

(ii) Explain why the features of the brightly-coloured plants enable them to grow successfully in the areas where they are not collected by humans.

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(Total for question = 6 marks)

Q2.

Single-celled algae can be trapped in gel beads and used to study photosynthesis.

The beads are placed in a test tube of hydrogencarbonate indicator.

The table shows the colour of the indicator when it contains different concentrations of carbon dioxide.

Colour of indicator	Relative carbon dioxide concentration
yellow	highest
orange	higher than atmospheric air
red	same as atmospheric air
magenta	lower than atmospheric air
purple	lowest

A student used the following method to investigate the effect of light intensity on the rate of photosynthesis.

1. Set up five test tubes, each half-filled with red hydrogencarbonate indicator.
2. Add a teaspoon of gel beads containing single-celled algae to each test tube and close with a bung.
3. Place each test tube at a different distance from a lamp in a dark room.
4. Leave the tubes for 30 minutes.
5. Record the colour of the hydrogencarbonate indicator in each tube and the position of the gel beads.

The table shows the results.

Distance from lamp / cm	5	15	25	35	45
Colour of indicator after 30 minutes	purple	purple	red	orange	orange
Position of gel beads in tube after 30 minutes	half-way up	less than half-way up	bottom	bottom	bottom

(i) Describe two control tubes that should be used in this investigation.

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(ii) Explain the changes in colour of the hydrogencarbonate indicator in this investigation.

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(Total for question = 5 marks)

Q3.

Single-celled algae can be trapped in gel beads and used to study photosynthesis.

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Colour of indicator after 30 minutes	purple	purple	red	orange	orange
Position of gel beads in tube after 30 minutes	half-way up	less than half-way up	bottom	bottom	bottom

The colour of the indicator and the position of the beads can be used to give a quantitative measure of the effect of light intensity.

Describe how the method could be modified to give valid, quantitative results.

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(Total for question = 3 marks)

(ii) Justify the method used by the scientist.

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(Total for question = 8 marks)

Q5.

(a) A student investigated the effect of ethanol on plant cell membranes.

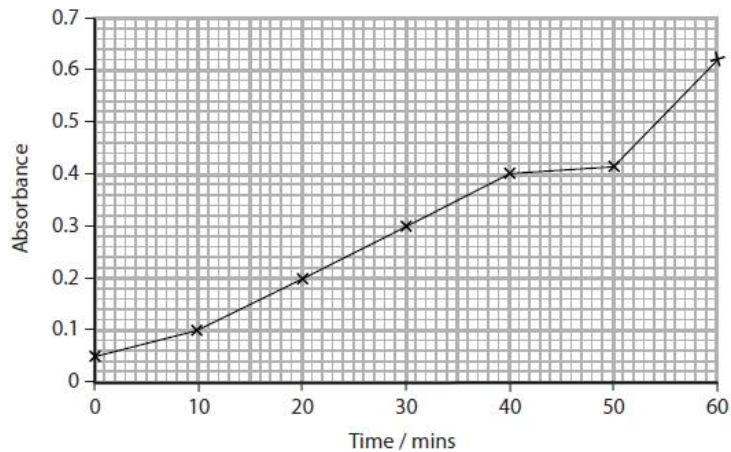
Step 1: The student cut leaf discs from leaves, using a cork borer.

Step 2: These leaf discs were then added to a boiling tube containing 10 cm³ of 40% ethanol solution. The pigments in the leaf discs dissolved in the ethanol, producing a green solution.

Step 3: The boiling tube was shaken and the amount of red light absorbed by this solution (absorbance) was measured at the start.

Step 4: The absorbance was measured every 10 minutes, for an hour.

The graph shows the results of this investigation.



(i) Explain why red light was used in this investigation.

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(ii) Explain the absorbance value at 0 minutes.

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(iii) Explain the effect of ethanol on plant cell membranes.

