Surname	StemUp Model Solution	Centre Number	Candidate Number
Other Names			2

GCE A LEVEL

A400U10-1

S19-A400U10-1

BIOLOGY – A level component 1
Energy for Life

THURSDAY, 6 JUNE 2019 – MORNING

2 hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**17**	
2.	**14**	
3.	**16**	
4.	**15**	
5.	**18**	
6.	**11**	
7.	**9**	
Total	**100**	

A400U101
01

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

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

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 pages 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 **7**.

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

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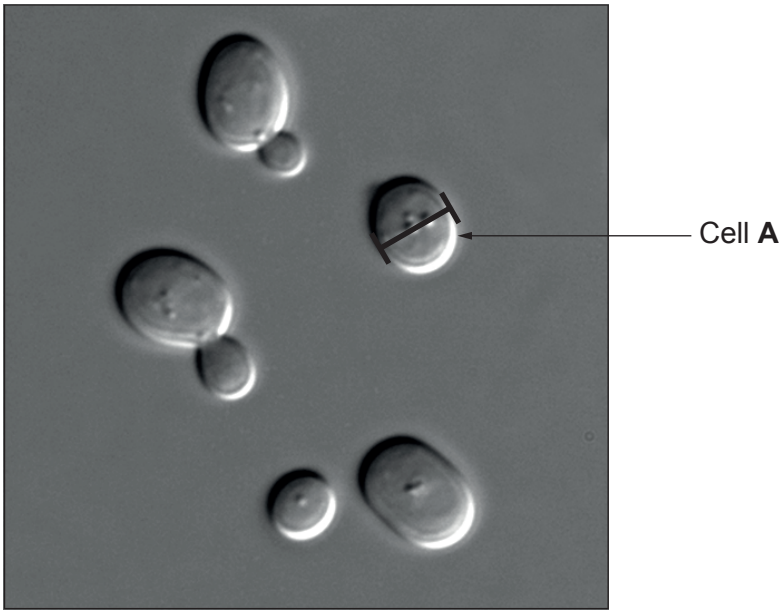
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Answer **all** *questions.*

1. Yeast *(Saccharomyces cerevisiae)* is a eukaryotic organism which undergoes sexual reproduction when under environmental stress, forming resistant spores, but under normal conditions reproduces asexually by budding, as shown in the photograph below.



Magnification × 1000

(a) (i) Calculate the actual size of yeast cell **A** shown above. [2]

Length of cell A on the image = 11 mm = 11 000 µm

actual size = image size ÷ magnification

= 11 000 µm ÷ 1000

Actual size = 11 µm

(ii) Give **two** reasons why yeast would be classified as a eukaryotic organism. [1]

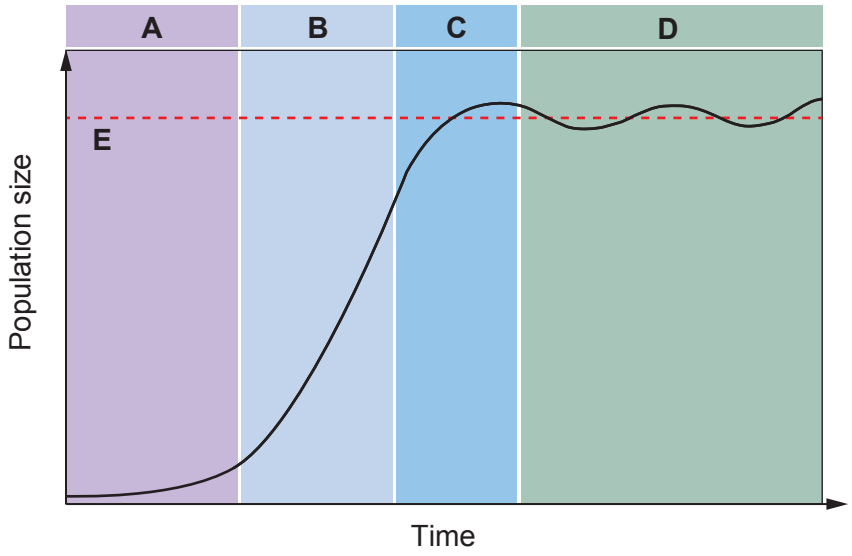
It has a nucleus and membrane-bound organelles (e.g. mitochondria), and 80S ribosomes.

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Population growth curves can be modelled using simple organisms such as yeast. One such growth curve using yeast is shown below.
Dried yeast cells were placed in a nutrient solution in an anaerobic fermenter with excess glucose as a respiratory substrate. Samples were taken at intervals and the number of cells determined. The results of this work are shown below.



(b) (i) Suggest a unit for time on the x-axis. [1]

Hours

(ii) State what is represented by line **E**. [1]

Carrying capacity

(c) (i) Identify phases **A**, **B** and **D** labelled on the graph and explain what is happening to the yeast population in each phase. [3]

A *Lag phase: cells rehydrate and synthesise enzymes, so the rate of cell division is slow.*

B *Log (exponential) phase: maximum rate of reproduction, greater than death, as there are no limiting factors.*

D *Stationary phase: reproduction = cell death, as limiting factors (intraspecific competition) stop growth; carrying capacity reached.*

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(ii) Suggest **one** factor that has caused the change in the shape of the graph in phase **C** and suggest what you would expect to have happened to the population at the end of phase **D**. [2]

Build-up of toxic waste, such as ethanol from anaerobic respiration, slows the growth of the yeast.

