UNIT 10 Respiration

THEORY Section

Question 1

(a) Fig. 4.1 shows the front view of a person's rib cage.

Fig. 4.1

On Fig. 4.1,

(i) draw a label line to show the position occupied by the intercostal muscles; [1]

(ii) draw in the diaphragm as it appears after breathing out. [1]

(b) The apparatus shown in Fig. 4.2 can be used to illustrate the action of breathing.

Fig. 4.2

(i) Describe and explain what would happen to the balloons if the rubber sheet is pulled down. [2]

(ii) Suggest how Fig. 4.2 is not an accurate model to show the action of breathing. [3]

[D01/P2/Q4]
Solution

(a)

(b) (i) The size of the balloons increase. When the rubber sheet is pulled down the volume of the space in the bell jar increases causing a drop in the air pressure. The atmospheric pressure is now higher than the air pressure inside the bell jar and causes the air outside to be sucked into the balloons through the tube.

(ii) The model cannot demonstrate the enlargement of the thoracic cavity as the walls of the bell jar is hard and rigid. The movement of the ribs during breathing also cannot be shown in the model.

During inhalation, the ribs swing upwards and outwards to increase the volume of the thoracic cavity. The model does not have any parts that stimulate the contraction and relaxation of the intercostal muscles of the ribs which cause the movements of the rib cage.

COMMENT on ANSWER

(b) ii) Focus on the limitations of the model to show the action of breathing only.

Question 2

State

(i) the similarities, and

(ii) the differences between aerobic and anaerobic respiration. [5]

Solution

(i) Both aerobic and anaerobic respiration releases energy which is essential for vital body activities and processes. Both involve the breakdown of food substances to release energy.

(ii) Aerobic respiration is the oxidation of food substances to release energy. Full oxidation of food takes place in the presence of oxygen. Anaerobic respiration is the breakdown of food substances in the absence of oxygen to release a small amount of energy. A large amount of energy is produced in aerobic respiration compared to anaerobic respiration, therefore, aerobic respiration is more efficient. The by-products of aerobic respiration are carbon dioxide and water whereas the by-products of anaerobic respiration are ethanol and carbon dioxide.
**Question 3**

Fig. 1.1 shows some cells from the lining of a human trachea.

(a) (i) On Fig. 1.1, label P, Q and R.

(ii) Name the structures found in R.

(iii) Identify W and X.

(iv) Describe the functions of W and X.

Smoking has a direct effect on W and X.

(b) (i) Name three harmful chemicals found in cigarette smoke.

(ii) Describe the effects that these, and other substances present in cigarette smoke, may have on W and X, and also on other parts of the respiratory system.

**Solution**

(a) (i) P: cell membrane

Q: cell cytoplasm

R: nucleus

(ii) chromosomes

(iii) W: cilia

X: mucus

(iv) W: The rhythmic beating of the cilia helps to sweep mucus up the trachea into the back of the mouth where they are swallowed.

X: The mucus trap dust and germs from air inhaled from the atmosphere.

(b) (i) 1. Nicotine

2. Tar

3. Carbon monoxide

**COMMENT ON QUESTION**

(a) The diagram shows the two types of cell lining the wall of the trachea: ciliated cells and goblet cells. The goblet cells are found between the ciliated cells.

(b) i) The nucleus contains chromosomes which are made of DNA (deoxyribonucleic acids) that carry hereditary information.

ii) The microscopic hair-like structures are called cilia. The goblet cell secretes mucus.

iii) There are more than 4000 chemicals in cigarette smoke. Besides tar, nicotine and carbon monoxide, other irritants such as carbon particles, hydrogen cyanide and carcinogens are also present.
(ii) Effect on W and X: These chemicals paralyses the cilia lining the air passages causing the flow of mucus from the lungs to the pharynx to stop. They cause narrowing of air passages and stimulate excessive secretion of mucous. The air passages become inflamed and clogged with mucus resulting in smoker’s cough and chronic bronchitis.

Effect on other parts of the respiratory system: Tar contains cancer causing chemicals which deposits in the alveoli of the lungs and causes lung cancer. It also causes chronic bronchitis, emphysema and lung cancer.

**Question 4**

Fig. 1.1 shows the volume of air in the lungs of a person measured over a period of time.

![Graph showing volume of air in lungs over time](image)

**Fig. 1.1**

(a) (i) With reference to Fig. 1.1, calculate, in breaths per minute, the rate of normal breathing between A and B.