(2)

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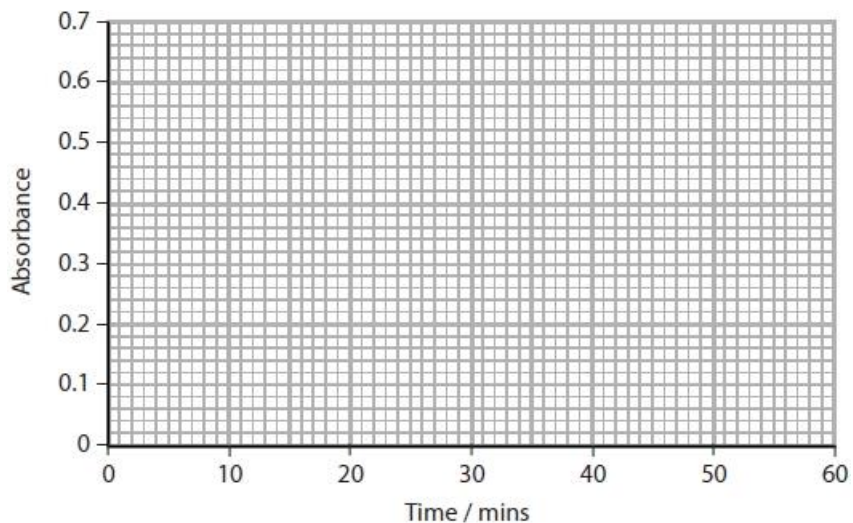
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- (b) The student also carried out a control, using water instead of 40% ethanol.
Draw a line on the graph to show the results for this control.

(2)



- (c) The student then investigated the effect of ethanol concentration on leaves from different plant species.

Justify the modifications to the procedure in part (a) that will be required to obtain valid data.

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(Total for question = 13 marks)

Q6.

Photosynthetic pigments are found in plant leaves.

Describe how you could use chromatography to separate these pigments.

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(Total for question = 3 marks)

Q7.

Plant pigments are involved in photosynthesis.

The action spectrum of chloroplasts and the absorption spectrum of the pigments can be determined.

(i) State the difference between an action spectrum and an absorption spectrum.

(1)

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(ii) State how an action spectrum and an absorption spectrum show that chlorophyll is used in photosynthesis.

(1)

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(Total for question = 2 marks)

Q8.

White clover plants provide a rich source of nitrogen for cattle when grown with grass plants in fields.

The photograph shows a clover plant growing in a field of grass.



A student noticed that the grass plants growing near patches of clover were a darker green than other grass plants.

Devise an investigation to show whether the presence of clover plants affects the concentration of the green pigment chlorophyll in grass plants.

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(Total for question = 6 marks)

Q9.

Macroalgae and microalgae are photosynthetic organisms.

Seaweeds are macroalgae that live attached to rock in coastal areas.

Some seaweeds are green, some are brown and some are red.

The colour of seaweeds depends on the photosynthetic pigments contained in their cells.

Green seaweeds contain chlorophyll, brown seaweeds contain chlorophyll and fucoxanthin and red seaweeds contain chlorophyll and phycoerythrin.

(i) Explain why these seaweeds have different absorption spectra and action spectra.

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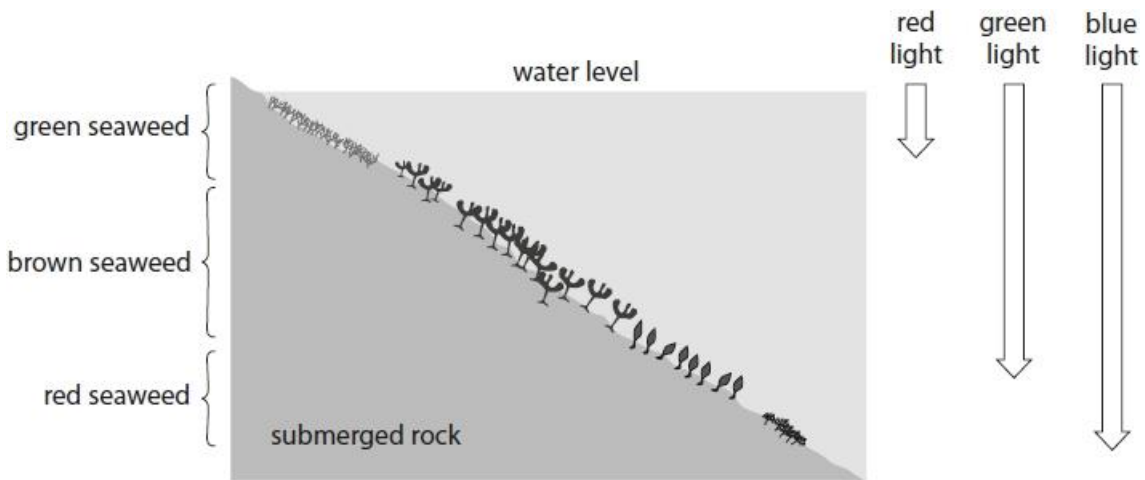
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(ii) The diagram shows the position that these seaweeds occupy on submerged rock and the depth to which different wavelengths of light penetrate into the water.