At the end of phase D the population will decrease, going into a decline (death) phase.

(d) Identify the phases during which you would expect sexual reproduction of the yeast cells to be occurring. Explain why sexual reproduction would be an advantage to the yeast. [3]

Phases C and D.

Here the environment is stressful and changing, so sexual reproduction is an advantage because it produces genetic variation in the offspring, so some may be adapted to survive the changing environment.

Some individuals may also survive the poor conditions as resistant spores.

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(e) A knowledge of population numbers is very important in ecology so that changes can be detected quickly. To estimate the populations of mobile animals, a method of mark and recapture is commonly used. The photograph below shows a marked Chittenango snail *(Novisuccinea chittenangoensis)*, which is classified as an endangered species.



The table below shows the method used to estimate the population and the results obtained.

Method	Result
1. Capture and count animals.	430 snails
2. Mark/tag them.	
3. Release them back into the community.	
4. Capture a second sample and count them.	410 snails
5. Record the number of marked/tagged individuals re-captured.	100 snails

The population can be estimated using the following equation.

$$\frac{M}{P} = \frac{R}{n}$$

P is the population size to be estimated.
M is the number of members of the population that are captured initially and tagged.
n is the number of members of the population that are captured subsequently.
R is the number of members of this re-captured population that are tagged.

Use the equation to calculate the population of snails. [2]

M / P = R / n, so P = (M × n) ÷ R

P = (430 × 410) ÷ 100 = 176 300 ÷ 100

Population = 1763 snails

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(f) Suggest **two** assumptions that must be made when using this technique to estimate snail population numbers. [2]

There are no births or deaths, so the population size stays constant, and there is no immigration or emigration during the study.

Marked snails mix evenly back into the population, so all snails have an equal chance of being recaptured, and the mark is non-toxic, is not rubbed off and does not make the snails more visible to predators.

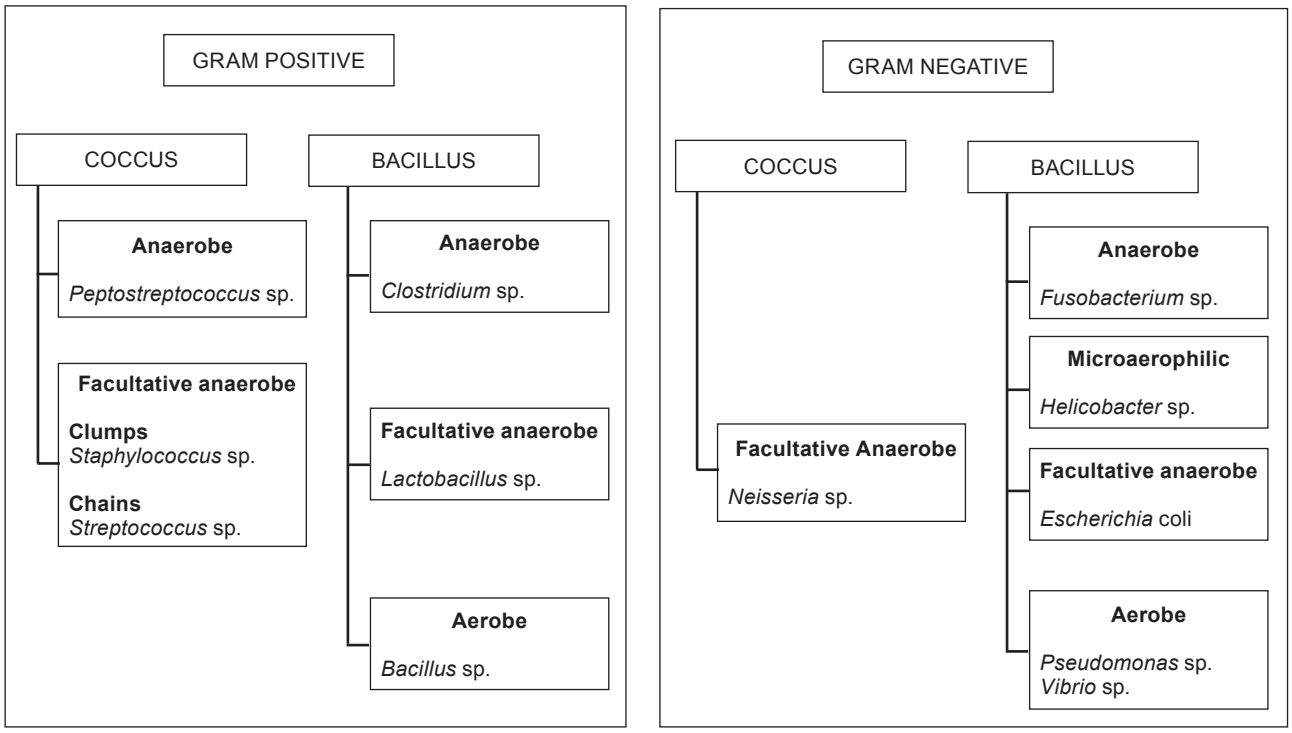
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2. Accurate and definitive bacterial identification is essential for disease diagnosis, treatment and the trace-back of outbreaks associated with microbial infections. Bacterial identification is also used in a wide variety of other applications including microbial forensics, criminal investigations, bio-terrorism threats and environmental studies.

