krishnagar academy

BIOLOGY

CHAPTER-7

RESPIRATION IN PLANTS

Class -9

Chapter Outline

- Process of Respiration
- Respiration and Combustion
- Types of Respiration
  - Aerobic Respiration
  - Anaerobic Respiration
- Respiration and Photosynthesis
- Experiments on Respiration in Plants

All organisms require a constant supply of energy for carrying out various body activities and life processes. These activities include growth, cell multiplication, repair of cells, nutrition, reproduction, etc. Also, several other activities such as manufacture of carbohydrates by photosynthesis, absorption of water and minerals from soil, formation of cell wall, etc., take place utilising energy. In fact, energy is required to conduct every chemical reaction in a cell. Plants obtain this energy by breakdown of carbohydrates by the process of respiration.

Respiration is a fundamental process, during which the complex sugars present in the food combine with oxygen and break down into simpler substances within the cells. This reaction of sugars with oxygen releases energy and is called **oxidation**. This energy is utilised by the organisms for performing various biological activities.

This Chapter is focussed on the process of respiration in plants. You will study about respiration in human beings in Chapter 14.

PROCESS OF RESPIRATION

Like any other organism, plants also obtain energy by the process of respiration. Each and

every part of the plant respires. The cells which do not respire cannot live and eventually die.

Respiration is a **catabolic process** as it involves the breakdown of complex food substances into simpler substances. The process liberates energy and thus is also an **exergonic process**. The process of respiration can be categorised into two main phases, *i.e.*, external respiration and internal respiration.

External Respiration

External respiration involves the **exchange of gases** between the cells and the environment. Plant cells obtain oxygen from the atmosphere and release carbon dioxide and water into the atmosphere. The oxygen is carried to each part and each cell of the plant, where the second phase of respiration (internal respiration) takes place. In plants, the gaseous exchange takes place by the process of simple diffusion.

Diffusion

Diffusion is a process by which gases move from a region of high concentration to a region of low concentration.

During respiration, the cells utilise oxygen to breakdown food. As a result, the concentration of oxygen decreases in the cells, while the concentration of carbon dioxide produced during the process increases. This creates a concentration gradient of gases due to which the oxygen present in the atmosphere diffuses in and the carbon dioxide moves out to the atmosphere.

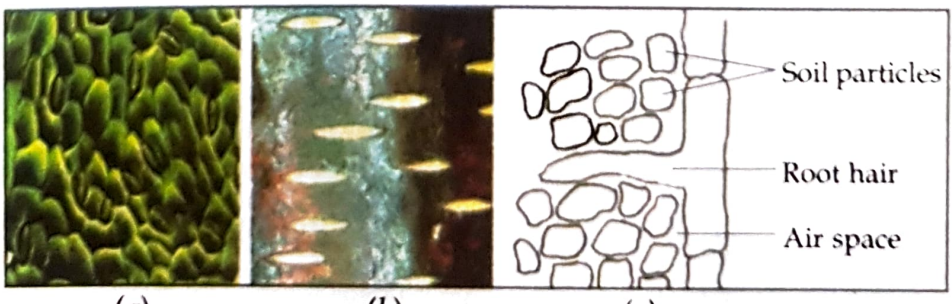
All plant parts exchange gases with the environment individually with the help of special structures. There are primarily three structures which take part in gaseous exchange.

Leaves

The *surface of leaves* is provided with numerous tiny apertures called **stomata** (*singular*–stoma). Leaves obtain oxygen from the atmosphere through diffusion *via* these pores. When the concentration of carbon dioxide is increased in these cells, the stomata release it into the atmosphere.

Stems

Plants with a *woody stem or a stem covered with waxy* cork cells have small raised pores called **lenticels**. These let oxygen to reach the intercellular spaces of the tissues and allow carbon dioxide to release into the atmosphere.



(*a*) (*b*) (*c*)

Fig. 7.1: Structures for gaseous exchange in plants: (*a*) Stomata (*b*) Lenticels (*c*) Root hair

Roots

Roots take up the oxygen present in between the soil particles with the help of **root hair**. The oxygen diffuses into the cells of root hair and passes into the roots. Similarly, carbon dioxide moves out from the roots into the soil through the root hair.

