Surname	Centre Number	Candidate Number
First name(s)		2

GCE A LEVEL

S24-A400U10-1

A400U10-1

WEDNESDAY, 5 JUNE 2024 – AFTERNOON

BIOLOGY – A level component 1
Energy for Life

2 hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**15**	
2.	**18**	
3.	**18**	
4.	**19**	
5.	**21**	
6.	**9**	
Total	**100**	

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ADDITIONAL MATERIALS

A calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question **6**.

The quality of written communication will affect the awarding of marks.

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Answer **all** questions.

1. ATP has been described as the universal energy currency in cells.

(a) (i) **Draw** and **label** a simple diagram to show the structure of ATP. [2]

(ii) With reference to the **structure of ATP**, explain what is meant by the term **universal energy currency**. [2]

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(iii) State **one** structural difference between the nucleotides found in **DNA** compared to those found in an **ATP** nucleotide. [1]

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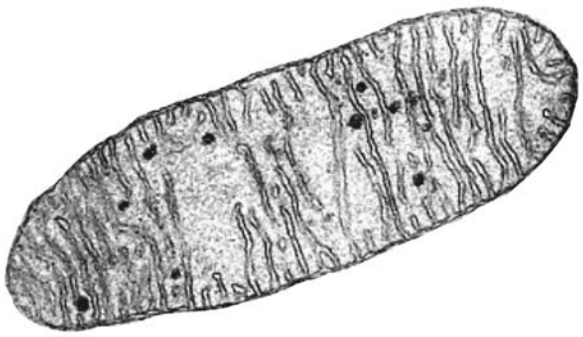
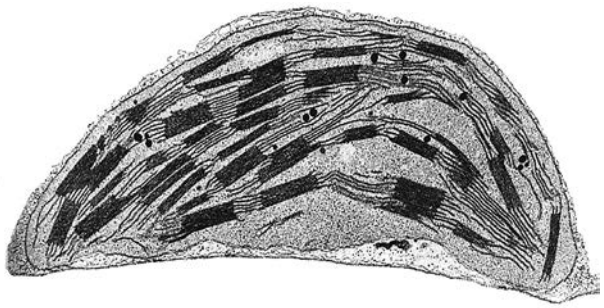
(b) In eukaryotic cells ATP is produced mainly by mitochondria and chloroplasts. Electron micrographs of these organelles are shown in **Images 1.1** and **1.2**.

Image 1.1



a mitochondrion

Image 1.2



a chloroplast

The endosymbiotic theory proposes that both mitochondria and chloroplasts evolved from prokaryotic ancestors.

(i) Identify **two** structural features of mitochondria and chloroplasts that are also found in prokaryotic cells. [2]

I. .....

II. .....

(ii) Name the **two** Domains which contain prokaryotic organisms. [1]

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In both mitochondria and chloroplasts ATP synthesis requires the movement of protons and electrons, which results in the transfer of energy to ATP molecules.

(iii) Complete the table below to identify **where** in chloroplasts and mitochondria the following processes in ATP synthesis take place. [2]

Process in ATP synthesis	Chloroplasts	Mitochondria
Protons are pumped across this membrane by proton pumps using energy from electrons.	.....	.....
A high concentration of protons is formed here.	.....	.....

