Light is Necessary for Photosynthesis

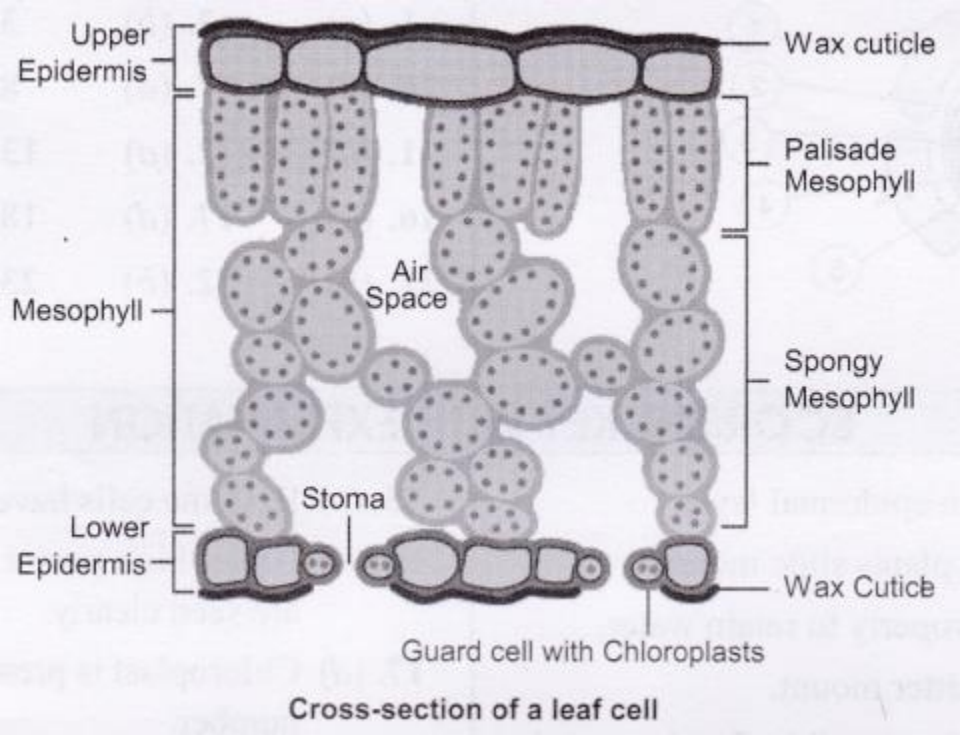
Introduction

- Photosynthesis is a process by which plants prepare food. During this reaction, carbon dioxide and water are converted into glucose by chlorophyll in the presence of light energy.

$$\text{Carbon dioxide} + \text{Water} \xrightarrow[\text{Chlorophyll}]{\text{Light}} \text{Glucose} + \text{Oxygen}$$

$$6CO_2 + 6H_2O \xrightarrow[\text{Light}]{\text{Chlorophyll}} C_6H_{12}O_6 + 6O_2$$

- Photosynthesis takes place in leaf cells. These contain chloroplasts, which are tiny objects containing chlorophyll.



Cross-section of a leaf cell

- Plants absorb water through their roots, and carbon dioxide through their leaves. They makes food in the form of glucose. Glucose is further converted into starch. Oxygen is the by-product released during photosynthesis.
- The following events occur during the process of photosynthesis:
  (a) Light is absorbed by the chlorophyll pigments present in the leaf.
  (b) Light energy is converted into chemical energy and splits water into hydrogen and oxygen molecules.
  (c) Carbon dioxide is reduced to carbohydrates.

- The above step may not occur simultaneously in some plants. For example, desert plant take up CO_2 at night and prepare an intermediate which is acted upon by the chlorophyll during the day.
- Destarching: When a plant is kept in darkness for about forty eight hours all the carbohydrates made and stored by the plants are utilised for providing energy to the plants. This process is called destarching.
- Boiling of leaf in alcohol: The leaf to be tested for presence of starch is boiled in alcohol to remove the pigment chlorophyll otherwise it will interfere with the starch test. Alcohol is not heated directly over the flame because it will evaporate quickly without being much in contact with the leaves. It is therefore important to heat the test tube containing alcohol and leaves in water bath.
- Starch test: On adding iodine solution to the starch, it forms starch-iodine complex which is blue-black in colour. When partially covered leaf is treated with iodine solution then the covered portion do not turn blue-black on adding iodine solution whereas the uncovered portion which received the light turns blue-black due to synthesis of starch in them.

Science Lab Manual Experiment 2

Aim

To show experimentally that light is necessary for photosynthesis.

