pressure of oxygen in alveoli (104 mm Hg) is higher than the deoxygenated blood (40 mm Hg) as well as oxygenated blood (95 mm Hg). This difference is required to allow passive diffusion of oxygen into the blood stream in the lungs. If the pO_2 is equal in alveoli and blood, then there would be no net diffusion of gases. If the pO_2 is less in alveoli than in blood, then the oxygen would diffuse from blood to alveoli. In alveoli, pO_2 is greater than pCO_2 and in the blood surrounding the alveoli, pO_2 is lesser than pCO_2.

Related Theory

Internal respiration occurs as simple diffusion due to a partial pressure gradient. However, the partial pressure gradients are opposite of those present at the respiratory membrane. The partial pressure of oxygen in tissues is low, about 40 mm Hg, because oxygen is continuously used for cellular respiration. In contrast, the partial pressure of oxygen in the blood is about 100 mm Hg. This creates a pressure gradient that causes oxygen to dissociate from haemoglobin, diffuse out of the blood, cross the interstitial space, and enter the tissue.



Alveolus Gas Exchange

19. (A) The alveoli are tiny air sacs located at the end of the respiratory bronchioles in the lungs. They are the primary sites of gas exchange in the respiratory system. Oxygen from the inhaled air diffuses across the thin walls of the alveoli into the surrounding capillaries, where it binds to red blood cells and is transported to the body's tissues. At the same time, carbon dioxide, a waste product produced by cellular metabolism, diffuses out of the capillaries into the alveoli to be exhaled from the body.

20. (A) The movement of solutes (gas or ions) from a high concentration area to a low concentration area is referred to as simple or passive diffusion. Gases diffuse across the systemic capillary membrane and the target tissue's cell membranes. Oxygen diffuses from lungs to systemic tissues, and carbon dioxide diffuses from systemic tissues to lungs. It is due to the partial pressure difference in respiratory gases. The partial pressure of oxygen in the alveoli is higher (104 mm Hg) than in deoxygenated blood (40 mm Hg), causing oxygen diffusion from the alveoli to the blood. The partial pressure of carbon dioxide in alveoli (40 mm Hg) is lower than in blood from tissues (45 mm Hg), resulting in the release of CO_2 in alveoli.

Related Theory

- *Osmosis is a passive process that occurs without the use of any energy. It involves movement of molecules from a higher concentration region to a lower concentration region until concentrations on both sides of the membrane are equal.*
- *Active transport is a biological process in which molecules move against the concentration gradient and require chemical energy to transport biochemical compounds from one region to another.*
- *Passive transport is a biological process in which molecules are transported from a higher concentration region to a lower concentration region without the use of energy.*

21. (B) The alveolar wall is very thin and has a dense network of blood capillaries. Squamous epithelium, epithelial basement membrane, a thin interstitial space, capillary basement membrane, and capillary endothelium make up the majority of the alveolar capillary membrane. In the lungs, two layers separate the air from the blood. The squamous layer of the epithelium of the alveolar walls of the lungs is one, and the endothelium lining (innermost) of the blood vessel is the other. On the other hand, the tunica media is the thickest layer of the arterial wall, and hence, it is not suitable for diffusion. It does not exist in the lungs. The transitional epithelium is also not present in the lungs. It is found in the kidneys.

22. (C) About 20-25% of CO_2 is transported as carbamino-haemoglobin, which forms when haemoglobin binds to CO_2. This binding occurs in tissues with high pCO_2 and low pO_2, facilitating CO_2 transport from tissues to the lungs for exhalation.

23. (A) In the alveoli, high pO_2, low pCO_2, lesser H^+ concentration, and lower temperature, are all favourable factors for the formation of oxyhaemoglobin.

24. (A) There are two ways in which oxygen gets transported. In the first way, red blood cells (RBCs) transport approximately 97 percent of oxygen, while in the second way; blood plasma transports the remaining 3 percent. The partial pressure of oxygen in the alveoli is the highest. In the alveoli, oxygen binds with haemoglobin to form oxyhaemoglobin. This is known as oxygenation of haemoglobin. However, in tissues, the partial pressure of oxygen is low and the partial pressure of carbon dioxide is high. As a result, oxyhaemoglobin dissociates in tissues, releasing oxygen. As a result, 100 mL of oxygenated blood will deliver approximately 5 mL of oxygen to the tissues.