Explain why the seaweeds occupy different positions on the submerged rock.

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(Total for question = 6 marks)

Q10.

Macroalgae and microalgae are photosynthetic organisms.

Seaweeds are macroalgae that live attached to rock in coastal areas.

Some seaweeds are green, some are brown and some are red.

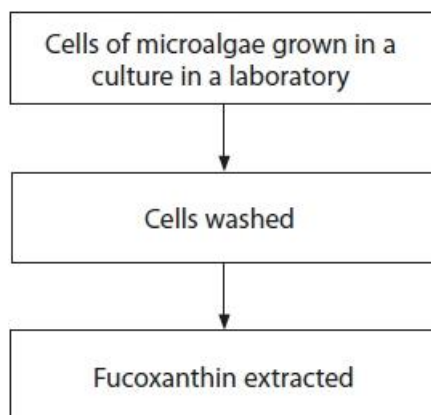
The colour of seaweeds depends on the photosynthetic pigments contained in their cells.

Green seaweeds contain chlorophyll, brown seaweeds contain chlorophyll and fucoxanthin and red seaweeds contain chlorophyll and phycoerythrin.

Fucoxanthin is found in both macroalgae and microalgae.

Fucoxanthin has anti-inflammatory, anti-tumour, anti-diabetes, anti-malarial and anti-obesity activity in humans.

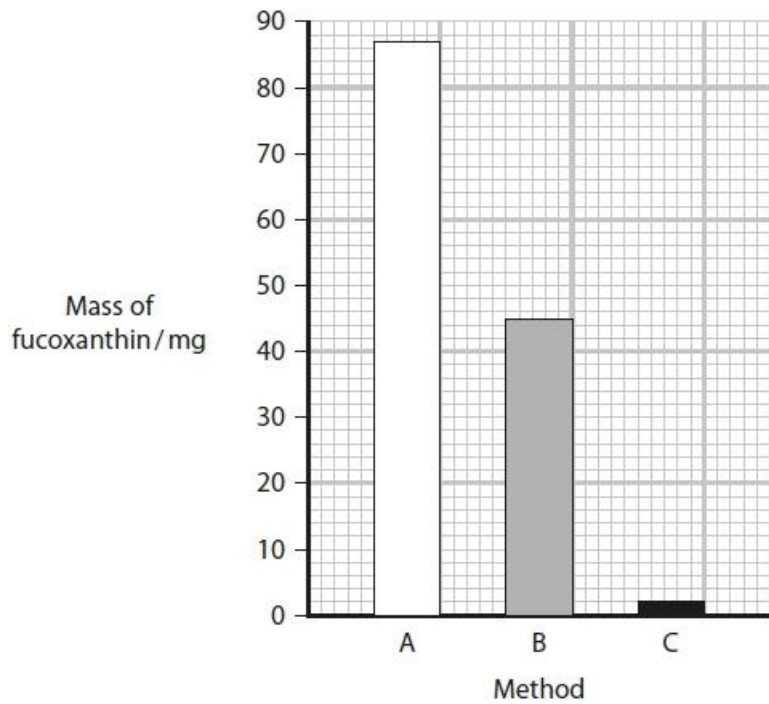
The diagram outlines the steps taken to extract fucoxanthin from microalgae.



The table shows three methods used for washing the cells and extracting the fucoxanthin.

Method	Liquid used for washing cells	Chemical used to extract fucoxanthin
A	water	ethanol
B	culture media	ethanol
C	culture media	water

The graph shows the mass of fucoxanthin extracted from 1 dm³ of cell culture.



(i) Calculate how many times more fucoxanthin was extracted using method A compared with method B.

(1)

Answer

(ii) Explain why different masses of fucoxanthin were extracted using these three methods.

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(Total for question = 4 marks)

Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An answer that includes four of the following:</p> <ul style="list-style-type: none"> • obtain DNA (from the two types of plants) (1) • {use of restriction enzymes to cut DNA into fragments / use of PCR to amplify DNA} (1) • {DNA / fragments} (loaded) on (agarose) gel with {current passed through / voltage or potential difference applied} (1) • fragments of DNA are separated (1) • {same / similar} (banding) pattern suggests they are the same species (1) 	<p>Accept movement of (negatively charged) DNA moves to positive electrode</p> <p>Accept description / diagram of banding pattern Accept shorter fragments travel further</p> <p>Accept converse</p>	Exp (4)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An answer that includes two of the following:</p> <ul style="list-style-type: none"> • (if leaf is green it contains) chlorophyll / photosynthetic pigments (1) • so more {light / more wavelengths of light} absorbed for photosynthesis (1) • so more glucose produced for growth (1) <p>OR</p> <ul style="list-style-type: none"> • (if flower is brightly coloured) it attracts {pollinators / insects} (1) • so (more likely to) reproduce successfully (1) • to produce seeds / pass trait on (1) 	<p>Accept more light / wavelengths of light leads to higher rate of photosynthesis</p> <p>Accept more GALP / TP / GP for growth</p> <p>Accept so increased genetic variation (as less self-pollination)</p> <p>Accept asexual reproduction (through bulb) still possible if pollination does not occur</p>	Exp (2)

Q2.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An answer that includes the following:</p> <ul style="list-style-type: none"> • tube with no gel beads (tube containing hydrogencarbonate indicator in light) (1) • tube (containing hydrogencarbonate indicator and gel beads) in light-proof cover (1) 	<p>Accept tube containing gel beads without algae (tube containing hydrogencarbonate indicator in light) / no algae</p> <p>Accept tube (containing hydrogencarbonate indicator and gel beads) in the dark</p>	Exp (2)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that includes three of the following:</p> <ul style="list-style-type: none"> • {at 5cm and 15cm / at high light intensity / close to lamp} (indicator is purple) there is more photosynthesis, so carbon dioxide being taken in (1) • (at 5 and 15cm) more photosynthesis than respiration so net uptake of carbon dioxide (1) • at 25cm (indicator is red) the carbon dioxide used in photosynthesis equals the carbon dioxide produced in respiration (1) • {at 35 or 45cm / at low light intensity / far from lamp} (indicator is orange) there is more respiration than photosynthesis, so carbon dioxide released (1) 	<p>Allow ref to LDR or carbon fixation for photosynthesis</p> <p>Accept at 5 and 15 cm light is not a limiting factor for photosynthesis, so carbon dioxide is taken in. Accept converse</p> <p>Mp2 may also get mp1</p> <p>Accept reference to compensation point Accept rate of photosynthesis equals rate of respiration</p> <p>Accept there is less light for photosynthesis so less carbon dioxide is used than is produced in respiration Accept net increase in carbon dioxide</p>	<p>Exp (3)</p>

Q3.

Question Number	Answer	Additional Guidance	Mark
	<p>An answer that includes three of the following:</p> <ul style="list-style-type: none"> • two examples of standardisation (2) <p>and a maximum of two from:</p> <ul style="list-style-type: none"> • set up a reference set of solutions at different carbon dioxide concentrations (1) • compare by {colour matching / using a colorimeter} (1) • time taken for algal balls to rise (a known distance / to the surface of the tube) (as oxygen is being produced in photosynthesis) (1) 	<p>eg equal volume of sodium hydrogen carbonate indicator / equal number of algal balls in each tube / mass of algae / mass or volume of beads / same temperature</p> <p>Accept measurement of position of / distance moved by algal beads in tube</p>	Exp (3)

Q4.

Question Number	Answer	Mark
(i)	<p>An answer that makes reference to the following:</p> <ul style="list-style-type: none"> • decreases chlorophyll and carotenoid / plant pigment (synthesis) (1) • chlorophyll a (synthesis) is less than chlorophyll b (synthesis) / chlorophyll a more inhibited / chlorophyll b less inhibited (1) • carotenoid (synthesis) is less than chlorophyll (synthesis) / carotenoid more inhibited than chlorophyll / chlorophyll less inhibited than carotenoid (1) • SD show difference is significant (1) 	(3)

Question Number	Answer	Mark
(ii)	<p>An answer that makes reference to five of the following:</p> <ul style="list-style-type: none"> grown in darkness for a week so leaves big enough to obtain discs / so leaves contain {less / no pigment} (1) discs same {diameter / leaves / leaf age} because affects pigment {amount / content / concentration} (1) 25 discs used so that sufficient pigment obtained / calculate SD (1) {control / 0.0} solution allows comparison (1) same temperature as it affects enzymes (1) same light {wavelength / source / intensity} as light affects synthesis of pigments (1) 48 hours allows time for pigment synthesis (1) 	(5)

Q5.