Theory

- Plants prepare their food by the process called photosynthesis. To make food, plants need CO_2water, chlorophyll and light/sunlight. In absence of any of these plants cannot prepare their food.
- Plants can prepare their food in blue light.
- The rate of photosynthesis depends on all three factors i.e.—light, temperature, availability of components, i.e.,— CO_2 and H_20.
- If the intensity of light increases the rate of photosynthesis also increases.
- When light falls on plants they show light reaction. In this light reaction the water in leaves undergo photolysis
  i.e.,—the water splits to form oxygen and hydrogen due to photons of light. The oxygen gas is released out in the atmosphere but hydrogen is kept by the plant. It is this hydrogen that combines with CO_2 to form carbohydrate (reduction reaction). Hence; photosynthesis is an oxidation-reduction reaction.
- Photosynthesis reaction:

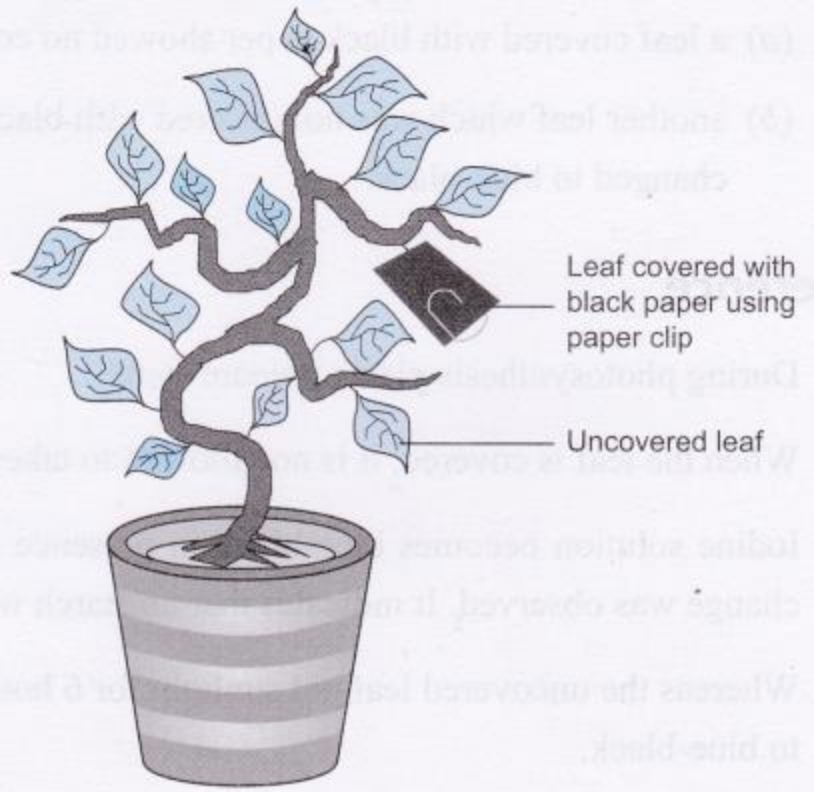
$$6CO_2 + 12H_2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