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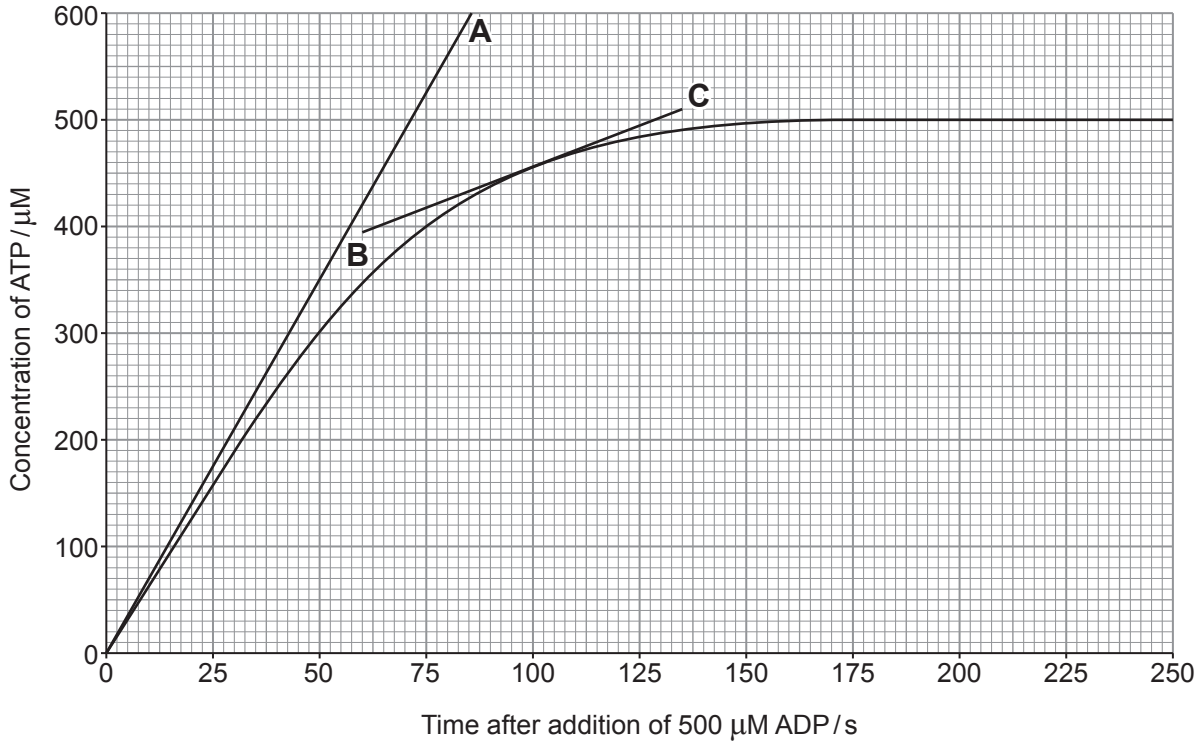
(c) A laboratory experiment was carried out on isolated mitochondria to determine the rate of ATP synthesis. Isolated mitochondria were mixed with 500μM of ADP and excess inorganic phosphate. The concentration of ATP was recorded every 25 seconds over a period of 250 seconds. The results are shown in **Graph 1.3**.

Graph 1.3



(i) Use the tangent marked **B–C** to calculate the rate at 100 seconds following the addition of ADP and **state the unit** of your calculated value.
Show how you obtained the values used in your calculation on Graph 1.3.
[4]

Rate at 100 s = ... unit = ...

(ii) Explain why the initial rate calculated using the line marked **A** was higher than the rate at 100 s. [1]

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2. All animals are consumers and depend on producers as sources of nutrients and energy. Due to the increasing human population size, questions have been raised about the sustainability of human consumption of farmed and natural food sources. Some scientists believe that we are approaching the maximum human population that can be sustained by current plant productivity levels.

(a) (i) State the **types of nutrition** used by the following to obtain energy: [1]

producers .....

consumers .....

(ii) Plant productivity can be expressed as GPP or NPP.
Explain why only NPP is available to consumers. [2]

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(iii) Human population density is increasing exponentially.
Explain what is meant by the term **exponential growth**. [1]

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(iv) State the term used to describe the phrase:

'… maximum human population that can be sustained by current plant productivity levels.' [1]

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(b) NPP is limited by the amount of light energy available to plants and the efficiency at which light energy can be transferred to organic compounds.

(i) Deserts and arctic-alpine regions have very low NPP per km^2.
Identify **one density-independent** factor that accounts for the very low NPP per km^2 of **both** regions.
Explain your answer. [2]

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(ii) Wavelengths of light between 650 and 750 nm (red light) are absorbed more readily by water than shorter wavelengths (blue light).
Use this information and your own knowledge of photosynthesis to explain why marine ecosystems only account for 40.8% of global NPP even though they cover 71.1% of the world's surface. [3]

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(c) In 1987, there were approximately 5×10^9 humans on planet Earth. The mass of organic matter produced and consumed each year is usually expressed in petagrams (Pg), where 1 Pg = 10^{15} g.