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(i)	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> red is absorbed (1) because of the presence of chlorophyll (1) 		(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(ii)	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> {chlorophyll / leaf pigment} was present (1) because some cells are damaged / discs not washed (1) 		(2)

Question Number	Answer	Additional Guidance	Mark
(a)(iii)	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> ethanol {disrupts / damages / dissolves / affects} the phospholipid (1) therefore the membrane {becomes more permeable / allows pigment out} (1) 		(2)

Question Number	Answer	Additional Guidance	Mark
(b)	<p>An answer that makes reference to the following:</p> <ul style="list-style-type: none"> starts at 0.05 absorbance value (1) flat line along 0.05 absorbance value (1) 		(2)

Question Number	Answer	Additional Guidance	Mark
(c)	<p>An answer that makes reference to five of the following:</p> <ul style="list-style-type: none"> use leaves of {same age / same position on plant} because this affects concentration of pigment (1) obtain leaf discs from the same part of the leaf because this affects concentration of pigment (1) use same {cork borer / size of leaf disc / diameter of leaf disc} because this affects concentration of pigment (1) use same temperature because temperature affects the rate of diffusion (1) use same volume of ethanol so chlorophyll is diluted the same (1) replicate each ethanol concentration to {see if results are consistent / identify anomaly / to calculate standard deviation / allow statistical test} (1) wash discs to remove pigment (1) 		(5)

Q6.

Question Number	Answer	Additional Guidance	Mark
	<p>A description that makes reference to three of the following:</p> <ul style="list-style-type: none"> • add {extract / pigment} to (start) line (1) • (concentrate spot by) dry and repeat (1) • place paper in named solvent (1) • obtain solvent front / place paper so line or spot above solvent / until reaches near top (1) 	<p>e.g. propanone / ethanol / petroleum ether DO NOT ACCEPT water</p>	(3)

Q7.

Question Number	Answer	Additional Guidance	Mark
(i)	absorption spectrum shows absorption of light of different wavelengths and action spectrum shows rate of photosynthesis at each wavelength	ACCEPT absorption spectrum involves wavelengths only and action spectrum involves photosynthesis / oxygen production only	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	spectra are similar / spectra overlap / peaks and troughs follow similar pattern	ACCEPT similar peak at blue / similar peak at red / similar trough at green	(1)

Q8.

Question Number	Answer	Additional Guidance	Mark
	<p>An explanation that makes reference to six of the following:</p> <ul style="list-style-type: none"> • grass taken from in or near clover and from an area without clover (1) • standardised mass of grass plants collected (1) • use of known volume of (named) solvent to extract pigment from (known mass of) grass (1) • absorbance measured in colorimeter (1) • red filter used to measure absorbance of green chlorophyll(1) • colorimeter zeroed with solvent (1) • replicates taken and means calculated (1) • t test used to look for significant difference (1) • other relevant factor monitored (1) 	<p>Allow lab-based experiment where grass is grown with and without clover</p> <p>Allow use of {sand / pestle and mortar/food mixer} to grind up grass Allow extract filtered</p> <p>Allow details of chromatography if carried out as an alternative with area or intensity of green spots measured</p> <p>Allow compare standard deviation</p>	(6)

Q9.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> • each pigment will absorb different wavelengths (of light) (1) • each pigment will absorb different amounts of light at each wavelength (1) • action spectrum is different because the seaweeds are absorbing different wavelengths of light (1) • the rate of photosynthesis will therefore be different at each wavelength (1) 	<p>ACCEPT each pigment will reflect different wavelength (of light) description of which colour light is {reflected / absorbed}</p>	(3)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> • green seaweeds found in shallow water as they {cannot absorb the green light / can absorb the red light} (1) • {brown / red} seaweeds can absorb {green / blue / other} wavelengths of light so are positioned further down as these wavelengths can penetrate further (1) • seaweeds positioned so that they can absorb light for {photosynthesis / light-dependent reactions / photolysis} (1) • seaweeds positioned to avoid competition with the other types of seaweed (1) 	<p>ALLOW plants for seaweeds</p>	(3)

Q10.

Question Number	Answer	Additional Guidance	Mark
(i)	<ul style="list-style-type: none"> • 2.0 / 1.9 / 1.93 (times / ×) 	DO NOT ACCEPT 1.93 recurring	(1)
(ii)	<p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> • water is more effective than culture media for washing (1) • {water is not the solvent / ethanol is the solvent} for fucoxanthin(1) • ethanol {increases permeability of / disrupts} (cell / vacuole)membrane (1) • more fucoxanthin extracted in method A (compared with methodB) because water enters the seaweed {by osmosis / causing the cells to burst} (1) 	ACCEPT more fucoxanthin extracted in A because washed with water	(3)