The simplified key shown below can be used to identify bacteria given some of their features.

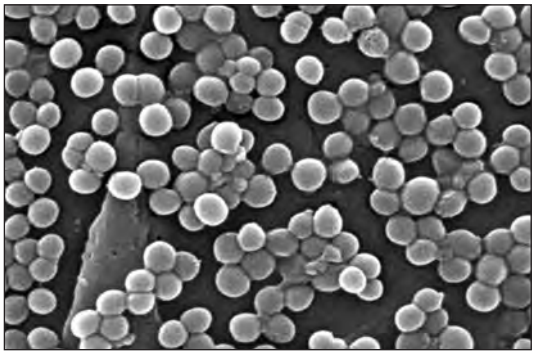
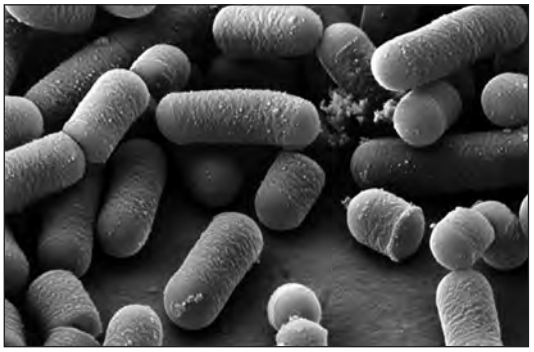


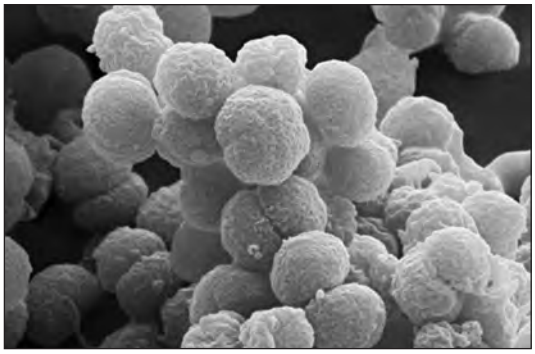
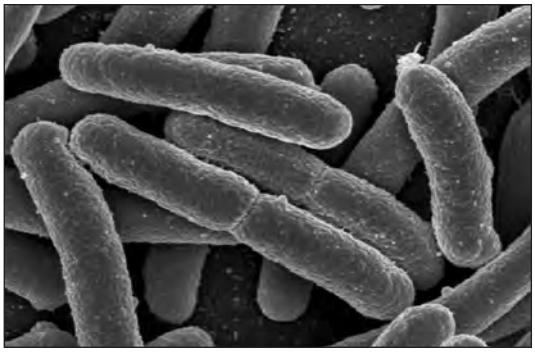
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The images below show four different bacteria together with information about their oxygen requirements and the results of Gram staining.

A	B
	
Facultative anaerobe Gram positive	Facultative anaerobe Gram positive

C	D
	
Facultative anaerobe Gram negative	Facultative anaerobe Gram negative

(a) Using the key provided, identify the **four** bacteria in the images. [4]

A *Staphylococcus sp.*

B *Lactobacillus sp.*

C *Neisseria sp.*

D *Escherichia coli*

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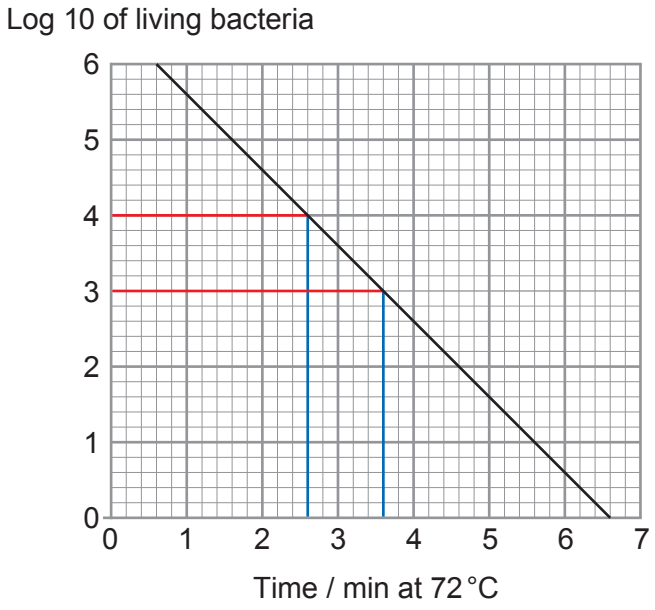
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Each bacterial species has its own particular heat tolerance. During a process such as pasteurisation, the rate of cell destruction is logarithmic. Bacteria subjected to heat are killed at a rate that is proportional to the number of bacteria present. The process is dependent both on the temperature of exposure and the time required at this temperature to accomplish the desired rate of destruction.