(i) Calculate the **annual** consumption of organic matter by humans in 1987 if the average consumption of organic matter was 500 g per human per day.
Express your answer in petagrams to two significant figures. [3]

Annual human consumption of organic matter = ... Pg

(ii) In 1987, it was estimated that humans harvested 1.15 Pg of global NPP and directly consumed 0.76 Pg of organic matter derived from plants.
Calculate the percentage of harvested NPP lost or wasted by the human population at that time. [2]

Percentage of harvested NPP lost or wasted by humans = ... %

(iii) Annual consumption of animal products by humans in 1987 was estimated at 0.15 Pg. Estimated global consumption of plants by livestock in 1987 was 2.2 Pg.

It has been recommended that humans eat fewer animal products as one way of improving sustainability.
Use the data provided to justify this conclusion. [3]

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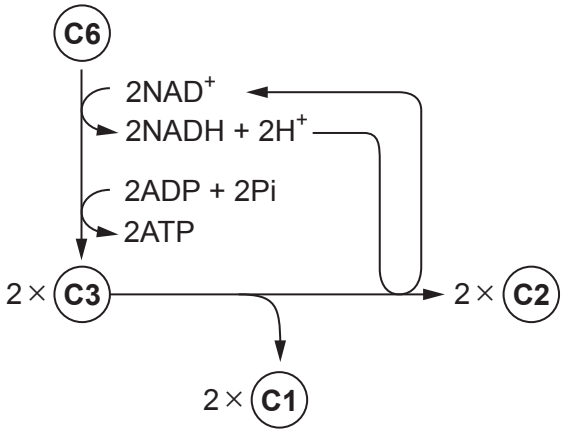
3. Yeast (*Saccharomyces cerevisiae*) is a unicellular fungus that feeds saprotrophically on a range of substrates which are rich in sugars. Yeast is used extensively in the production of bread and sparkling (fizzy) wine through a process known as fermentation. Fermentation is summarised in **Image 3.1**.

Image 3.1



(a) (i) Explain what is meant by the term **saprotrophically**. [1]

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(ii) Name the type of respiration shown in **Image 3.1**. [1]

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(iii) In **Image 3.1**, **C1**, **C2**, **C3** and **C6** indicate the number of carbon atoms in different organic molecules.

I. Name the molecules that contain 1, 2 and 3 carbon atoms. [2]

C1 .....

C2 .....

C3 .....

II. Suggest why the **C1** molecule is important when producing bread and why both the **C1** and **C2** molecules are used when producing sparkling wine. [2]

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(iv) If yeast cells respire for a long time using the process summarised in **Image 3.1** they eventually die. When animal cells respire in a similar way it does not cause cell death. Explain these statements. [3]

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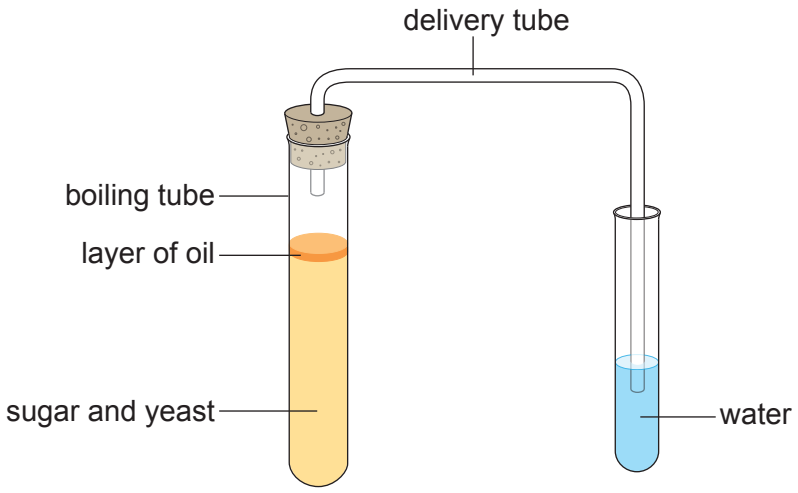
(b) During the production of sparkling wine, additional sugar and yeast are added during a second fermentation.
An experiment was carried out to determine the best sugar to use when producing sparkling wine.