Materials Required

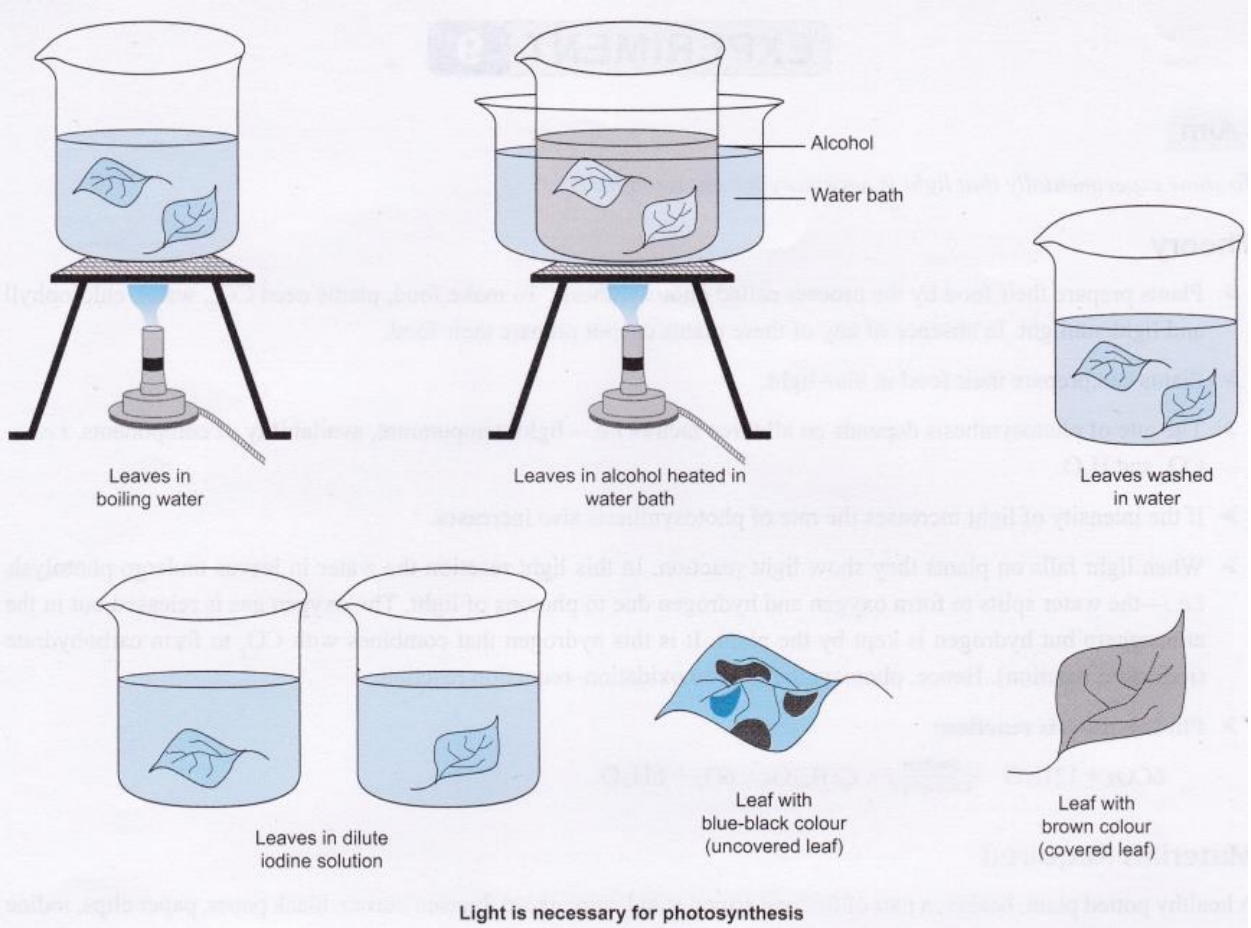
A healthy potted plant, beaker, a pair of forceps, tripod stand, wire gauze, bunsen burner, black paper, paper clips, iodine solution, alcohol, water bath etc.

Procedure I

1. Take a healthy potted plant and keep it in a dark room for 48 hours so that all the starch gets used up.
2. Now cover one leaf of a plant with a black paper using paper clip.
3. Keep this plant in sunlight for about six hours.
4. Pluck two leaves from the plant, one that is covered and the other one that is uncovered.
5. Dip the leaves in boiling water for a few minutes.
6. Now immerse the leaves in a beaker containing alcohol.
7. Carefully place this beaker in water bath and heat it till the alcohol begins to boil.
8. Observe the colour of the leaves and solution.
9. Wash the leaves with lot of fresh water.
10. Now dip the leaves in iodine solution for a few minutes.
11. Now observe the colour of leaves and compare them.