Ploughing or **tilling** of the soil creates tiny air spaces in the soil for better aeration. **Compact** or **water-logged soil** does not have much air space in between the soil particles. Thus, it prevents the roots from obtaining oxygen for gaseous exchange.

At A Glance

Plants such as *Sonneratia* grown in marshy areas are called **mangroves**. These plants give rise to special roots called **pneumatophores** which grow out of water. These bear lenticels on the apical region, which help in exchange of gases with the atmosphere.

Internal Respiration or Cellular Respiration

The oxidation of simple sugars such as glucose, present within each cell is called **internal respiration**. It results in the formation of carbon dioxide and water with the release of a huge amount of energy. The overall reaction that takes place during respiration can be represented as follows:

$$\underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Oxygen}}{6\,O_2} \longrightarrow \underset{\text{Carbon dioxide}}{6\,CO_2} + \underset{\text{Water}}{6\,H_2O} + \text{Energy}$$

The oxidation of glucose, as given above, is not so simple.

- It involves a series of complex **biochemical reactions**.

- Each reaction requires a particular **enzyme**.
- The **energy produced** is utilised for various metabolic activities, may be stored in the form of ATP (Adenosine triphosphate) molecules or released as **heat**.

ATP is called the **energy currency** of the cell. Whenever the cell requires energy, ATP breaks down into ADP (Adenosine diphosphate) and inorganic phosphate (Pi). The process releases energy stored in it.

The oxidation of glucose takes place in two phases:

- Anaerobic phase or Glycolysis
- Aerobic phase or Krebs Cycle.

Anaerobic Phase

The first phase takes place within the cytoplasm of the cells in the **absence of oxygen**. In this phase, glucose breaks down into pyruvic acid and produces net 8 ATP molecules. As this phase involves the breakdown of glucose, it is known as **glycolysis**, *i.e.*, **lysis of glucose**.

$$\text{Glucose} \longrightarrow 2 \text{ Pyruvic acid} + 8 \text{ ATP}$$

Aerobic Phase

The second phase is completed within the mitochondria of the cells in the *presence of oxygen*. The pyruvic acid formed during first phase breaks down into carbon dioxide and water. This phase produces 30 ATP molecules and is called the **Krebs cycle**.