Caution

- *Students should always remember that every 100 mL of deoxygenated blood delivers approximately 4 mL of CO_2 to the alveoli.*

25. (A) In the alveoli, the factors favourable for the formation of oxyhaemoglobin are high pO_2, low pCO_2 and lesser H^+ concentration and lower temperature.

Related Theory

- *In the tissues, where low pO_2, high pCO_2, high H^+ concentration and higher temperature exist, the conditions are favourable for dissociation of oxygen from the oxyhaemoglobin.*

26. (B) In alveoli, high pO_2, low pCO_2, low H^+ concentration and lower temperature are the factors that favours the formation of oxyhaemoglobin.

Related Theory

- *Oxygen is carried in the blood bound to haemoglobin and dissolved in plasma (and intracellular fluid). Once oxygen has diffused across the alveolar membrane, it binds reversibly to haemoglobin within the pulmonary capillaries in a cooperative manner forming oxyhaemoglobin. One haemoglobin molecule can carry four molecules of oxygen.*

Caution

- *To avoid confusion, students should remember that with high amount of CO_2, pH decreases or H^+ ions increases. The reverse goes for oxygen.*

27. (A) Carbon dioxide molecules can be transported in the blood from body tissues to the lungs by any one of the three methods: in dissolved form through plasma, binding to haemoglobin, or carried as a bicarbonate ion. About 5 to 7 percent of all carbon dioxide is dissolved in the plasma. Nearly 20-25% of carbon dioxide is carried by haemoglobin as carbamino-haemoglobin. The majority of carbon dioxide molecules (about 70 percent) are carried as part of the bicarbonate buffer system. In this system, carbon dioxide diffuses into the red blood cells.

Related Theory

- *The partial pressure of carbon dioxide is high in the tissues where more binding of carbon dioxide occurs. In the alveoli where the partial pressure of oxygen is high, carbon dioxide gets dissociated from carbamino-haemoglobin. The enzyme carbonic anhydrase present in a high concentration in RBCs, and in small quantities in the plasma, facilitates this reaction in both the directions. So, the bicarbonate formed at the tissues releases carbon dioxide at the alveoli.*

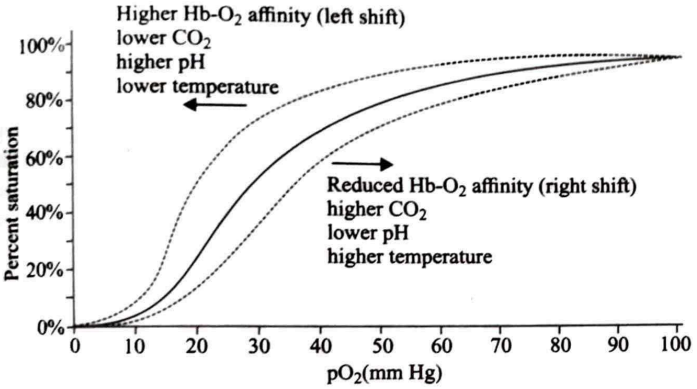
$$CO_2 + H_2O \underset{}{\overset{\text{Carbonic anhydrase}}{\rightleftharpoons}} H_2CO_3 \overset{\text{Carbonic anhydrase}}{\rightleftharpoons} H^+ + HCO_3^-$$

28. (D) While under strenuous conditions or during exercise, the muscle cells needs more oxygen, this demand of the muscle cells is fulfilled by the oxygen, which is left unused in the human blood. During exercise, the partial pressure of O_2 in the tissue falls, as a result of which, the oxygen concentration of blood at the tissue level is reduced to 4.4 mL of oxygen/100 mL of blood. Thus, approximately 15 mL of oxygen is transported to tissues by 100 mL of blood during muscular exercise.

29. (A) About 97 percent of O_2 is transported by RBCs in the blood. The remaining 3 percent of O_2 is carried in dissolved state through the plasma. Nearly 20-25 percent of CO_2 is transported by RBCs, whereas, 70 percent of it is carried as bicarbonates. About 7 percent of CO_2 is carried in a dissolved state through the plasma.

Related Theory

The oxygen dissociation curve demonstrates that, as the partial pressure of oxygen increases, more oxygen binds haemoglobin. However, the affinity of haemoglobin for oxygen may shift to the left or the right depending on environmental conditions.