For each sugar, the following method was followed:

1. Add 10 cm^3 of 1 g cm^{-3} yeast suspension to a boiling tube.
2. Add 10 cm^3 of a 2 g cm^{-3} solution of the sugar being tested to a test tube.
3. Place both test tubes in a water bath at 30°C and leave for 5 minutes.
4. Pour the sugar solution into the yeast suspension and mix well.
5. Cover the surface with a thin layer of oil and place the bung with the delivery tube into the boiling tube as shown in **Image 3.2**.

Image 3.2



6. When gas bubbles emerge regularly from the delivery tube, count the number released in one minute.
7. Repeat step 6 for two more periods of 1 minute.

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(i) Both test tubes were left in the water bath for 5 minutes in step 3. Explain why this was necessary. [1]

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(ii) Explain the purpose of the layer of oil. [2]

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(c) Four naturally occurring sugars were tested. **Table 3.3** shows the results of this experiment.

Table 3.3

Sugar	Number of bubbles produced in 1 minute			
	Trial 1	Trial 2	Trial 3	mean
fructose	13	14	14	14
glucose	31	48	45	41
lactose	0	0	0	0
sucrose	12	8	11	10

Both glucose and fructose are sugars containing six carbons. Lactose and sucrose are disaccharides.

(i) Explain why glucose and fructose are known as structural isomers of each other. [1]

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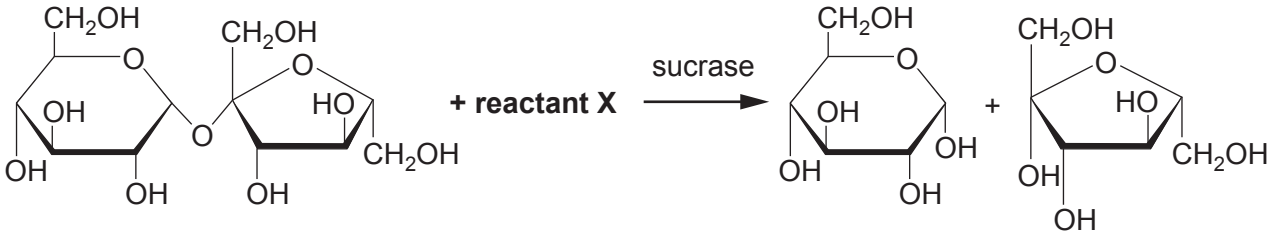
Image 3.4 shows the hydrolysis of sucrose catalysed by the enzyme sucrase.

Image 3.4



sucrose

monosaccharide **Y**

monosaccharide **Z**

(ii) Name reactant **X**, monosaccharide **Y** and monosaccharide **Z** in **Image 3.4**. [2]

reactant **X** .....

monosaccharide **Y** .....

monosaccharide **Z** .....

(iii) Give **one** reason why using sucrose as the respiratory substrate resulted in fewer bubbles being produced than when using glucose. [1]

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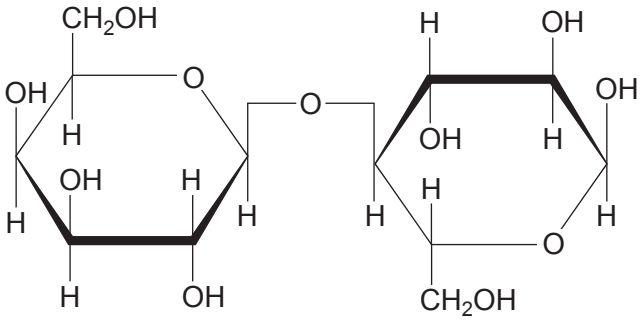
Lactose is the sugar found in milk. **Image 3.5** shows the structure of lactose.

Image 3.5



(iv) Suggest an explanation for the results of the experiment for lactose shown in **Table 3.3**. [2]