$$\text{Pyruvic acid} \longrightarrow 3\ CO_2 + 3\ H_2O + 30\ ATP$$

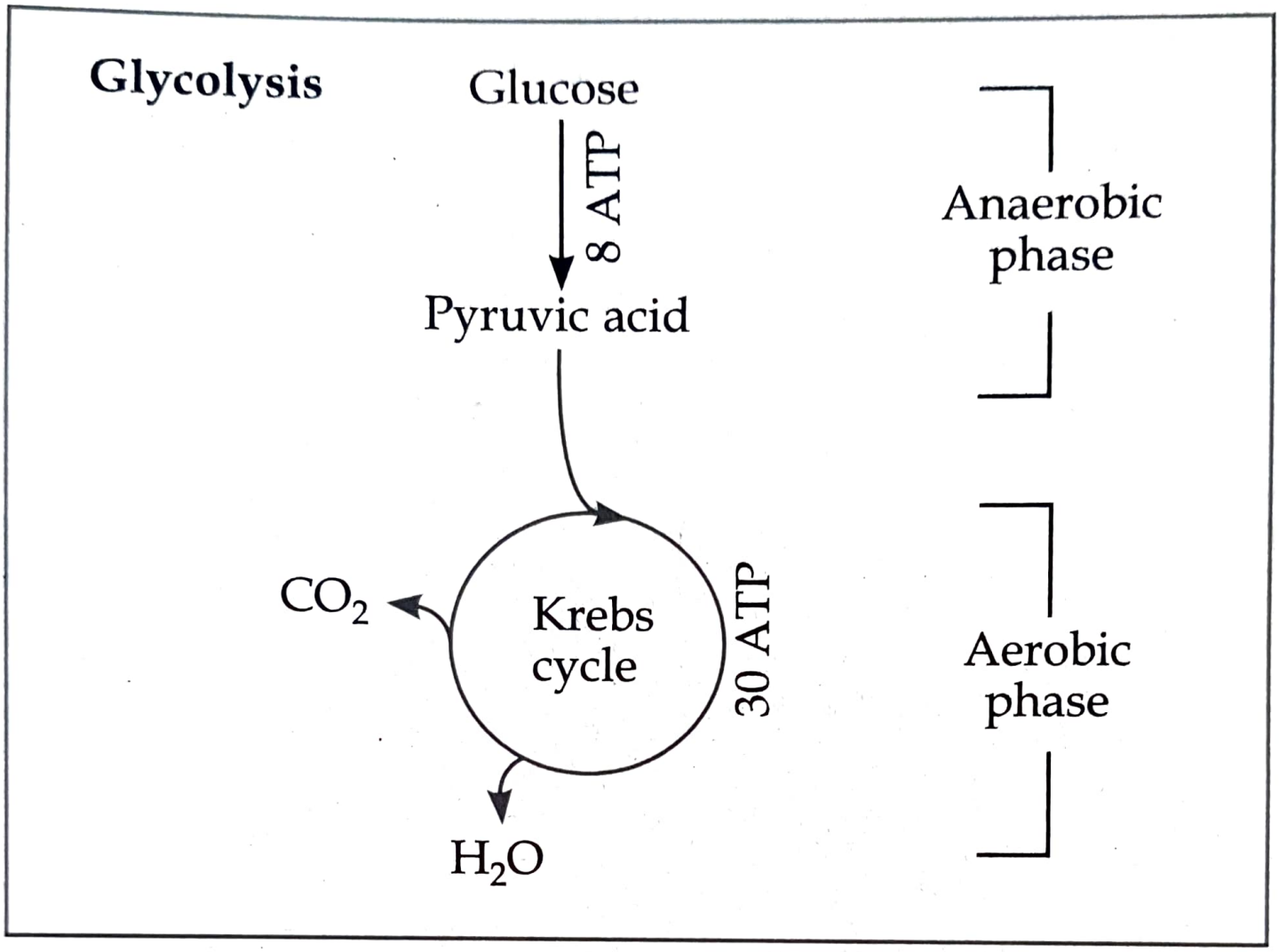


Fig. 7.2: Schematic representation of cellular respiration

RESPIRATION AND COMBUSTION

Respiration in cells is often compared with burning or **combustion**, such as burning of coal. This is because both

(*a*) take place in the presence of oxygen,

(*b*) release huge amount of energy, and

(*c*) produce carbon dioxide after the completion of the process.

TYPES OF RESPIRATION

You have studied that the process of respiration involves breakdown of food in the presence of oxygen. What will happen if oxygen is not available to carry out respiration? Can plants survive in the absence of oxygen?

Based on the utilisation of oxygen by the plants, respiration can be categorised into two types:

Aerobic Respiration

The respiratory process that completely *oxidises the food into carbon dioxide and water with the help of free oxygen* is called **aerobic** (*aer* = air; *bios* = life) or **oxybiotic respiration**. It releases a considerable amount of energy which is either utilised by the plants for carrying out various activities or is stored in the form of ATP molecules for future use. The process is represented as:

$$\underset{\text{Glucose}}{C_6H_{12}O_6} + 6\,\underset{\text{Oxygen}}{O_2} \longrightarrow 6\,\underset{\text{Carbon dioxide}}{CO_2} + 6\,\underset{\text{Water}}{H_2O} + 38\,\underset{\text{Energy (280 kcal)}}{ATP}$$

The process of aerobic respiration involves both the anaerobic phase (glycolysis) and the aerobic phase (Krebs cycle).

Anaerobic Respiration

Sometimes, certain parts of plants such as fruits and seeds, temporarily respire in the absence of oxygen. It is called **anaerobic** (*an* = not; *aer* = air; *bios* = life) or **anoxybiotic respiration**. During the process, *food is incompletely broken down* and releases a very small quantity of energy (2 ATP). The end products formed are ethyl alcohol and carbon dioxide. The reaction can be represented as follows:

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \longrightarrow 2\ \underset{\text{Ethyl alcohol}}{C_2H_5OH} + 2\ \underset{\text{Carbon dioxide}}{CO_2} + 2\ \underset{\text{Energy (15 kcal)}}{ATP}$$

The process of anaerobic respiration lacks the second aerobic phase of Krebs cycle.