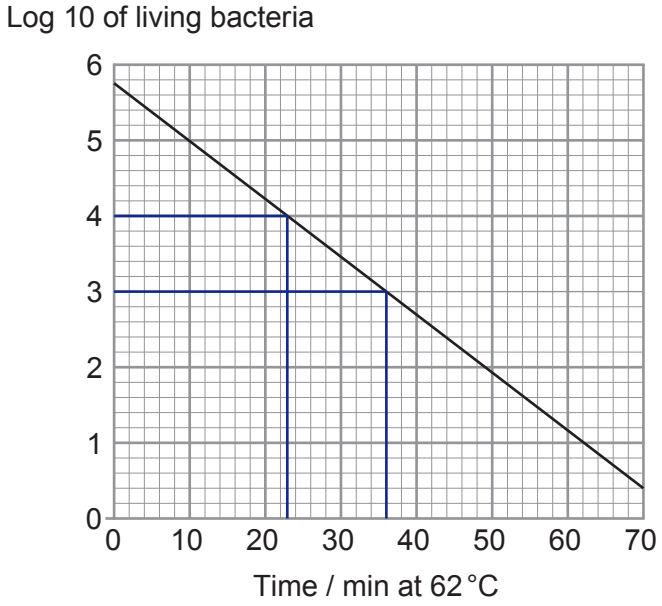
The D value is the time in minutes at a given temperature required to destroy 90% of the bacterial population.

Graph 1



In the example shown above at 72 °C, the D value = 1 minute. This means that for each minute of processing at 72 °C the bacterial population will be reduced by 90%.

Graph 2



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(b) Follow the method shown on graph **1** to calculate the D value for 62 °C (graph **2**). [3]

From graph 2: log 4 at 23 min and log 3 at 36 min

(a 90% fall from 10 000 to 1000 bacteria)

D = 36 − 23 = 13 min

D Value = 13 minutes

(c) Describe a method that you could use to determine the number of living bacteria in the original sample prior to heat treatment. No reference to aseptic technique is required. [4]

Carry out a serial dilution of the sample, e.g. 1 cm^3 of sample in 9 cm^3 sterile water, to make a 10× dilution series.

Spread 0.1 cm^3 (1 cm^3 or less) of each dilution onto separate nutrient agar plates.

Incubate at 25 to 30 °C for 24 to 48 hours.

Count the colonies on a plate with separate colonies; each colony grew from one living bacterium.

Multiply by the dilution factor to calculate the number of bacteria per cm^3 of the original sample. Repeat three times and calculate a mean.

(d) Describe the effect of heat in the process of pasteurisation on the proteins in the bacteria. [3]

Heat increases the kinetic energy of the molecules, so the hydrogen bonds break and the protein is denatured.

These bonds hold the specific 3-D shape, so the shape changes, e.g. the active site of an enzyme changes shape.

The protein can no longer carry out its function, as enzyme-substrate complexes can no longer form.

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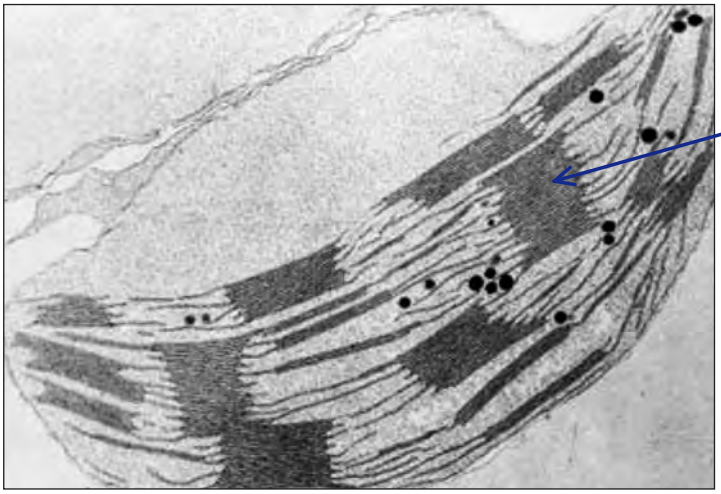
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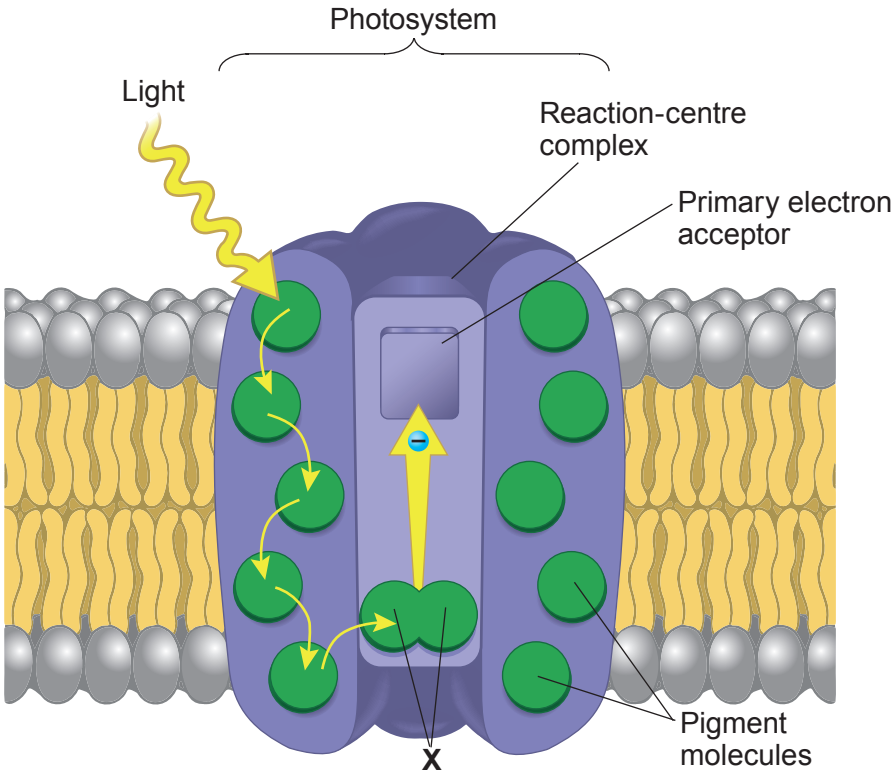
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3. The electron micrograph below shows a chloroplast, taken from a eukaryotic organism.