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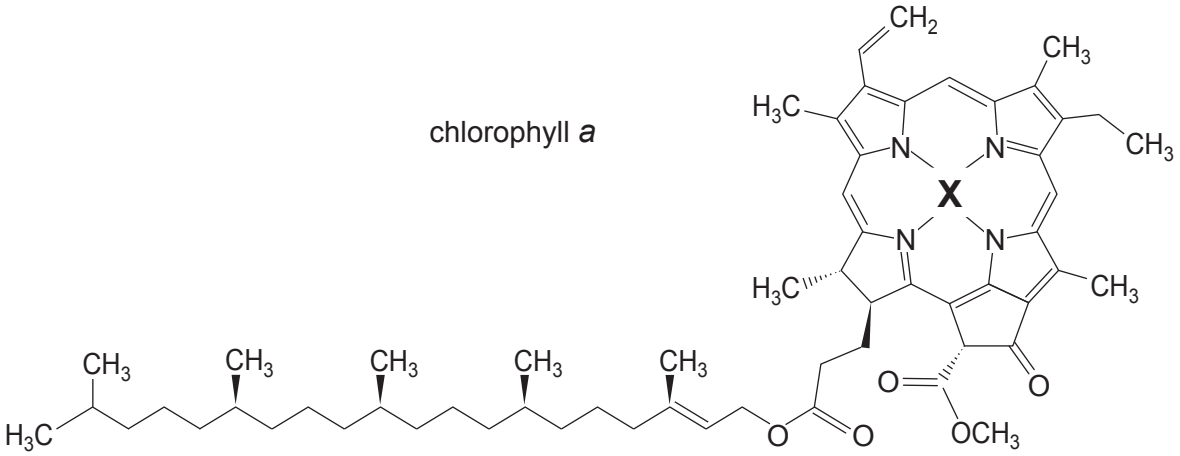
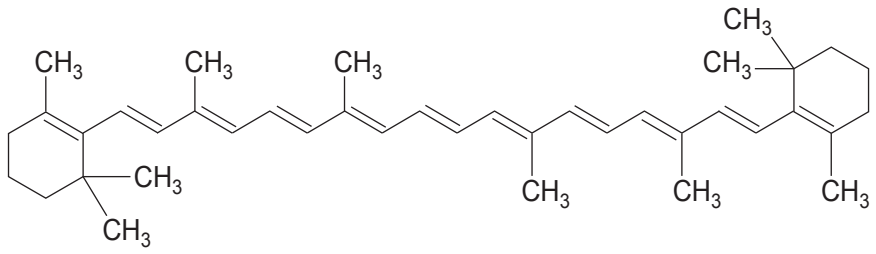
4. Photosynthetic pigments are compounds which absorb some wavelengths of light and reflect others.
Image 4.1 shows the molecular structure of two photosynthetic pigments found in chloroplasts.

Image 4.1

chlorophyll *a*



carotene



(a) (i) Name the inorganic ion **X** found in chlorophyll *a*. [1]

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(ii) Hydrocarbons, such as carotene, contain atoms of carbon and hydrogen only. Apart from the presence of ion **X**, explain why chlorophyll *a* cannot be classified as a hydrocarbon. [1]

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(iii) Carotene is a hydrophobic molecule.
Suggest why carotene molecules are found embedded in thylakoid membranes rather than in the stroma. [2]

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(iv) Research has shown that carotenes have a similar function in membranes to that of cholesterol.
Describe this function. [1]

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Question continued overleaf

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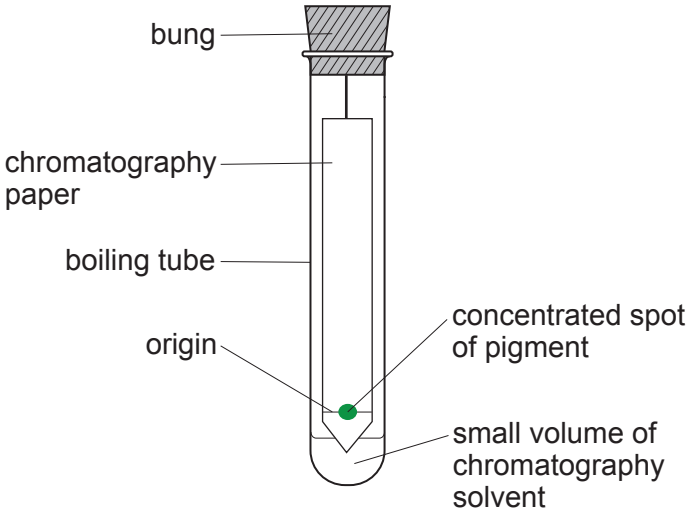
(b) In a school laboratory, photosynthetic pigments can be separated and identified using chromatography. This is shown in **Image 4.2**.

Image 4.2



(i) Propanone is one of the solvents used to extract and separate the pigments. The safety symbol shown in **Image 4.3** is shown on bottles containing this solvent.