The plant parts cannot continue respiration in the absence of oxygen for more than a few days because of very less amount of energy released. However, there are many lower organisms, such as bacteria and yeast, and some multicellular animals, such as liver flukes and roundworms; which live in an oxygen-free environment and can release energy anaerobically throughout their life. The anaerobic respiration carried out by yeast is also called **fermentation**.

Significance of Respiration

The process of respiration plays a very significant role in plant life. The process *releases energy* stored in the food and makes it available to the plants. A part of the energy released (65%) is *stored as ATP molecules* in the mitochondria while the rest is *released as heat energy* (35%). The energy released is used for various biological activities or life processes performed by the plants.

It *removes carbon dioxide* produced during various chemical reactions from the plant body, as it can change the pH of the internal environment and be harmful. Plants also utilise a great amount of carbon dioxide produced during respiration for photosynthesis. This *maintains the balance of carbon dioxide in the atmosphere.*

RESPIRATION AND PHOTOSYNTHESIS

The process of respiration is often compared with photosynthesis, but both are opposite processes. The *requirements of one process are the products of the other process*. During respiration, plants utilise O_2 and release CO_2 while during photosynthesis, plants take in CO_2 and give out O_2.

Nevertheless, respiration and photosynthesis *maintain the CO_2-O_2 balance* in the atmosphere. This is essential not only for the life of plants but also for human beings and other animals because all organisms survive on O_2 released by the plants during photosynthesis while the plants survive on the CO_2 released by animals during respiration. Thus, *respiration and photosynthesis are indispensable and complement each other*.

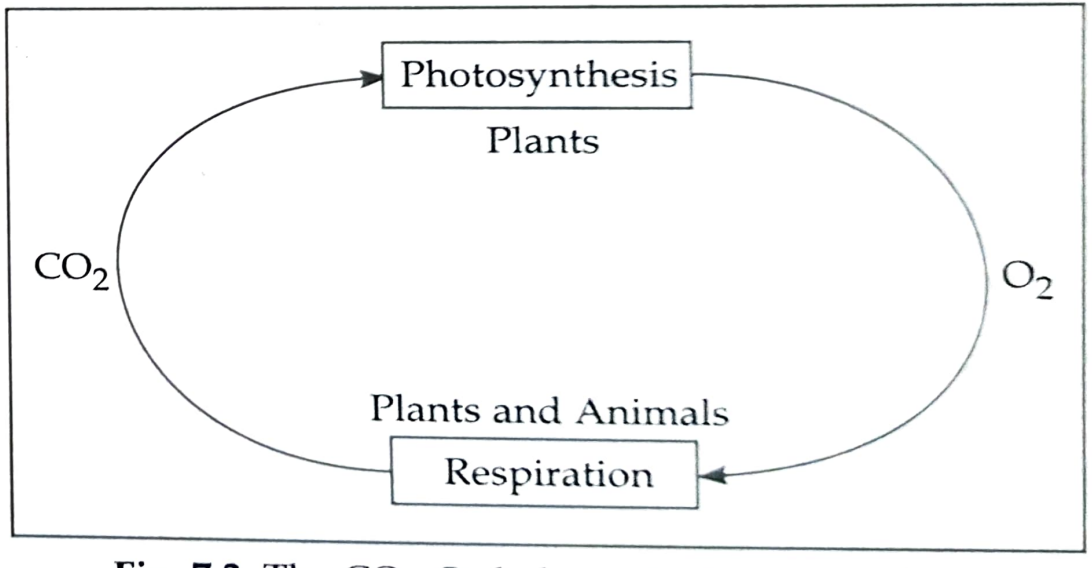


Fig. 7.3: The CO_2-O_2 balance in the atmosphere

Table 7.1: Differences between External Respiration and Internal Respiration

No.	*External Respiration*	*Internal Respiration*
1.	It is a physical process.	It is a biochemical process.
2.	It involves the gaseous exchange between the cells and atmosphere.	It involves the oxidation of glucose breaking it into carbon dioxide, water and energy.
3.	It does not release any energy.	It releases energy in the form of ATP molecules.
4.	It takes place outside the cells.	It occurs inside the cells.
5.	It does not require any enzymes.	It requires many enzymes.

