**PHOTOSYNTHESIS DATA ANALYSIS AND ESSAY QUESTIONS**

**1.** Explain the reactions involving the use of light energy that occur in the thylakoids of the chloroplast. (Total 8 marks)

**2.** Explain how the light-independent reactions of photosynthesis rely on light-dependent reactions. (Total 8 marks)

**3.** Outline the effect of temperature, light intensity and carbon dioxide concentration on the rate of photosynthesis. (Total 6 marks)

**4.** There are many abiotic factors that affect the rate of photosynthesis in terrestrial plants. Wheat is an important cereal crop in many parts of the world. Wheat seedlings were grown at three different concentrations of carbon dioxide (in parts per million) and the rate of photosynthesis was measured at various light intensities.



[Source: Adapted from J P Kimmins, *Forest Ecology*, (2nd edition) page 161]

(a) Describe the relationship between the rate of photosynthesis and light intensity for wheat seedlings grown at a CO2 concentration of 500 ppm. (2)

(b) Outline the effect of CO2 concentration on the rate of photosynthesis of the wheat seedlings.(3)

(c) The normal atmospheric concentration of CO2 is 370 ppm. Deduce the effect of doubling the CO2 concentration to 740 ppm on the growth of wheat plants.(2)

 Leaf area and chlorophyll levels were measured in sun leaves and shade leaves of *Hedera helix* (English Ivy) and *Prunus laurocerasus* (Cherry Laurel). Sun leaves developed under maximal sunlight conditions while shade leaves developed at reduced sunlight levels in the shadow of other leaves.

|  |  |  |  |
| --- | --- | --- | --- |
| **Species** | **Leaf Type** | **Chlorophyll/g ml**-1 | **Leaf Area/cm**2 |
| Ivy | Shade | 4.3 | 72.6 |
|  | Sun | 3.8 | 62.9 |
| Laurel | Shade | 4.7 | 38.7 |
|  | Sun | 4.2 | 25.7 |

[Source: D Curtis, *Plant Ecology independent project*, 1990]

(d) Calculate the percentage increase in the amount of chlorophyll in shade leaves of ivy compared to sun leaves of ivy(1)

(e) Suggest a reason for the differences in chlorophyll concentration and leaf area in sun and shade leaves in these two species.(2)

(Total 10 marks)

**5.** The rate of carbon dioxide uptake by the green succulent shrub *Aeonium goochiae* can indicate the amount of photosynthesis taking place in the plant. This rate was measured at 15°C and 30°C over a 24-hour period. The units of carbon dioxide absorption are mg CO2 h–1.

 The results are shown below. The centre of the graph corresponds to –2 mg CO2 h–1 and the outer ring is +2.5mg CO2 h–1.



[Source: adapted from www.biologie.uni-hamburg.de/b-online/e24/9.htm]

(a) Identify a time that carbon dioxide uptake was the same at both temperatures.(1)

(b) State the maximum rate of carbon dioxide uptake at 15°C.(1)

(c) Compare the rate of carbon dioxide uptake at each temperature in daylight and darkness.(3)

(d) Suggest why the carbon dioxide uptake may at times be negative.(1)

(Total 6 marks)

**6.** State **two** products of the light dependent reaction of photosynthesis.(Total 2 marks)

**7.** (a) State the site of the light-independent reactions in photosynthesis.

(1)

 The absorption spectrum of chlorophyll a and chlorophyll b are shown in the graph below.



(b) On the graph above, draw the action spectrum of photosynthesis for a green plant.(1)

(c) Explain photophosphorylation in terms of chemiosmosis.(3)

(Total 5 marks)

**8.** (a) State the main photosynthetic pigment in plants.(1)

(b) State the **two** materials used to convert carbon dioxide to organic molecules in plants.(2)

(c) Explain **two** ways in which the rate of photosynthesis can be measured.(4)

(Total 7 marks)

**9.** During photosynthesis in plants, light energy is absorbed by chlorophyll. This energy is then used to carry out photolysis, which supply substances that are needed to convert carbon dioxide into organic molecules such as glucose.