Potted plant



Observations

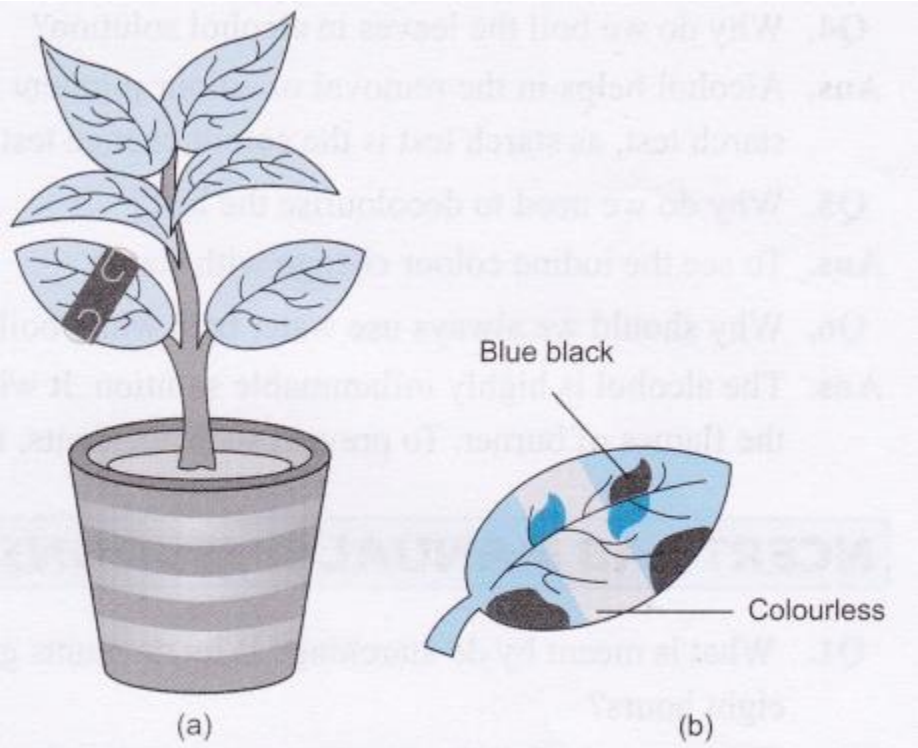
1. When leaves are boiled in alcohol, the alcohol solution becomes green and the leaves become colourless.
2. When iodine solution is added on the leaves
   (a) a leaf covered with black paper showed no colour changes with iodine solution.
   (b) another leaf which was not covered with black paper when dipped in dilute iodine solution, the colour of leaf changed to blue-black.

Inference

- During photosynthesis plants prepare starch.
- When the leaf is covered, it is not allowed to take sunlight and hence, no starch was prepared in the leaf.
- Iodine solution becomes blue-black in presence of starch. On adding iodine solution to covered leaf no colour change was observed. It indicates that no starch was made by this leaf.
- Whereas the uncovered leaf got sunlight for 6 hours and when iodine solution was added to it, the colour changed to blue-black.
- This proves that sunlight is required for photosynthesis.

Procedure II

1. Select a potted plant, keep it in dark room for 48 hours.
2. Select a healthy leaf and clip a portion of it with dark colour paper using clips.
3. Keep this plant in sunlight for 6 hours.
4. Then do the same steps (4-11) as in procedure 1 on previous page.



(a) A de-starched potted plant with part of a leaf covered with black paper strips on either side;
(b) An experimental leaf after treatment with iodine

Important Note

1. When you cover a portion of leaf with dark paper the results are not clearly visible. There is a possibility of translocation of food from uncovered leaf to a covered part of leaf.
2. The above experiment can be done by covering a portion of leaf with black paper.

Precautions

1. Select a small healthy, herbaceous potted plant.
2. Do not destarch the plant for more than 48 hours.
3. Choose a leaf and clip it carefully so that it does not break or crack from the stem.
4. Alcohol is highly inflammable, be careful while boiling leaf in alcohol using water bath.

5. Wash the alcohol from the leaves and then do the iodine test.
6. Satisfactory results will not be obtained if the plant is not completely de-starched.

Science Lab Manual Viva Voce

Question 1:
If plant is kept in a room with lights on, can it perform photosynthesis?
Answer:
Yes, plants can prepare their food in any light i.e.-tube light, bulb-light, sunlight.

Question 2:
In which colour of light, plants can prepare their food best.
Answer:
Plants can prepare their food best in blue light.

Question 3:
In which part of the plant the photolysis reaction initiates?
Answer:
In chloroplast.

Question 4:
What is the original colour of iodine solution?
Answer:
Brown.

Science Lab Manual Practical Based Questions

Question 1:
What are the raw materials required by plants for photosynthesis?
Answer:
Plants need light, carbon dioxide, water and chlorophyll pigments in leaf for photosynthesis.

Question 2:
What is the use of light in photosynthesis?
Answer:
In the presence of light, photolysis reaction takes place in a plant.
In photolysis reaction, the water decomposes to form hydrogen and oxygen gas.

Question 3:
In a plant if there are no leaves for a short period of time, i.e.,-Autumn, how do such plants survive?
Answer:

Plants store the food in roots, stems and this stored food is used/transported by plant to all the parts wherever the food is required.

Question 4:
Why do we boil the leaves in alcohol solution?
Answer:
Alcohol helps in the removal of colour pigment chlorophyll from the leaf which may otherwise interfere in the starch test, as starch test is the colour change test.

Question 5:
Why do we need to decolourise the leaf?
Answer:
To see the iodine colour change with starch.

Question 6:
Why should we always use water bath while boiling the leaf in alcohol solution?
Answer:
The alcohol is highly inflammable solution. It will catch fire if we heat the beaker containing alcohol directly on the flames of burner. To prevent such accidents, it is always advised to use water bath.