(ii) State the volume of air remaining in the lungs after the deep breath out.

(iii) Explain how the intercostal muscles are involved in breathing from time B to time C.

At time D, the person performed one minute of vigorous exercise.

(b) (i) On Fig. 1.1, starting at time E, continue the graph to show the person’s breathing pattern after this exercise.

(ii) Explain why the breathing pattern changes after a period of exercise.

**Solution**

(a) (i) Since 3 breaths were taken in 12 seconds, the number of breaths per minute (60 seconds) = \( \frac{3}{12} \times 60 = 15 \) breaths

(ii) 1500 cm³
(iii) When a deep breath is taken the external intercostal muscles contract to its fullest extent and the internal intercostal muscles relax. This causes the ribcage to move upwards and outwards more forcefully and the volume of the chest cavity increases to a maximum.

(ii) Both the rate and depth of breathing increase during vigorous exercise. During vigorous exercise more glucose is oxidised to release more energy for rapid muscle contractions. The increase in carbon dioxide levels in the blood stimulates the breathing centre in the medulla oblongata of the brain. More nerve impulses are sent to the intercostal muscles and diaphragm to increase the rate and depth of breathing to remove carbon dioxide more rapidly. The rate and depth of breathing continue to be high in the recovery period after the exercise. Breathing rate gradually returns to normal as the concentration of carbon dioxide in the blood returns to normal.

**Question 5**

Figure 10.1 shows structures associated with breathing and gaseous exchange.

Describe the roles of the labelled structures A to G, from the moment air enters the nose until the time oxygen leaves the lungs in the blood. In your answer, you should clearly identify each of the labelled structures. [12]
Solution

A — Diaphragm muscles
B — External intercostal muscle
C — Trachea
D — Thin film of moisture (water)
E — Thin membrane of alveolus
F — Capillary wall
G — Red blood cell

The diaphragm is a sheet of muscular tissue with its circumference attached to the wall of the thoracic cavity. During inspiration, the diaphragm contracts and flattens. The external intercostal muscles between ribs contract causing the rib cage move upwards and outwards. The volume of the chest cavity increases and air pressure inside chest cavity and lungs decreases. The atmospheric pressure drives air through the nose into trachea and finally into the lungs.

The trachea is a windpipe supported by C-shaped cartilage which allows the free passage of air to the lungs via the bronchi. It is lined with ciliated mucous membrane which helps to remove dust and bacteria from air.

The oxygen from the air in the lungs dissolves in the thin film of moisture on the cells lining the alveolus. The oxygen then diffuses across the thin alveolus wall and through the wall of the capillary into the blood plasma. The oxygen in the plasma diffuses into the red blood cells and combines with haemoglobin to form oxyhaemoglobin.

The thin, one cell thick walls of the alveoli and capillaries allow rapid diffusion of oxygen into the blood. The numerous alveoli in the lungs and the dense capillary network arounding the alveoli provide a very large surface area for rapid and efficient diffusion of oxygen into the blood.

Question 6

Fig. 10.1 shows a family running some risks to their health.

Identify as many risks as you can and, for each risk identified, explain its possible harmful effects.
## Solution