Table 7.2: Differences between Respiration and Combustion

S.No.	Respiration	Combustion
1.	It is a process which is vital for the sustenance of life.	It is a physical process which occurs in non-living things.
2.	It takes place within the cells.	It is a non-cellular process.
3.	It occurs in a series of steps and thus releases energy in a step-wise manner.	It occurs in a single step and thus releases energy spontaneously.
4.	The energy released is controlled and most of it is stored in the form of ATP molecules.	The energy is released in an uncontrolled manner and cannot be stored.
5.	It generates only a small amount of heat and does not harm the cell.	It generates enormous amount of heat and destroys the substance.
6.	No light energy is produced.	It produces light energy.
7.	It takes place with the help of enzymes.	No enzymes are involved.
8.	It occurs at body temperature, which is much lower than that of combustion.	It occurs at very high temperature as compared to respiration.

Table 7.3: Differences between Aerobic Respiration and Anaerobic Respiration

S.No.	*Aerobic Respiration*	*Anaerobic Respiration*
1.	It takes place in the presence of oxygen.	It takes place in the absence of oxygen.
2.	Glucose gets completely oxidised during the process.	Glucose is broken down incompletely.
3.	The end products are carbon dioxide and water.	The end products are ethyl alcohol and carbon dioxide.
4.	It liberates 38 ATP molecules from the oxidation of 1 molecule of glucose. Thus, it is an efficient process.	It forms only 2 ATP molecules from 1 glucose molecule. Thus, it is not a very efficient process.
5.	Aerobic respiration occurs throughout the life of a plant.	Anaerobic respiration occurs only for a few days in the plants, if it prolongs, they may die.

Table 7.4: Differences between Respiration and Photosynthesis

S.No.	*Respiration*	*Photosynthesis*
1.	It is a catabolic process during which complex food substances break down into simpler substances.	It is an anabolic process during which complex food substances are synthesised from simpler substances.
2.	It is a continuous 24 hours process which does not require sunlight.	It requires the presence of sunlight and thus occurs only during the day.
3.	It converts chemical energy of the food into stored energy (ATP) or heat energy.	It converts light energy of the sun into chemical energy, which gets stored as food in the plants.
4.	During the process, oxygen is used up and carbon dioxide is released.	During the process, carbon dioxide is used up and oxygen is released.
5.	The dry weight of the plant decreases because of utilisation of food.	The dry weight of the plant increases because of the synthesis of food.
6.	It takes place in all organisms.	It occurs only in green plants, a few bacteria, green algae and green protists.

1. Give reasons for the following:

(*a*) The dry weight of the plant decreases during respiration.

(*b*) Roots of the plant can respire more efficiently in ploughed soil than in water-logged soil.

(*c*) A major part of the energy released during respiration gets stored in the plants.

(*d*) Krebs cycle releases more energy than glycolysis.

(*e*) Plants cannot respire anaerobically throughout their life.

(*f*) Respiration and photosynthesis collectively maintain the balance of O_2 and CO_2 in the atmosphere.

2. Describe the experiments to demonstrate the following:

(*a*) Oxygen is utilised during respiration.

(*b*) Carbon dioxide is evolved during respiration.

(*c*) Germinating seeds evolve heat.

(*d*) Germinating seeds can also respire anaerobically.

3. Differentiate between the following:

(*a*) Aerobic and anaerobic respiration

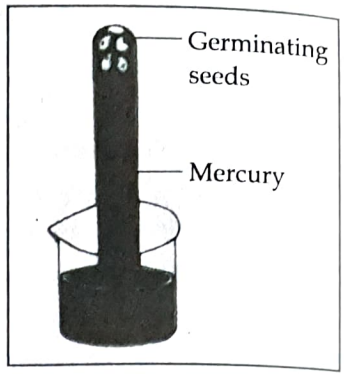
(*b*) External and internal respiration

(*c*) Photosynthesis and respiration

(*d*) Respiration and combustion

(*e*) Catabolism and anabolism

2. The figure given alongside shows an experiment performed by using germinating seeds. Observe it carefully and answer the following questions:



(*a*) What is the aim of the experiment?