30. (D) When CO_2 concentration in blood increases, breathing becomes faster and deeper. The effect of increased CO_2 is to decrease the affinity of haemoglobin for O_2. Thus, due to Bohr's effect the CO_2 released in respiring tissue accelerates the delivery of oxygen through faster and deeper breathing.

31. (A) During the transport of CO_2 through the bloodstream, bicarbonate ions diffuse out of RBCs while chloride ions from plasma enter the RBCs, to maintain ionic equilibrium. This is called chloride shift or Hamburger shift.

32. (B) Haemoglobin is a pigment that is involved in the respiratory process. It has a red colour and is found in human blood. It enhances the blood's oxygen-carrying capacity.

Related Theory

Haemoglobin (Hb) is a conjugated protein. It is made up of a basic protein called globin and a non-protein group called heme. Heme is an iron-porphyrin ring. A mammalian Hb molecule is made up of four heme molecules linked together with four globin molecules. It is found in RBC and transports O_2 from the lungs to the tissues as well as CO_2 from the tissues to the lungs.

33. (D) Both RBCs and plasma transport O_2 and CO_2 either in chemically bonded state or in dissolved state. Here, blood serves as the medium of transport for O_2 and CO_2. RBCs in the blood transport approximately 97% of the oxygen. The remaining 3% of O_2 is carried in dissolved form through the plasma. RBCs transport roughly 20-25% of CO_2, while 70 percent of it is carried as bicarbonate. Approximately 7% of CO_2 is carried in a dissolved state through plasma.

34. (B) Despite the fact that blood contains a lot of CO_2, it does not become acidic due to the buffering action of blood. Bicarbonate is the primary buffer found in the body. Bicarbonate exists in equilibrium with carbonic acid, which can be converted to CO_2 and water.

$$H_2O + CO_2 \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

Related Theory

Buffers are solutions that can withstand pH changes even when an acid or a base is added. They have a specific pH level. Even after diluting the solution, the pH value remains constant. The pH value cannot be changed by adding a strong acid or a base.

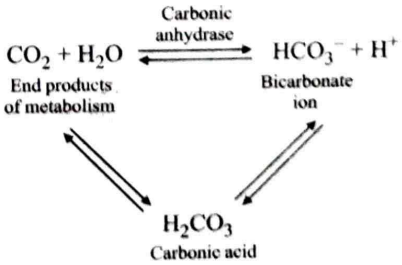
35. (A) Oxygen dissociation curve shows the relationship between oxygen saturation of haemoglobin across a range of oxygen pressures. The oxygen dissociation curve for adult haemoglobin is sigmoidal (*i.e.*, S-shaped) due to cooperative binding.

Related Theory

The oxygen–haemoglobin dissociation curve is also called the oxyhaemoglobin dissociation curve or oxygen dissociation curve (ODC). This curve plots the proportion of haemoglobin in its saturated (oxygen-laden) form on the vertical axis against the prevailing oxygen tension on the horizontal axis.

36. (A) Carbon dioxide is transported from tissues to respiratory surface by only plasma and erythrocytes. The transportation of carbon dioxide (CO_2) is much easier than oxygen due to its high solubility in water. 7% of CO_2 is transported as dissolved state in plasma, nearly 20-25% is transported as carbamino-haemoglobin and 70% is transported as bicarbonate ion (HCO_3^-).

37. (C) Carbonic anhydrase is an enzyme found in red blood cells, gastric mucosa, pancreatic cells, and renal tubules that catalyses the interconversion of CO_2 and carbonic acid (H_2CO_3). Carbonic anhydrase contributes to respiration by influencing CO_2 transport in the blood.



Carbonic anhydrase enzyme catalyses the conversion of carbon dioxide and water to carbonic acid dissociated ions. This results in the formation

of bicarbonate anions, which dissolve in the blood plasma. In the lungs, the catalysed reaction is reversed, resulting in the formation of CO_2, which is then exhaled.

38. (B) Pneumotaxic centre is present in pons region of brain. O_2 dissociation curve is useful in studying the effects of factors, like pCO_2, H^+ concentration, on binding of oxygen with haemoglobin. Carbonic anhydrase enzyme is present on the surface of RBCs. Primary site of gaseous exchange is alveoli.