(a) (i) **Identify using a clearly labelled arrow** where photosystems are found on the electron micrograph above. [1]

The diagram below represents one photosystem.



(ii) Identify the pigment found at **X**. [1]

Chlorophyll a

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(b) Explain the role of photosystems in the light dependent stage of photosynthesis. [3]

Pigment molecules absorb light energy (photons) and pass the energy to the reaction centre.

Acting as a transducer, chlorophyll a in the reaction centre is excited and emits high-energy electrons.

The electrons pass down the electron transport chain, powering proton pumps so ATP is synthesised and NADP is reduced.

Many micro-organisms living in dark regions of the oceans use chemosynthesis to produce organic molecules. Some deep sea vent bacteria oxidise hydrogen sulfides. This releases energy which is used to combine carbon dioxide and hydrogen to synthesise carbohydrates. Sulfur and water are released in this process as shown in the equation below.

$$CO_2 + 4H_2S + O_2 \longrightarrow CH_2O + 4S + 3H_2O$$

(c) Complete the table to state **four** differences between chemosynthesis and photosynthesis. [4]

Chemosynthesis	Photosynthesis
No light required	*Light required*
No chlorophyll, no photosystems or chloroplasts	*Chlorophyll in photosystems (chloroplasts) required*
High-energy electrons come from hydrogen sulfide; sulfur produced	*High-energy electrons come from chlorophyll; no sulfur produced*
Oxygen is used and water is produced	*Oxygen is produced and water is used*

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(d) Following the synthesis of carbohydrate, a number of inorganic ions are needed to synthesise other biological molecules.

State **three** different biological molecules **and** the inorganic ions required to synthesise them. [3]

I. Proteins (amino acids) — Nitrate ions

II. Phospholipids — Phosphate ions

III. Chlorophyll — Magnesium ions (Mg^{2+})

(e) Herbicides inhibit photosynthesis in many ways.
One group of herbicides block electron transport, so chlorophyll continues to absorb light energy but cannot pass this energy on.
Light energy not used in electron emission damages chlorophyll leading to chlorosis.
Desiccation occurs because of the formation of oxygen free-radicals, which are highly destructive to cell membranes.

Use the information given and your own knowledge to explain how blocking electron transport from photosystems with this herbicide could lead to the death of a plant. [4]

Light energy that is not used damages chlorophyll, so the photosystems can no longer absorb light energy.

With no electron transport, no ATP or reduced NADP is made for the light-independent reactions (Calvin cycle).

So no carbohydrate (glucose) is synthesised for respiration or for making other biological molecules.

Less respiration means less ATP for cell division, protein synthesis and active transport.

Oxygen free radicals destroy cell membranes, so the cells dry out and die, killing the plant.

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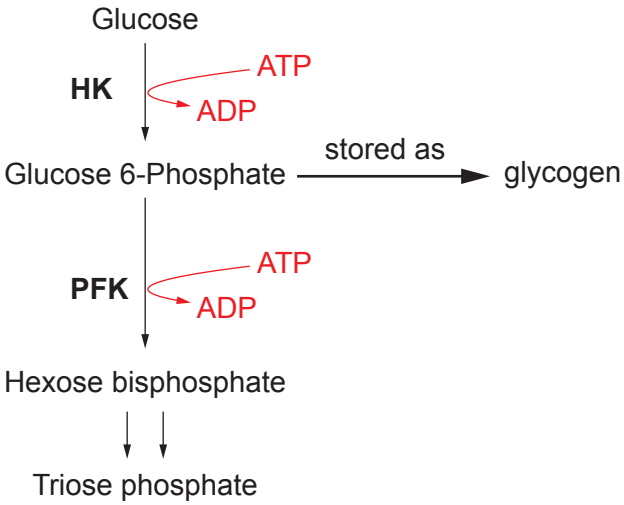
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4. Glycolysis is the initial stage of respiration and involves hydrolysis of glucose and the production of ATP. The diagram below shows part of glycolysis.