Science Lab Manual Questions

Question 1:
What is meant by de-starching? Why do plants get de-starched when kept in continuous darkness for about forty eight hours?
Answer:
The removal of all the starch present in plant is called de-starching. When plants are kept in continuous darkness for about forty eight hours, all the starch present in them is used up for various biological processes and no new starch is formed due to absence of light.

Question 2:
Will you get the same result if you perform the experiment without de-starching the plant? Give reason.
Answer:
The variable we are testing here is light that affects photosynthesis and the product formed is starch. If the starch is already present in the plant, the experiment will not give the fair test.

Question 3:
Why do we warm the leaves in alcohol?
Answer:

Alcohol helps in the removal of colour pigment chlorophyll from the leaf which may otherwise interfere in the starch test, as starch test is the colour change test.

Question 4:
Arrange the following steps in correct sequence:
(i) de-starching the plant;
(ii) treatment with iodine;
(iii) attaching black paper strips to the leaf;
(iv) keeping the set-up in sunlight;
Answer:
The correct order is: (i), (iii), (iv), (ii).

Question 5:
Why do we keep the experimental plant in bright sunlight?
Answer:
After destarching, we keep the plant in the bright sunlight so that it undergoes photosynthesis to produce starch.

Question 6:
Can this experiment be performed with a de-starched leaf detached from the plant? Give reasons.
Answer:
The leaf cannot undergo photosynthesis if it is detached from the plant and the experiment will not give fair test.

Science Lab Manual Multiple Choice Questions (MCQs)

Questions based on Procedural and Manipulative Skills
Question 1:
The first step in photosynthesis is
(a) convert light energy into chemical energy
(b) reduction of $C0_2$ gas to carbohydrates
(c) photolysis of water
(d) absorption of light energy by chlorophyll.

Question 2:
In desert plants, the first step of photosynthesis can be
(a) absorption of sunlight
(b) photolysis of water
(c) intake of $C0_2$ at night
(d) convert light energy into chemical energy.

Question 3:
In an experiment to show that sunlight is necessary for photosynthesis, the leaf is boiled

in alcohol for a few minutes using a water bath. It is essential because:
(a) alcohol is highly volatile
(b) the steam from water bath heats the leaf rapidly
(c) steam from water bath dissolves the chlorophyll
(d) alcohol is flammable.

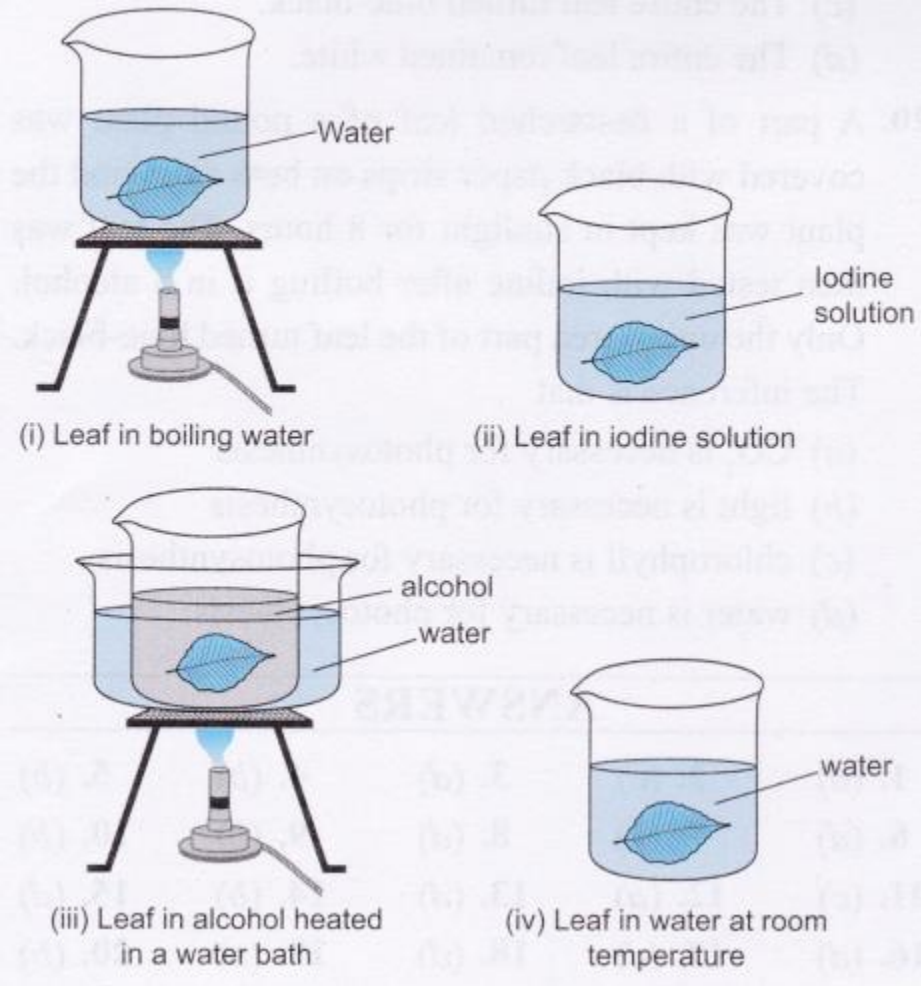
Question 4:
Before testing the leaf for starch at the end of the experiment, “light is necessary for photosynthesis”, the experimental leaf, should be boiled in
(a) water
(b) alcohol
(c) KOH solution
(d) hydrochloric acid.