<table>
<thead>
<tr>
<th>Risk</th>
<th>Risk factors</th>
<th>Possible harmful effects on human body</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Increase risk of suffering from constipation and colon (large intestine) cancer</td>
<td>Poor diet and eating habits. Lack of dietary fibre in diet as no vegetables or fruits are included in meal prepared.</td>
<td>Poor peristaltic movements along alimentary canal. Toxins and poisonous substances are not absorbed by dietary fibres and egested.</td>
</tr>
<tr>
<td>2. Increase risk of high blood pressure and coronary heart disease.</td>
<td>(a) Poor diet and eating habits. Excessive consumption of food rich in saturated fats (animal fat) such as egg yolks, butter, cheese, fatty meat such as sausages.</td>
<td>Coronary heart disease is caused by the deposition of fats, particularly cholesterol, in the arteries leading to the heart. This can cause in a blockage in the coronary artery resulting in a heart attack.</td>
</tr>
<tr>
<td></td>
<td>(b) Lack of exercise leading to overweight of the father.</td>
<td>nicotine in cigarette smoke increases the heart rate by increasing secretion of hormone adrenaline and constricts blood vessels increasing blood pressure.</td>
</tr>
<tr>
<td></td>
<td>(c) Smoking excessively—Both mainstream cigarette smoke or passive smoking.</td>
<td>Carbon monoxide in cigarette smoke increases the rate of deposition of cholesterol and decrease oxygen supply to heart.</td>
</tr>
<tr>
<td>3. Increase risk of miscarriage, stillbirth and infant death for the pregnant mother.</td>
<td>Pregnant mother smoking</td>
<td>nicotine in cigarette smoke constricts blood vessels in the placenta reducing the blood supply to the foetus. Carbon monoxide present in cigarette smoke combines irreversibly with haemoglobin to form carboxyhaemoglobin decreasing oxygen supplied to the foetus leading to poor development of foetus.</td>
</tr>
<tr>
<td>4. Increase risk of respiratory diseases such as: Chronic Bronchitis, Emphysema, Lung Cancer, Throat Cancer, Mouth Cancer</td>
<td>Excessive smoking by both parents and passive smoking by child.</td>
<td>nicotine causes addiction and result in withdrawal symptoms such as irritation and tension. Carbon monoxide is a colourless, odourless poisonous gas which causes a reduction of oxygen supply to heart and increases fatty deposition on the walls of blood vessels. Tar contains cancer causing chemicals deposits in the lungs and causes the persistent smoker's cough and shortness of breath. Irritant substances - carbon particles, oxides of nitrogen, etc. cause narrowing of air passages and stimulate excessive secretion of mucous.</td>
</tr>
</tbody>
</table>
**Question 7**

Fig. 3 shows models which demonstrate the actions of two different sets of muscles used during breathing in a mammal.

![Diagram of models A, B, C, and D]

Fig. 3

(a) The action of which muscles is represented by
   
   A and B?
   
   C and D? [2]

(b) Which two diagrams represent the thorax after breathing in? [2]

(c) Which structures in the human thorax are represented by the following parts labelled on the models?
   
   P ........................................
   
   Q ........................................
   
   R ........................................
   
   S ........................................ [2]

(d) State three ways in which the model shown in C/D does not accurately represent the process of breathing in a mammal. [3]

**Solution**

(a) A and B? External and internal intercostal muscles
   
   C and D? Diaphragm

(b) 1. B
   
   2. C

**COMMENT on QUESTION**

"(a) The muscles which move the ribs, and the muscles which changes the volume of the thoracic cavity during breathing.

(b) The changes to the ribs and diaphragm during inspiration."

**COMMENT on ANSWER**

"(a) Mention both internal and external intercostal muscles as they are antagonistic.

(b) The ribs swing upwards and outwards when we breathe in; the diaphragm contracts and flattens, increasing the volume of the thoracic cavity."
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(c) P: vertebral column
Q: rib
R: external intercostal muscles
S: nostrils

(d) 1. The cavity in C/D is directly linked to the external environment and air is sucked into the cavity and expelled from the cavity directly. In the mammal, air is sucked into the lungs, not the thoracic cavity.

2. The diaphragm changes the volume of the thoracic cavity by contraction and relaxation in the mammal. In C/D, the volume of the cavity is changed by physical movement of the piston.

3. The diaphragm is in a relaxed state during expiration. However, force is exerted on the piston to push the air out.

Question 8

The apparatus shown in Fig. 5 was used by a student to investigate the effect of temperature on the activity of yeast.

![Diagram of apparatus](image)

Fig. 5

Three different temperatures were provided by a refrigerator, a laboratory bench and a hot water bath. Each time, the apparatus was cleaned and set up afresh at room temperature using similar quantities of materials. The apparatus was checked 15 minutes after being placed in its experimental conditions and any observations noted.

Each experiment ran for the same length of time and the change in mass of the soda lime was carefully recorded. The results are shown in the table.

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Observation after 15 minutes</th>
<th>Increase in mass of soda lime / g</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. refrigerator</td>
<td>no bubbles</td>
<td>0.03</td>
</tr>
<tr>
<td>2. laboratory bench</td>
<td>many bubbles</td>
<td>1.33</td>
</tr>
<tr>
<td>3. hot water bath</td>
<td>no bubbles</td>
<td>0.16</td>
</tr>
</tbody>
</table>

(a) In Experiment 2,
(i) what process caused the bubbles?
(ii) what gas do the bubbles contain?
(iii) why did the soda lime increase in mass? [3]

(b) What chemical would be present in the flask at the end of Experiment 2 that was not present at the start? [1]

(c) What conclusions could the student draw from the results of these experiments? [2]

(d) Suggest why there was an increase in mass of the soda lime in Experiment 3, even though no bubbles were visible after 15 minutes. [2]
Solution

(a) (i) Anaerobic respiration.
   (ii) Carbon dioxide.
   (iii) Soda lime increased in mass because of the carbon dioxide absorbed.