Control of glycolysis is largely by end-product inhibition:

- High levels of ATP allosterically inhibit the enzyme PFK in the liver thus lowering its affinity for its substrate.
- PFK is the main regulatory enzyme in glycolysis, but it is not the only one.
- HK, the enzyme catalysing the first step of glycolysis, is inhibited by its product, glucose 6-phosphate.

(a) Explain the term *allosteric inhibition*. [2]

The inhibitor (ATP) binds to the enzyme at an allosteric site, away from the active site.

This changes the shape of the active site, so the substrate no longer fits and enzyme-substrate complexes cannot form.

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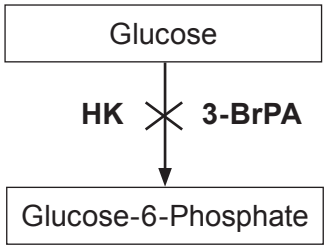
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(b) (i) Explain why the cell uses inhibition of PFK as the main method of slowing glycolysis, rather than using the inhibition of HK. [2]

Inhibiting PFK means glucose 6-phosphate is still made and can be converted to glycogen, allowing the storage of excess glucose.

If HK were inhibited, no glucose 6-phosphate could be produced, so no glucose could be stored as glycogen.

3-BrPA is a chemical which is an inhibitor of HK. It appears to add a small chemical group to the enzyme thus changing its shape.



3-BrPA has been shown to stop ATP production and cause severe depletion of cellular ATP.

3-BrPA exhibits potent cytotoxic activity against cancer cells. It is currently undergoing trials as an anti-cancer agent, particularly in cancer cell types which rely heavily on ATP from glycolysis.

(ii) Explain how 3-BrPA acts as a potential anti-cancer agent. [3]

3-BrPA changes the shape of HK, so HK is no longer able to bind with glucose.

Glucose 6-phosphate cannot be synthesised, so glycolysis cannot take place.

No ATP is produced, so the cancer cells, which rely heavily on ATP from glycolysis, stop mitosis (cell division) and the cells die.

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(c) NAD is a hydrogen acceptor used in many stages of respiration. Methylene blue can be used as an artificial hydrogen acceptor. It decolourises when reduced and can be used to give an indication of the rate of respiration.

An experiment was set up using isolated liver mitochondria extracted in ice-cold, isotonic buffer. The same volume and concentration of pyruvate, mitochondrial suspension and methylene blue was added to each experiment. The temperature was changed for each experiment and the experiment repeated three times. Thermostatic water baths were used throughout.

(i) Explain why the mitochondria were initially suspended in **ice cold**, **isotonic buffer**. [3]

Ice cold: slows enzyme activity (e.g. enzymes that would digest the mitochondria) and stops disruption of the membranes.

Isotonic: keeps the same water potential (Ψ) inside and outside the mitochondria, so no water moves by osmosis and they do not burst (lyse).

Buffer: maintains the optimum pH, stopping pH changes.

(ii) Explain why pyruvate was used as the respiratory substrate and not glucose. [2]

Glycolysis (the breakdown of glucose) occurs in the cytoplasm, not in the mitochondria.

Pyruvate is the substrate used by mitochondria, in the link reaction and Krebs cycle.

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The results of the experiment are shown in the table below.

Temperature / °C	Time taken for methylene blue to decolourise / seconds				
	Trial 1	Trial 2	Trial 3	Mean	Standard deviation
10	320	290	385	332	±48.6
20	280	275	282	279	±3.6
30	165	172	159	165	±6.5
40	102	105	98	102	±3.5
50	156	162	148	155	±7.0
60	330	355	342	342	±12.5

(iii) State **one** conclusion you can draw from this experiment and comment on the reliability of the results in the table shown. [3]

40 °C is the optimum temperature, as methylene blue decolourised fastest (mean 102 s), so the rate of respiration was highest.

The results at 10 °C are the least reliable, as the trials vary widely (290 to 385 s) giving a large standard deviation of ± 48.6.

From 20 to 60 °C the results are reliable, e.g. at 40 °C the standard deviation is only ± 3.5.

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5. The sea rises and falls twice a day; this is called tidal movement. In river estuaries there is still tidal movement but little wave action. As the seawater on a rising tide moves across bare rock it brings sand, mud particles and detritus. The lack of wave action in estuaries results in this material settling out when the tide stops moving. These materials build-up and in time raise the level of mud and eventually form soil. This habitat is called a saltmarsh where rooted plants grow. Higher land, frequently used for agriculture, drains through the saltmarsh into the river.



(a) State the term used to describe the

I. process by which the saltmarsh community is formed. [1]

Primary succession

II. first organisms to colonise the mud. [1]

Pioneer species

III. the final group of organisms which inhabit the area which was once mud. [1]

Climax community

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(b) A saltmarsh is an extreme environment for organisms trying to survive.