Question 5:
For the experiment that, “light is necessary for photosynthesis” the potted plant is first kept in darkness for a day. This is to:
(a) deactivate the chloroplast
(b) destarch leaves
(c) activate chloroplasts
(d) prepare leaves for photosynthesis.

Question 6:
The steps, necessary for setting up the experiment “To demonstrate that light is necessary for photosynthesis” are not given here in proper sequence. The correct order is:
I. keep the potted plant in sunlight for 3 to 4 hours
II. keep the potted plant in darkness for about 48 hours
III. cover a leaf of the plant with a strip of black paper
IV. pluck the leaf and test it for starch.
(a) I, III, IV, II
(b) I, IV, III, II
(c) II, IV, III, I
(d) II, III, I, IV.

Question 7:
Before carrying out the test for the presence of starch in a leaf-on exposure to sunlight, the leaf is put into alcohol contained in a beaker and boiled over a water bath. This step is carried out to
(a) extract starch
(b) dissolve chlorophyll
(c) allow water to move into the leaf
(d) make membrane of leaf cells more permeable.

Question 8:
A student performed the starch test on a leaf, some steps involved are shown below:
The correct sequence of steps should be:



(a) (iv), (iii), (ii), (i)
(b) (i), (ii), (iii), (iv)
(c) (ii), (iii), (iv), (i)
(d) (i), (iii), (iv), (ii).

Question 9:
What is the right procedure to remove chlorophyll from a destarched leaf?
(a) Boil the destarched leaf in lime water.
(b) Boil the destarched leaf in alcohol.
(c) Boil the destarched leaf in water only.
(d) Boil the destarched leaf in a mixture of alcohol and water.

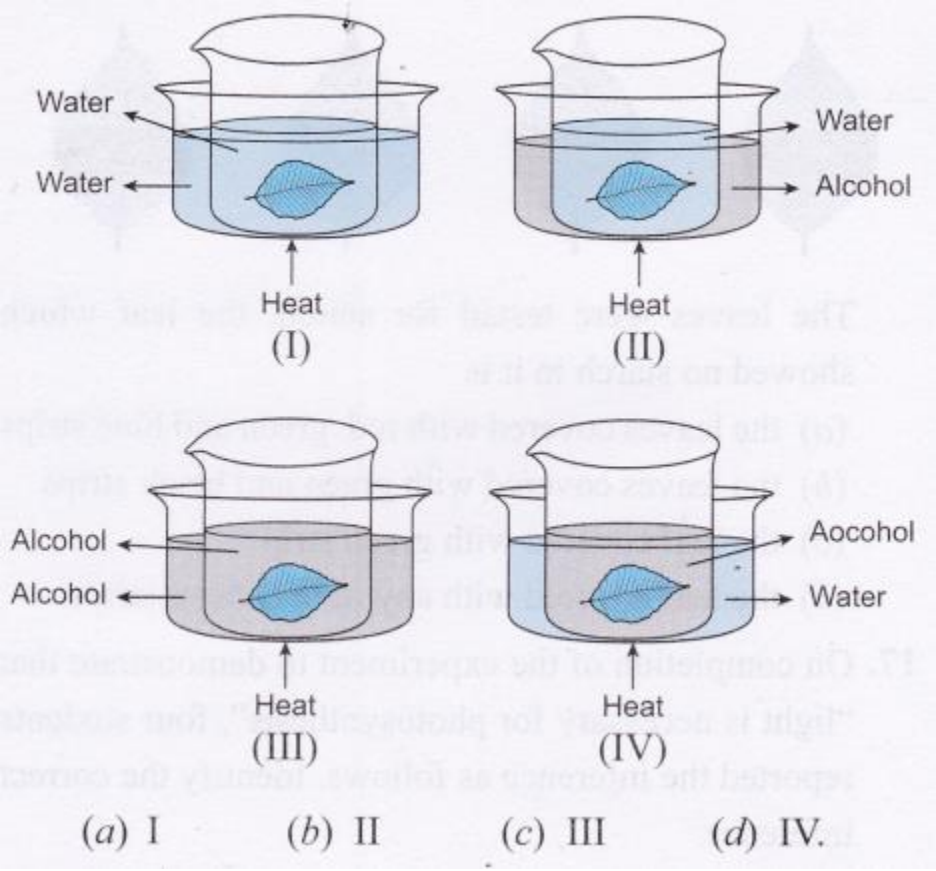
Questions based on Observational Skills
Question 10:
A potted plant is kept in different coloured lights. The best rate of photosynthesis is seen in