39. (B) When we hold our breath, the level of carbon dioxide increases in lungs and blood, triggering the respiratory centre of the brain giving feedback to urge to breathe.

Related Theory

During respiration, oxygen is carried by haemoglobin of the red blood cells. Haemoglobin has a great affinity for oxygen. Each haemoglobin molecule binds to four molecules of oxygen. However, carbon dioxide is more soluble in water than oxygen. So, some of it is transported in the dissolved form in our blood. Some carbon dioxide is also transported by haemoglobin.

40. (B) The medulla oblongata (lowest part of the brain) is the primary respiration control center. The main function of medulla is to send signals to the muscles that control respiration to cause breathing to occur.

41. (C) Asthma is the inflammation of bronchioles, while emphysema is an inflation or abnormal distension of bronchioles or alveolar sacs of the lungs, leading to a decrease in the respiratory surface.

Related Theory

During asthma attack, the muscles surrounding the airways become tight and there is decrease in passage of air through it, causing the airways of lungs to swell and narrow. There are certain substances, which can trigger asthma attack known as allergens like pollen, dust, animal hair, etc. On the other hand, emphysema is caused due to the damage in the air sacs of lungs. The main cause is cigarette smoking.

42. (B) Silicosis is an occupational respiratory disorder, due to the excessive inhalation of silica dust. Botulism is food poisoning caused by bacteria *Clostridium botulinum*. Anthracis or anthrax is a bacterial infection caused by *Bacillus anthracis*. Emphysema is a lung disease, caused by the damage of air sacs.

Related Theory

Among the occupational diseases, silicosis is the major cause of permanent disability and mortality. It is caused by inhalation of dust containing free silica or silicon dioxide (SiO_2). It includes mining industry, pottery and ceramic industry, etc. Particles between 0.5 to 3 microns are the most dangerous because they reach the lungs with ease.

43. (A) Allergy is the hypersensitivity of the body against foreign particles. During an allergic response, allergen stimulates B-cells to produce IgE and activates mast cells to release histamine, cytokines, heparin, and many proteases, which lead to characteristic symptoms of allergy. Asthma is the allergic reaction in the lungs. Inflammation, accumulation of fluid, *etc.* are due to the bacterial infection.

Related Theory

Allergens elicit the formation of IgE antibodies, which attach to the surface of mast cells or basophils. In human, mast cells are found in the lungs, in upper respiratory tract, in the skin and in the intestinal tract. This binding interaction triggers the rapid release of tissue mediators mainly histamine from granules secreted by the mast cells. Histamines and other chemicals show up the symptoms of allergic diseases. Histamine causes vasodilation and increase capillary permeability, ensuing oedema. It also contracts the smooth muscles and stimulates the exocrine glands and swells the membranes, and produces thick mucus leading to congestion, making breathing more strenuous.

44. (C) Workers in grinding and stone-breaking industries may suffer from lung fibrosis. Exposure to environmental pollutants, like silica, metal dusts, bacteria and animal proteins can lead to lung fibrosis. On the other hand, cigarette smoking causes an immunogenic response, which results in increased levels of inflammatory markers and cause development of irreversible narrowing of bronchial tubes due to inflammation and scarring. It causes cancer, chronic lung disease. The pneumotaxic centre in the pons region of the brainstem moderate the functions of the respiratory rhythm centre. It reduces the duration of inspiration and therefore, alters the respiratory rate. Carbon dioxide is carried in blood as bicarbonate, dissolved CO_2 and carbamino-haemoglobin. About 20-25% of it is carried as carbamino-haemoglobin.

45. (D) Carboxyhaemoglobin (CO-Hb) is a stable complex of carbon monoxide that forms in red blood cells when carbon monoxide is inhaled. CO-Hb is also useful in monitoring the treatment of carbon monoxide poisoning. Carbamino-haemoglobin is a compound of haemoglobin and carbon dioxide, and is one of the forms in which carbon dioxide exists in the blood.

Related Theory

Acute carbon monoxide (CO) poisoning has a number of characteristics at autopsy. A high concentration of carboxyhaemoglobin (CO-Hb) is detected in the blood. The most striking appearance of the body is the cherry-pink colour of post-mortem lividity (skin colour after 12 hrs of death).