Image 4.3

Explain why the method for this practical should include the instruction to make sure that there are no naked flames when this practical is carried out. [1]

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(ii) Explain why a pencil is used to draw the origin line on the chromatography paper. [1]

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(c) Paper chromatography was used to separate the pigments found in the leaves of a plant. The results are shown in **Image 4.4**. Reference values for the main photosynthetic pigments are given in **Table 4.5**.

Image 4.4

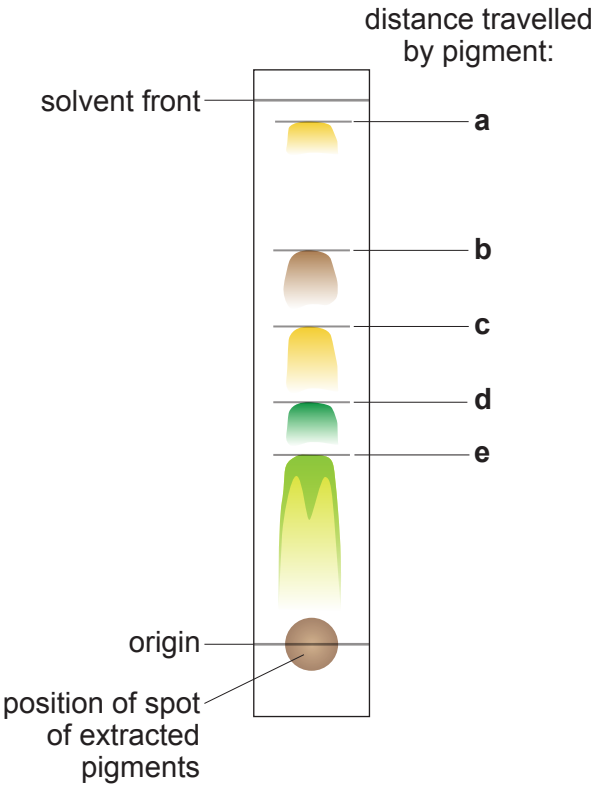

Table 4.5

Reference Rf Values	
Pigment	Rf
beta carotene	0.96
chlorophyll *a*	0.58
chlorophyll *b*	0.48
phaeophytin	0.70
xanthophylls	0.15 to 0.40

Pigments can be identified by calculating an Rf value and comparing this against reference values obtained using the same solvent and chromatography paper.

(i) I. Use the following formula to calculate the Rf value for pigment **b**. [2]

$$\text{Rf} = \frac{\text{distance travelled by pigment}}{\text{distance travelled by solvent front}}$$

Rf = ...

II. Use your calculated Rf value and **Table 4.5** to identify pigment **b**. [1]

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(ii) Suggest why it is important that the calculated Rf values are compared to reference Rf values obtained using the same solvent and chromatography paper. [3]

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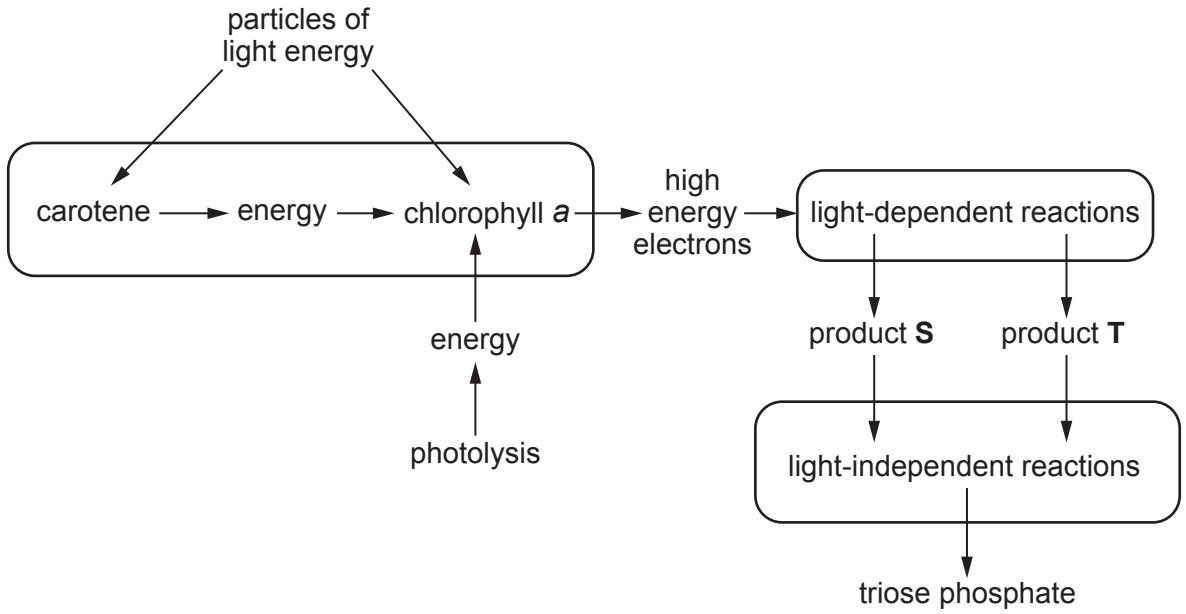
(d) **Image 4.6** summarises the light-dependent and light-independent stages of photosynthesis.