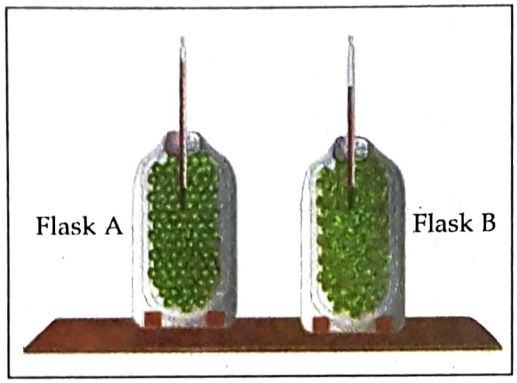
(*b*) What change will you observe in the set-up after a day?

(*c*) Why did you use the seeds after removal of their seed coat?

(*d*) Will you obtain the same results if water is used instead of mercury?

(*e*) Write the chemical equation for the process occurring in the experiment.

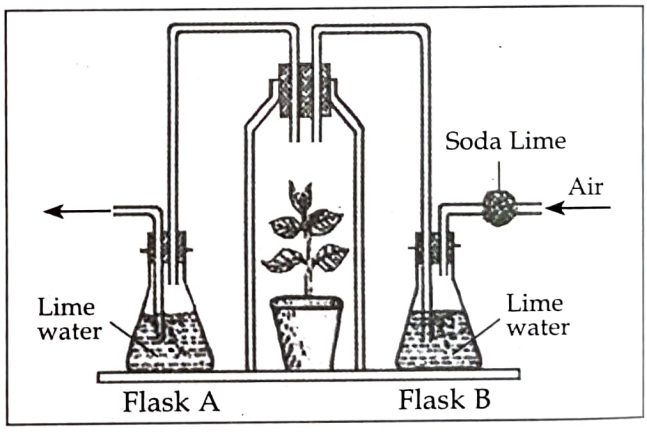
3. Observe the figure given below and answer the following questions:



(*a*) What does the experimental set-up demonstrate?

(*b*) Why does the thermometer of thermos flask B shows less temperature as compared to that of thermos flask A?

4. Given alongside is an experimental set-up by a candidate to study the process of respiration in plants. The candidate failed to get the expected results, as two mistakes were made while setting up the experiment:



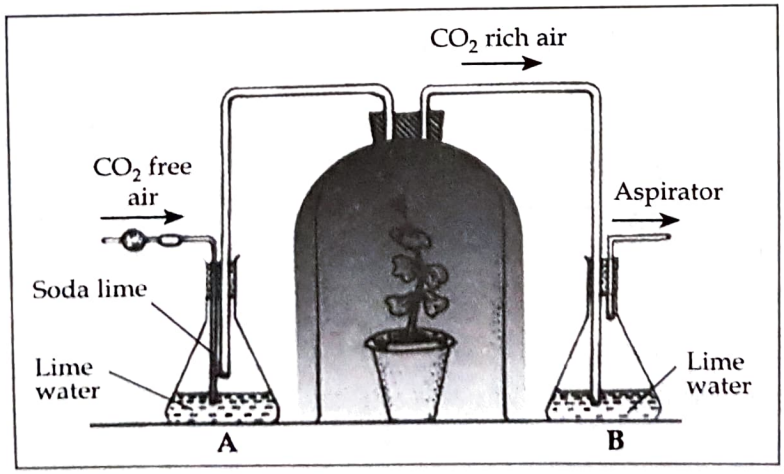
(*a*) Identify and state the **two** mistakes made by the candidate.

(*b*) What is the role of soda lime in the experiment?

(*c*) What is the purpose of using lime water in flasks 'A' and 'B'?

(*d*) Give the chemical equation to represent the process of respiration.

5. Study the experimental set-up shown in the figure below and answer the following questions:



(*a*) What is the aim of the experiment?

(*b*) Why was the bell jar covered with a black cloth?

(*c*) What is the significance of soda lime in the experiment?

(*d*) Will you get the same results if the green plant is replaced with

(*i*) germinating seeds? (*ii*) boiled or dead seeds?

(*iii*) green leaves of the plant? (*iv*) roots of the plants?

(*e*) Give an overall chemical equation of the process that is demonstrated by the experiment.