(a) green light
(b) blue light
(c) white light
(d) yellow light.

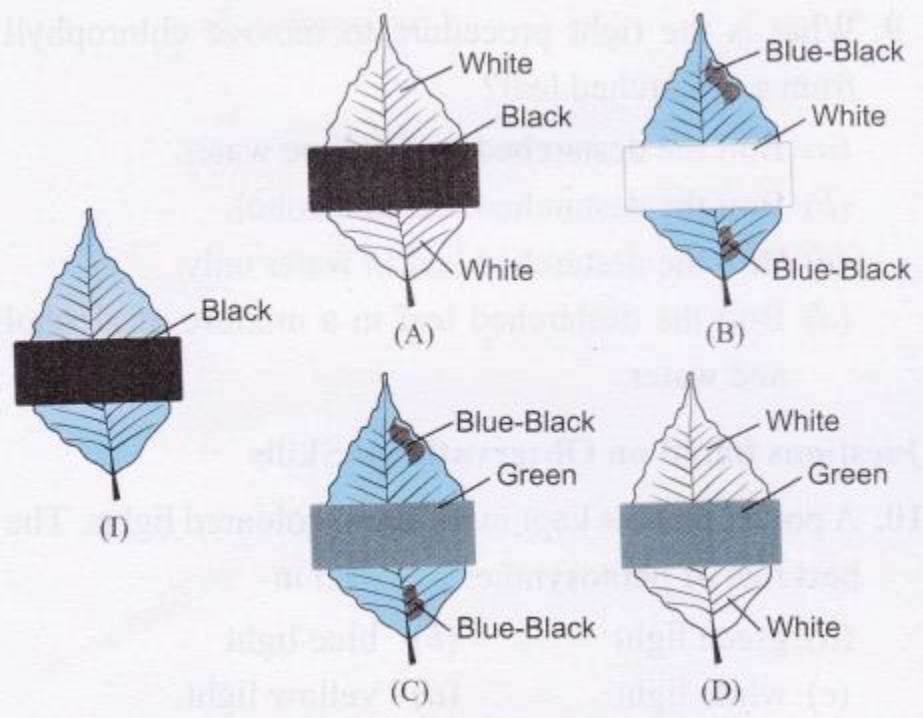
Question 11:
When leaf is boiled with ethanol and treated with iodine solution, its colour changes into:
(a) pink
(b) blue
(c) blue-black
(d) black.

Question 12:
The best result of the experiment that light is necessary for photosynthesis would be yielded by using leaves from a plant kept for over twenty four hours:
(a) in a pitch dark room
(b) in a dark room with table lamp switched on
(c) outside in the garden
(d) outside in the garden covered by glass case.

Question 13:
The figure that correctly depicts the removal of chlorophyll is:



Question 14:
A leaf from a destarched plant is covered with black paper strip as shown in figure I. The starch test is done on the leaf after 8 hours of exposure to light.