Using the information given, identify **three** abiotic factors which cause this to be an extreme environment for plant survival. Explain each of your answers. [6]

I. *High salt content: the low water potential means the rooted plants have problems getting water by osmosis, and water may leave the roots.*

II. *Waterlogging of the soil: low oxygen, so roots cannot respire aerobically for the active uptake of mineral ions, and the roots may die.*

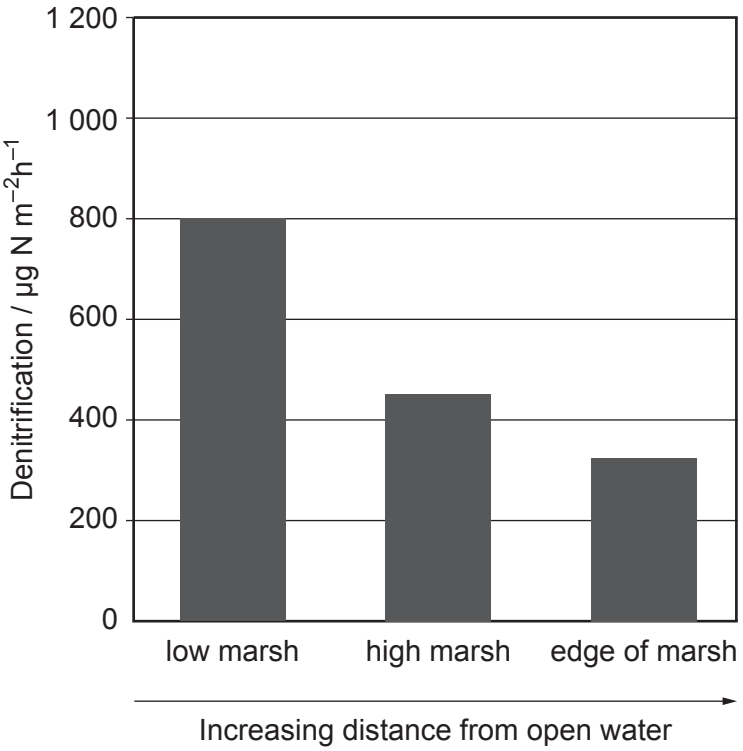
III. *Tidal flow twice a day causes a sideways drag on the plants, possibly uprooting them, while sand and mud scour the plants and cover leaves, reducing photosynthesis.*

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Denitrification is a biotic factor which affects saltmarsh ecology. The results of an investigation into rates of denitrification are shown in the chart below. Further investigations also showed that denitrification varied through the year. It was higher in the summer than the winter months.



(c) (i) State why denitrification is classed as a biotic factor. [1]

It involves living organisms: denitrifying bacteria (e.g. Pseudomonas).

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(ii) Using the information given and your own knowledge, identify **two** factors affecting denitrification. Explain each of your answers. [3]

Waterlogging: the low marsh is waterlogged most, giving anaerobic conditions (low O_2), so more denitrification occurs, as shown by the highest rate in the low marsh.

Temperature: denitrification is higher in summer, as warmer temperatures increase the rate of enzyme reactions and bacterial division, so there are more denitrifying bacteria.

(d) Describe a practical method which you could carry out on the saltmarsh to investigate the **change in vegetation over time**. [5]

Mark out a permanent area, e.g. 10 m × 10 m, or a permanent transect from the river to the edge of the marsh, so the same area is sampled each time.

Use quadrats placed at random coordinates (or at regular intervals along the transect).

In each quadrat identify all plant species and record their percentage cover (abundance), then calculate a species diversity index.

Review the area periodically, e.g. at the same time each year for several years, and compare.

Check tide times for safety and minimise trampling damage to the marsh.

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6. In the past, Red Kites *(Milvus milvus)* almost became extinct in the UK and by 1905 there were estimated to be only three breeding pairs in the UK, all of which were in West Wales.



It has taken a century for the UK Red Kite population to recover from the few remaining birds. In 1986 the recovery was helped by the re-introduction of some Red Kites from Wales to England and Scotland. Although they are still rare, between 2008 and 2011 they were found breeding in over 700 areas that were sampled across the UK.

The population recovery has involved keeping nest sites secret and round-the-clock protection by volunteers.

(a) In 1995 there were 284 Red Kites in the UK with numbers increasing to 1025 per cent of the original population between 1995 and 2017. Calculate the approximate **number of breeding pairs** of Red Kites present in 2017. [3]

2017 population = 284 × 1025 ÷ 100

= 284 × 10.25 = 2911 Red Kites

breeding pairs = 2911 ÷ 2 = 1455.5

1456 breeding pairs

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(b) In areas where Red Kites were absent and then re-introduced the numbers increased much more rapidly than in areas where they were already established. Explain the reasons for this. [3]

Where kites were re-introduced there was less intraspecific competition for food and nest sites, as there were few other kites. There were also fewer predators, and with low numbers disease was less likely to be passed on, so more chicks survived.

(c) Explain why the location of nest sites needed to be kept secret with round-the-clock protection. [1]

To prevent theft of eggs or chicks by poachers (egg collectors).

Many Red Kite chicks are tagged so that their survival and lifespan can be monitored. Survival rates in Northern Scotland are poorer than elsewhere, mainly because of illegal poisoning and shooting on grouse-shooting estates.

(d) Suggest **two** ways in which society could improve the survival rates of Red Kites. [2]

Prosecute people who poison or shoot kites, using stronger legislation. Make holding poisons illegal, and educate people to raise awareness.

Red Kites have often bred successfully in woodland SSSI's.

(e) State what is meant by an SSSI and why Red Kites may breed more successfully in these sites. [2]

A Site of Special Scientific Interest. SSSIs are protected by law from development or other damage, so nest sites are undisturbed.