(a) State the names of **two** products of photolysis in photosynthesis. (2)

(b) Explain briefly **one** method for measuring the rate of photosynthesis in a plant.(2)

(c) The rate of photosynthesis is affected by light intensity. Draw a line on the graph below to show the relationship between light intensity and the rate of photosynthesis.

(2)

(d) State **two** factors in the environment of a plant, apart from light intensity, that can affect the rate of photosynthesis in the plant. (2)

(Total 8 marks)

**10.** The graph below shows the variation in the concentration of atmospheric carbon dioxide since 1970.



[Source: C D Keeling and T P Whorf, *Atmosphere CO2 concentrations (ppm) derived from in situ air samples* collected at Mauna Loa Observatory, Hawaii]

 The annual fluctuation is mainly the result of changes in the levels of photosynthesis associated with the seasons in Northern Hemisphere forests.

(a) (i) Describe the overall trend shown in the graph.(1)

(ii) Suggest a cause for the overall trend throughout the period 1970–1999.(1)

(b) (i) Using a clear label, identify any **one** point on the graph which shows the CO2 level in mid-summer.(1)

(ii) Explain why the concentration of CO2 varies with the seasons.(2)

(c) Identify **one** gas, other than CO2 , which is contributing to the enhanced greenhouse effect. (1)

(Total 6 marks)

**11.** Explain the reasons for

(a) a large area of thylakoid membrane in the chloroplast.(2)

(b) low rates of photosynthesis in plants growing beneath trees, where the light has already passed through the trees’ leaves.(2)

(c) large amounts of RuBP carboxylase in the chloroplast.(2)

(Total 6 marks)

**12.** (a) State where, in the chloroplast, the enzymes of the Calvin cycle are located.(1)

(b) Explain how the proton gradient in the chloroplast is generated by chemiosmosis.(3)

(c) Explain the relationship between the position of a leaf on a tree and the photosynthetic rate of the leaf(2)(Total 6 marks)

**13.** (a) Draw and label the structure of the chloroplast as seen in the electron microscope.(3)

(b) Explain the relationship between the structure of the chloroplast and its function.(2)

(c) Outline the process of chemiosmosis.(2)

(Total 7 marks)

**14.** (a) Outline the induced fit model of enzyme activity.(3)

(b) (i) State **two** products of the light-dependent reactions of photosynthesis.(2)

(ii) Explain the light-**independent** reactions in photosynthesis.(4)

(Total 9 marks)

**15.** The unicellular green alga *Phaeodactylum tricornutum* is photosynthetic. Cell biologists genetically modified this organism by adding a glucose transporter gene. The modified and unmodified algae were grown in a nutrient medium under a series of different conditions and the growth rate of the cells was measured.



[Source: L A Zaslavskaia, et al., Adapted (2001) *Science*, **292**, pages 2073–2075]

(a) State the role of glucose in the metabolism of cells.(1)

(b) Deduce where you would expect to find the glucose transporter protein in the modified algae cells.(2)

(c) Compare the effect of light on the modified and the unmodified cells.(2)

 Commercially, unmodified algae are grown in shallow sunlit ponds or illuminated containers. The cells only grow in the top few centimetres. However, the modified algae can grow at any depth.

(d) Explain why the modified algae can grow at any depth whereas the unmodified algae can only grow at the surface.(3)

(Total 8 marks)

**16.** Biosphere 2, an enormous greenhouse built in the Arizona desert in the USA, has been used to study five different ecosystems. It is a closed system so measurements can be made under controlled conditions. The effects of different factors, including changes in carbon dioxide concentration in the greenhouse, were studied. The data shown below were collected over the course of one day in January 1996.



[Source: http://www.Ideo.columbia.edu/martins/climate\_water/labs/lab6/labinstr6/html]

(a) (i) Identify the time of day when the sun rose.(1)

(ii) Identify the time of minimal CO2 concentration.(1)

(b) Determine the maximum difference in the concentration of CO2 over the 24-hour period.(1)

(c) Suggest reasons for changes in CO2 concentration during the 24-hour period.

(2)

(Total 5 marks)