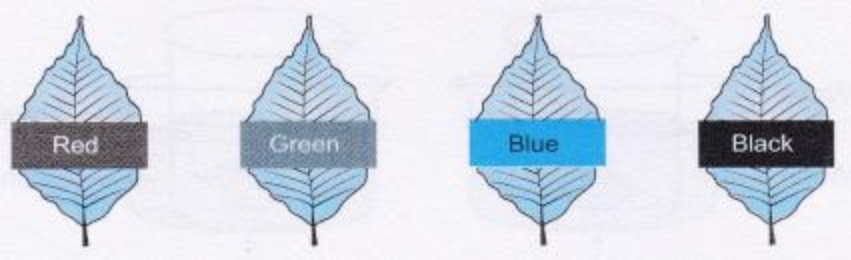


The result will be as shown in diagram:
(a) A
(b) B
(c) C
(d) D

Questions based on Reporting and Interpretation Skills

Question 15:
The best rate of photosynthesis is in blue light because:
(a) the leaves absorb maximum blue light
(b) the leaves reflect maximum blue light
(c) the blue light has maximum wavelength
(d) the blue light stimulates the chloroplast maximum.

Question 16:
A potted plant was kept in dark room for 3 days and then 4 leaves were covered with different coloured papers as shown below.



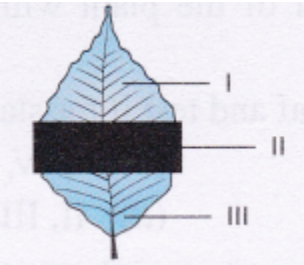
The leaves were tested for starch, the leaf which showed no starch in it is
(a) the leaves covered with red, green and blue strips
(b) the leaves covered with green and black strips
(c) the leaf covered with green strip
(d) the leaf covered with any of the above strips.

Question 17:

On completion of the experiment to demonstrate that
"light is necessary for photosynthesis", four students reported the inference as follows. Identify the correct inference.
(a) Part of the leaf covered with strip can only undergo photosynthesis
(b) Uncovered parts of the leaf cannot synthesises starch.
(c) Photosynthesis takes place only in the presence of sunlight
(d) Light is necessary for photosynthesis of starch in green plants.

Question 18:

Given below is a sketch of a leaf partially covered with black paper and which is to be used in the experiment to show that light is compulsory for the process of photosynthesis. At the end of the experiment, which one of the leaf parts labelled I, II and III will become blue-black when dipped in iodine solution?



(a) I only
(b) II only
(c) III only
(d) I and III only.

Question 19:

In an experiment of photosynthesis, a student fixed a strip of black paper on the dorsal surface of leaf in the morning, in the evening he tested the leaf for starch. The result was:
(a) The dorsal surface of the leaf was white but the ventral surface turned blue.
(b) Both the surfaces of the leaf were white.

(c) The entire leaf turned blue-black.
(d) The entire leaf remained white.

Question 20:
A part of a destarched leaf of a potted plant was covered with black paper strips on both sides and the plant was kept in sunlight for 8 hours. The leaf was then tested with iodine after boiling it in a alcohol. Only the uncovered part of the leaf turned blue-black. The inference is that
(a) $C0_2$ is necessary for photosynthesis
(b) light is necessary for photosynthesis
(c) chlorophyll is necessary for photosynthesis
(d) water is necessary for photosynthesis.

Answers:

1. (d)	2. (c)	3. (d)	4. (b)	5. (b)
6. (d)	7. (b)	8. (d)	9. (b)	10. (b)
11. (c)	12. (a)	13. (d)	14. (b)	15. (d)
16. (d)	17. (d)	18. (d)	19. (c)	20. (b)

Science Lab Manual Scoring Key With Explanation

1. (d) The light energy is absorbed to initiate the reaction.
2. (c) To avoid the loss of water during day times, the stomata will not open.
3. (d) Water bath prevents the direct heating of alcohol which is highly inflammable and can catch fire.
4. (b) Alcohol helps in removing the chlorophyll.
5. (b) Destarching helps in removing the starch from the leaf.
6. (d) It is the right procedure for the experiment.
7. (b) As starch test is colour change test, hence coloured pigment chlorophyll needs to be removed.
8. (d) It is the correct procedure.
9. (b) Alcohol helps in dissolving the chlorophyll without affecting the other cells.
10. (b) Blue light is better absorbed among the other given lights (red is the best).
11. (c) Starch test is iodine solution changes blue-black with starch.
12. (a) This helps in de-starching the leaves.
13. (d) Leaf should be in alcohol and this container should be heated in water.
14. (b) The covered part of leaf will not have starch and will not show colour change.
15. (d) The blue light is absorbed the best by chloroplast.
16. (d) Once the leaf is covered by paper, it is deprived of light and no photosynthesis occurs in it.
17. (d) Green plants can prepare starch by photosynthesis.

18. (d) I and III parts of leaf gets light and hence starch is made but II part gets no light.
19. (c) Covering the dorsal side of leaf will not deprive it from light.
20. (b) Light is must for photosynthesis as it initiates the reaction in cells.