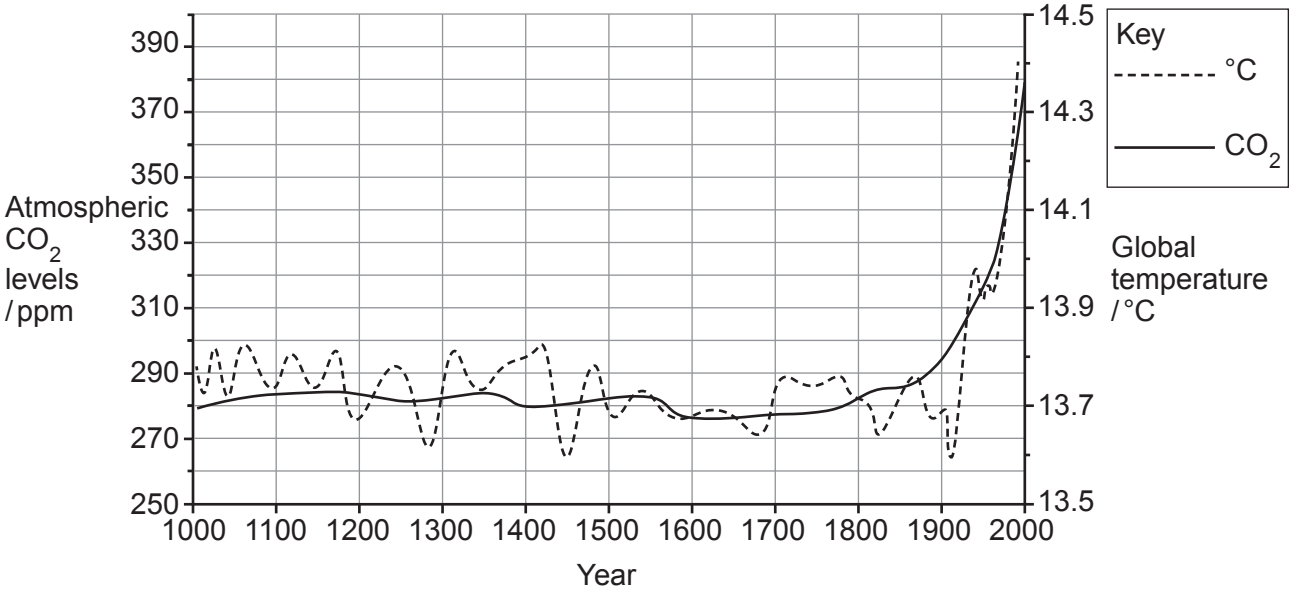
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7. Since the beginning of the Industrial Revolution (250 years ago), carbon dioxide concentration in the atmosphere has risen from about 280 parts per million to 408 parts per million in 2018. This means that for every million molecules in the atmosphere, 408 of them are now carbon dioxide, the highest concentration in two million years. Ice samples provide a record of the Earth's atmospheric temperature and CO_2 levels. The data below shows how global temperatures and atmospheric CO_2 levels have changed from the year 1000.



Use your knowledge of the carbon cycle to explain how humans have affected global carbon dioxide levels and temperature levels. Use the information and data provided to support your answer.
Describe the effects of increasing carbon dioxide levels and global temperatures on aquatic environments. [9 QER]

Carbon cycle: humans burn fossil fuels (coal, oil and gas), releasing carbon that was locked away for millions of years into the atmosphere as CO_2.

Trees store carbon in their biomass (wood, stems and leaves). Deforestation and clearing land for other uses removes plants that take CO_2 out of the atmosphere by photosynthesis, so less CO_2 is removed.

The land is replaced by crops, which store less carbon, or by cattle, which produce CO_2 and methane. Burning and increased decay of the cleared vegetation by decomposers release even more CO_2 by respiration.

CO_2 is a greenhouse gas: it absorbs and re-radiates heat, increasing the enhanced greenhouse effect and raising global temperatures. The oceans absorb

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heat, which causes a lag between rising CO_2 and rising temperature, so temperatures will not yet have reached their maximum.

Data: from 1000 to about 1800, CO_2 stayed fairly constant at about 280 ppm and the temperature fluctuated around 13.7 °C. Since the Industrial Revolution (about 1850 to 1900) there has been a significant increase in both: CO_2 rose to about 380 ppm by 2000 and is now 408 ppm (2018), an increase of about 28 ppm since 2000, while temperature rose to about 14.4 °C by 2000.

The CO_2 and temperature curves show a very close correlation, indicating a direct link: human activities increasing CO_2 are raising global temperatures, and both are now at their highest level since the year 1000.

Aquatic environments: CO_2 dissolving in the ocean forms carbonic acid, which increases the acidity of the water (ocean acidification), so the calcium carbonate shells of molluscs and plankton end up thinner and more fragile.

Higher temperatures cause coral bleaching, as corals expel their algae, leading to coral reef destruction and a loss of biodiversity.

Warmer water holds less dissolved oxygen, which affects fish, and fish migrate to cooler waters, which affects fisheries. Higher temperatures also increase algal blooms, although more CO_2 could increase photosynthesis by aquatic plants and algae.

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