(b) Ethanol.

(c) Room temperature is most suitable for the activity of yeast. At this temperature, and in the absence of oxygen, yeast respire anaerobically, producing ethanol and carbon dioxide.

(d) The hot water bath could have caused some of the carbon dioxide dissolved in the glucose solution to escape, and become absorbed in the soda lime.

Question 9

(a) Explain
   (i) the importance of an increased pulse rate during exercise, and
   (ii) why it takes several minutes for the pulse rate to return to normal after exercise. [6]

(b) If an athlete is a regular smoker, explain how this might affect both his pulse and his breathing rate during exercise. [6]

Solution

(a) (i) During exercise, more blood is sent to the muscles so that oxygen supply to the muscles is increased and the excess carbon dioxide from the muscle is removed. The heart beats faster to deliver more blood, hence the increased pulse rate.

(ii) After some time during the race, respiration takes place anaerobically because the maximum rate of oxygen uptake is less than the oxygen demand. There is a build up of lactic acid. After exercise, a period of recovery is needed to provide the oxygen so that the lactic acid can be oxidized, and to provide the energy for the recovery of the muscles.

(b) Nicotine in the blood causes the release of adrenaline into the blood stream. This results in an increase in heart rate and blood pressure.

Carbon monoxide in cigarette smoke also affects the transport of oxygen by combining with haemoglobin in red blood cells. A smoker therefore has to breathe faster to get more oxygen.

When a smoker exercises, he will experience much higher pulse rate and breathing rate.

COMMENT on ANSWER

(a) & (b) In the absence of oxygen, yeast respire anaerobically, producing carbon dioxide, ethanol and a little energy.

(c) The conclusions should be based on the information given in the question.

COMMON ERROR

(d) Some students get confused because of the increase in mass in Experiment 3.

COMMENT on ANSWER

(a) i) Increased pulse rate reflects increased heart beat to bring more blood to the muscles. Explain why this is required. So, give one reason for increase in pulse rate and the other for increase in breathing rate.

(b) Include the effects of nicotine and carbon monoxide.

COMMON ERROR

(a) (i) & (b) Students normally combine the 2 reasons and do not differentiate them.
**Question 10**

Explain the importance of the structure of each of the following in relation to their functions.

(a) the exchange surface of the alveoli

(b) the lining of the trachea

**Solution**

(a) The walls of the alveoli are only one cell thick so that gases can diffuse across easily. There is also a thin film of moisture on the wall to dissolve oxygen and carbon dioxide so that they can diffuse easily across the walls. The surfaces of the alveoli are covered by a network of blood capillaries for rapid absorption and transportation oxygen to and carbon dioxide from body cells.

(b) The epithelium lining the thinner walls of the trachea bears fine hairs called cilia and gland cells. The gland cells secrete mucus which traps dust and bacteria while the cilia helps to sweep these particles upward towards the pharynx and from here they are either removed through the mouth or swallowed into the oesophagus.

**Question 11**

(a) Explain how the following are involved in the process of breathing.

(i) the diaphragm

(ii) intercostal muscles

(b) Describe the function of the cilia in the trachea.

**Solution**

(a) (i) The diaphragm is the primary muscle of respiration. It is a dome-shaped muscle and separates the thoracic and abdominal cavities. Contraction of this muscle during inspiration flattens the dome and expands the vertical diameter of the chest cavity. The volume of the chest cavity increases and air pressure inside chest cavity and lungs decreases. The atmospheric pressure drives air through the nose into trachea and finally into the lungs.

(ii) The intercostal muscles – both internal and external intercostals muscles, are situated between the ribs. They act antagonistically i.e. when one contracts the other relaxes. Inhalation is the result of the expansion caused by the contraction of the diaphragm and external intercostal muscles. Exhalation results when the relaxation of the muscles of diaphragm and the contraction of the internal intercostal muscles (relaxation of external intercostals).

(b) The trachea is lined with a mucous layer and cilia. Cilia in the air passages move in a sweeping motion to keep the air passages clean. The constant action of these cilia carry mucous and debris upward into the pharynx whereupon they are swallowed.