NCERT Exemplar Solutions of Class 11 Biology – Chapter 17: Breathing and Exchange of Gases

VERY SHORT ANSWER TYPE QUESTIONS

1. Define the following terms?

a. Tidal volume b. Residual volume c. Asthma

Solution:

a. Tidal Volume (TV): Volume of air inhaled and exhaled during a normal breathing cycle without any forced breathing. Normal value ≈ **500 mL**.

b. Residual Volume (RV): Volume of air left in the lungs even after forced exhalation. Cannot be expelled voluntarily. Normal value ≈ **1200 mL**. Prevents alveolar collapse and maintains gas exchange between breaths.

c. Asthma: An inflammatory disease of the airways of the lungs characterized by:

- Bronchospasm (muscle contraction around airways)
- Excessive mucus production
- Airway inflammation and swelling
- Difficulty in breathing, wheezing, and coughing
- Often triggered by allergens, exercise, or stress

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

Solution: The fluid-filled double membranous layer surrounding the lungs is called **Pleura**.

Structure:

- **Visceral pleura** - Inner layer attached to lung surface
- **Parietal pleura** - Outer layer lining the chest cavity
- **Pleural cavity** - Space between layers containing pleural fluid

Important Functions:

- **Reduces friction** during respiratory movements
- **Maintains negative pressure** for lung expansion
- **Provides lubrication** between lung and chest wall surfaces
- **Facilitates smooth sliding** of lungs during breathing

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

Solution: The primary site of exchange of gases in our body is **Alveoli**.

Enhanced Details:

- **Structure**: Thin-walled, grape-like air sacs at the end of respiratory bronchioles
- **Number**: Approximately 300-500 million alveoli in adult lungs
- **Surface area**: ~70 m^2 for gas exchange
- **Wall thickness**: 0.5 micrometers for efficient diffusion
- **Blood supply**: Extensive capillary network surrounding each alveolus

4. Cigarette smoking causes emphysema. Give reason.

Solution: Excessive cigarette smoking leads to emphysema due to the presence of various harmful chemicals like **nicotine, tar, carbon monoxide, and free radicals**. These chemicals cause:

Mechanism:

- **Chronic inflammation** of alveolar walls
- **Destruction of elastic fibers** in lung tissue
- **Breakdown of alveolar septa** (walls between air sacs)
- **Loss of lung elasticity** and recoil capacity
- **Reduced surface area** for gas exchange
- **Formation of large air spaces** (bullae) from merged damaged alveoli

Result: Impaired gas exchange and breathing difficulties.

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

Solution: The amount of O_2 supplied to tissues through every 100 mL of oxygenated blood under normal physiological conditions is around **5 mL**.

Enhanced Explanation:

- **Total O_2 carrying capacity**: ~20 mL O_2/100 mL blood
- **Arterial blood O_2 content**: ~19-20 mL O_2/100 mL blood
- **Venous blood O_2 content**: ~15 mL O_2/100 mL blood
- **Arteriovenous O_2 difference**: 20-15 = **5 mL O_2/100 mL blood**
- This represents the **oxygen extraction** by tissues during one circulation cycle

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

Solution: The remaining **3% of O_2** is transported **dissolved in blood plasma**.

Enhanced Explanation: Oxygen Transport Mechanisms:

- **97% as Oxyhemoglobin** - Bound to hemoglobin in RBCs
- **3% dissolved in plasma** - Physical dissolution following Henry's Law

Factors affecting plasma O_2:

- **Partial pressure of O_2** in blood
- **Solubility coefficient** of O_2 in plasma
- **Temperature** and **pH** of blood
- Normal dissolved O_2 ≈ **0.3 mL/100 mL blood**

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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 Reserve Volume (ERV)

Solution: Ascending order: Tidal Volume (TV) < Residual Volume (RV) < Expiratory Reserve Volume (ERV) < Inspiratory Reserve Volume (IRV)

Normal Values:

- **TV** ≈ 500 mL
- **RV** ≈ 1200 mL
- **ERV** ≈ 1200 mL
- **IRV** ≈ 3100 mL

Note: RV and ERV have similar values, but IRV is significantly larger.

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8. Complete the missing terms

a. Inspiratory Capacity (IC) = _____ + IRV b. _____ = TV + ERV c. Functional Residual Capacity (FRC) = ERV + ____

Solution: a. Inspiratory Capacity (IC) = TV + IRV b. Expiratory Capacity (EC) = TV + ERV c. Functional Residual Capacity (FRC) = ERV + RV

Enhanced Relationships:

- **IC** = Maximum inhalable air = TV + IRV ≈ 3600 mL
- **EC** = Maximum exhalable air from resting position = TV + ERV ≈ 1700 mL
- **FRC** = Air remaining after normal expiration = ERV + RV ≈ 2400 mL
- **VC** = Maximum exchangeable air = TV + IRV + ERV ≈ 4800 mL
- **TLC** = Total lung air = VC + RV ≈ 6000 mL

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

a. Flatworm – _____ **b. Birds –** _____ **c. Frog –** _____ **d. Cockroach –** _____