Image 4.6



(i) State the term used to describe the **particles of light energy**. [1]

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(ii) Product **S** is synthesised via an electron transport chain while product **T** is synthesised from the final electron acceptor of this series of reactions. Name products **S** and **T**. [2]

Product **S** .....

Product **T** .....

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(iii) At high light intensities, carotene passes energy to other electron acceptor molecules rather than to chlorophyll *a*. This reduces the rate of photolysis to prevent chlorophyll *a* being damaged.
Some weedkillers inhibit the synthesis of carotene.
Using all the information provided, explain **one** way in which this type of weedkiller can cause plant death. [3]

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5. Avocados (*Persea americana*) have become a popular food in all parts of the world. More than 50% of world production is based in one Central American country and most are grown in a single region of this country.
To meet global demand, nearly 90 000 hectares (900 000 000 m^2) of land have been converted to avocado plantations. **Image 5** shows an avocado plantation.

Image 5

(a) With reference to **Image 5** suggest how avocado production may have contributed to:

(i) biodiversity loss; [2]

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(ii) climate change. [2]

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(b) The original forest shown in **Image 5** is an example of a climax community.

(i) State what is meant by the term **climax community**. [1]

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(ii) Suggest how the following abiotic factors would have changed following the establishment of the avocado plantation.
Explain your answers.

I. soil moisture content; [2]

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II. soil fertility. [3]

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(iii) Outline a method that could be used to estimate and compare the plant biodiversity of the original forest and the avocado plantation. [4]

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(c) In North America, 95% of all avocados consumed are of the Hass variety and most are imported from Central America. New varieties of avocado are produced by cross-pollination.
Avocados have a high degree of genetic polymorphism. Due to this, most attempts to breed useful new varieties have low success rates.

(i) Use the information to suggest why attempts to breed new useful varieties of avocado have low success rates. [2]

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(ii) The Hass avocado is highly susceptible to a soil-borne pathogen, *Phytophthora cinnamomi*, which causes a disease called root rot.
Infected plants wilt easily due to the pathogen affecting transpiration in the plant.
Leaf death follows as a result.
Use the information given to identify the tissue affected by this pathogen and conclude why infected plants wilt and eventually die. [3]

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(iii) Some wild species of avocado show resistance to *P. cinnamomi*.
Current practices in establishing avocado plantations are leading to some wild species becoming extinct.
Explain why it is important that these wild species are conserved **and** suggest **two** ways of conserving them for the future. [2]

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6. In 2004, it was estimated that approximately 18% of the human population lacked access to safe drinking water.
In most industrialised nations, samples of drinking water are cultured in laboratories. Any bacteria present are identified using microscopic methods. The samples are monitored for the presence and level of different types of faecal bacteria, some of which can be pathogenic. Bacterial load (the number of bacteria per cm^3) is determined using a viable count.

State the conditions needed to culture bacteria in a laboratory and explain why each of these conditions is required.
Describe how different types of bacteria can be identified using microscopic methods.
Explain what is meant by a viable count and describe how you could determine the bacterial load of a sample of drinking water. (Details of aseptic technique are not required.) [9 QER]

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END OF PAPER

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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