Solution: a. Flatworm – Surface of the body (cutaneous respiration) **b. Birds – Lungs with air sacs** (highly efficient respiratory system) **c. Frog – Lungs and moist skin** (dual respiratory system) **d. Cockroach – Tracheal system** (network of air tubes)

Enhanced Details:

- **Flatworm**: Direct diffusion through thin body wall
- **Birds**: Lungs connected to air sacs for unidirectional airflow
- **Frog**: Skin respiration in water, lung respiration on land
- **Cockroach**: Spiracles → Trachea → Tracheoles → Direct cellular gas exchange

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

Solution: Important parts:

1. **Diaphragm** - Primary respiratory muscle
2. **External intercostal muscles** of the ribs

3. **Internal intercostal muscles** of the ribs

Enhanced Mechanism: Inspiration:

- **Diaphragm contracts** → moves downward → increases thoracic volume
- **External intercostals contract** → lift ribs upward and outward → expands chest cavity
- **Thoracic volume increases** → **intrapulmonary pressure decreases** → air flows in

Expiration:

- **Diaphragm relaxes** → moves upward → decreases thoracic volume
- **Intercostals relax** → ribs move downward and inward → compresses chest cavity
- **Thoracic volume decreases** → **intrapulmonary pressure increases** → air flows out

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SHORT ANSWER TYPE QUESTIONS

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

Solution: CO_2 is transported in blood through **three main mechanisms:**

1. As Bicarbonate Ions (70%)

- $CO_2 + H_2O \rightarrow H_2CO_3$ (carbonic acid) [catalyzed by carbonic anhydrase in RBCs]
- $H_2CO_3 \rightarrow H^+ + HCO_3^-$ (bicarbonate ions)
- HCO_3^- moves to plasma, Cl^- moves into RBCs (Chloride shift)
- Most significant transport mechanism

2. As Carbaminohaemoglobin (23%)

- CO_2 binds directly to amino groups of hemoglobin
- Forms carbaminohaemoglobin ($HbCO_2$)
- Does not compete with O_2 binding sites
- Important in venous blood

3. Dissolved in Plasma (7%)

- Physical dissolution in blood plasma
- Follows Henry's Law of gas solubility
- Least significant quantitatively but immediately available

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

Solution: CO_2 has a **much higher diffusion rate** than O_2 through the respiratory membrane due to:

Primary Reason: Higher Solubility

- **CO_2 solubility** in water/plasma is **~24 times higher** than O_2
- **Henry's Law**: Gas diffusion rate ∝ solubility coefficient
- CO_2 readily dissolves in the aqueous layer of the respiratory membrane

Additional Factors:

- **Molecular size**: CO_2 and O_2 have similar molecular weights
- **Membrane thickness**: Same barrier for both gases (0.5 μm)
- **Surface area**: Same alveolar-capillary interface

Physiological Significance:

- Ensures efficient CO_2 elimination despite lower pressure gradients
- CO_2 pressure gradient: ~5 mmHg (45 → 40 mmHg)
- O_2 pressure gradient: ~64 mmHg (104 → 40 mmHg)
- Higher solubility compensates for lower driving pressure

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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

Solution: Correct sequence of respiratory process:

1. Pulmonary ventilation by which atmospheric air is drawn in and CO_2 rich alveolar air is released out **2. Diffusion of gases (O_2 and CO_2)** across alveolar membrane **3. Transport of gases by blood 4. Diffusion of O_2 and CO_2** between blood and tissues **5. Utilisation of O_2** by the cells for catabolic reactions and resultant release of CO_2

Enhanced Process Flow:

- **Breathing → External Respiration → Gas Transport → Internal Respiration → Cellular Respiration**
- This cycle ensures continuous oxygen supply and CO_2 removal from body tissues

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4. Differentiate between

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

Solution:

a. Inspiratory vs Expiratory Reserve Volume:

Parameter	Inspiratory Reserve Volume (IRV)	Expiratory Reserve Volume (ERV)
Definition	Maximum air inhaled after normal inspiration	Maximum air exhaled after normal expiration
Volume	~3100 mL	~1200 mL
Mechanism	Active contraction of accessory muscles	Active contraction of expiratory muscles
Function	Provides extra O_2 during increased demand	Helps expel extra CO_2 when needed

b. Vital Capacity vs Total Lung Capacity:

Parameter	Vital Capacity (VC)	Total Lung Capacity (TLC)
Definition	Maximum air exhaled after maximum inspiration	Total air in lungs after maximum inspiration
Components	TV + IRV + ERV	VC + RV
Volume	~4800 mL	~6000 mL
Measurement	Measurable by spirometer	Cannot be directly measured (includes RV)

c. Emphysema vs Occupational Respiratory Disorder:

Parameter	Emphysema	Occupational Respiratory Disorder
Location	Alveolar walls damaged	Upper lung fibrous tissue proliferation
Cause	Smoking, air pollution	Occupational exposure (asbestos, silica, coal dust)
Pathology	Elastic fiber destruction, alveolar wall breakdown	Fibrotic changes, scarring of lung tissue
Examples	Chronic smoking-related	Pneumoconiosis, asbestosis, silicosis
Progression	Gradual loss of lung elasticity	Progressive fibrosis and reduced lung compliance