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Pearson Edexcel
Level 3 GCE

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Thursday 6 June 2019

Morning (Time: 2 hours)

Paper Reference **9BN0/01**

Biology A (Salters Nuffield)

Advanced

Paper 1: The Natural Environment and Species Survival

You must have:

Calculator, HB pencil, ruler

Total Marks

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Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Show your working in any calculation questions and include units in your answer where appropriate.
- Answer the questions in the spaces provided
– *there may be more space than you need.*

Information

- The total mark for this paper is 100.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*
- You may use a scientific calculator.
- In questions marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ►

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Answer ALL questions.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

- 1** Photosynthetic plants use light as a source of energy for the synthesis of organic molecules. Photosynthesis is a two-stage process.

(a) The light-dependent reactions take place in the chloroplast.

- (i) Which of the following describes where, in the chloroplast, the light-dependent reactions take place?

(1)

- ☐ **A** cristae
- ☐ **B** matrix
- ☐ **C** stroma
- ☒ **D** thylakoids

- (ii) Which of the following are the products of the light-dependent reactions?

(1)

- ☐ **A** carbon dioxide and reduced NADP
- ☐ **B** glucose and oxygen
- ☐ **C** reduced NAD, ATP and oxygen
- ☒ **D** reduced NADP, ATP and oxygen

- (iii) Which of the following is the source of the hydrogen produced by the light-dependent reactions?

(1)

- ☐ **A** glucose
- ☐ **B** reduced NAD
- ☐ **C** reduced NADP
- ☒ **D** water

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- (b) In some commercial glasshouses, the concentration of carbon dioxide in the atmosphere is increased.

Explain why this increase in carbon dioxide concentration affects the growth of plants in glasshouses.

(3)

Carbon dioxide is a limiting factor for photosynthesis in the glasshouse, so increasing its concentration increases the rate of the light-independent reactions.

More carbon dioxide is fixed by RUBISCO, combining with RuBP to produce more GP, which is reduced to GALP.

Therefore more carbohydrate such as glucose, starch and cellulose (and other molecules such as amino acids and lipids) is produced.

This provides more energy and materials for new cells, leading to a greater rate of cell division and growth, so the plants grow faster.

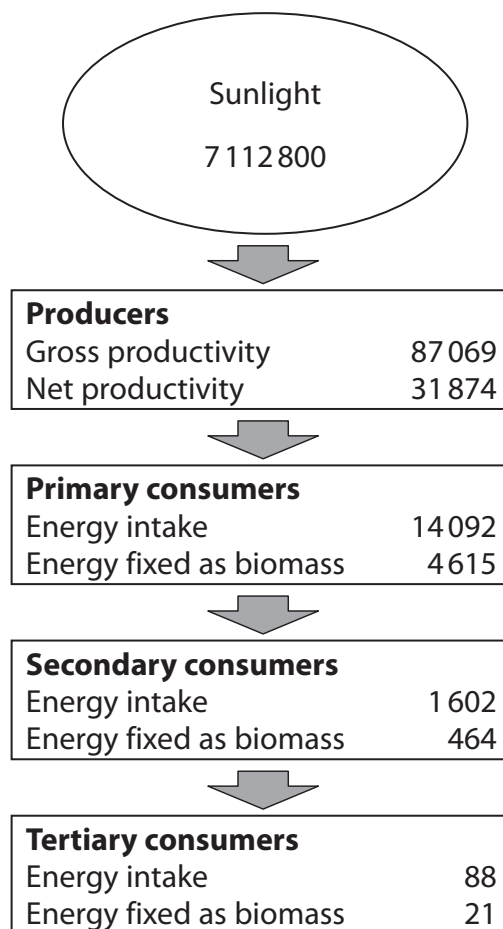
(Total for Question 1 = 6 marks)



- 2 Silver Springs is a state park in Florida. The photograph shows one of the many waterways in this state park.



- (a) Energy flow through this ecosystem has been studied. The results are shown in the flow chart. All values are given in $\text{kJ m}^{-2} \text{yr}^{-1}$.



- (i) Calculate how much energy is lost through respiration by the primary consumers. (1)

$$14\,092 - 4615 = 9477$$

Answer 9477 $\text{kJ m}^{-2}\text{yr}^{-1}$

- (ii) The table gives details of energy transfers at the different trophic levels.

Trophic level	Energy fixed as biomass / $\text{kJ m}^{-2}\text{yr}^{-1}$	Transfer efficiency (%)
Producers	31 874	
Primary consumers	4615	14.5
Secondary consumers	464	10.1
Tertiary consumers	21	4.5

Calculate the efficiency of energy transfer between primary consumers and secondary consumers.

(1)

$$(464 \div 4615) \times 100 = 10.05$$

..... 10.1 %

- (iii) The efficiency of photosynthesis can be measured as the percentage of energy from sunlight that is converted to gross primary productivity (GPP).

Which of the following shows the percentage efficiency of photosynthesis in this ecosystem?

(1)

- ☒ A 1.2%
- ☐ B 12%
- ☐ C 36.6%
- ☐ D 55.8%



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(b) Explain why the value for GPP is lower than the light energy available to the ecosystem. (3)

Not all of the light falls on the leaves of the producers; some falls on the water, soil or bark and other parts of the plant that do not photosynthesise.

Some of the light is reflected from the surface of the leaf.

Some of the light misses the chloroplasts (chlorophyll) and passes straight through the leaf.

Some of the light is the wrong wavelength, so it is not absorbed by the chlorophyll in the photosystems.

(Total for Question 2 = 6 marks)



- 3 A study of the genetics of grass snakes has led to the identification of a new species of grass snake in the UK.

The barred grass snake was thought to be a variation of the common grass snake, *Natrix natrix*.

However, the barred grass snake, *Natrix helvetica*, has been found to be a different species.

Both types of grass snake are normally found in lowland regions in the south of England. The snakes can be more than a metre long, are found near water and eat mainly amphibians such as frogs and newts.

The common grass snake is olive green with a bright yellow collar.

The barred grass snake, shown in the photograph, is grey with black markings.



- (a) State what is meant by the term species.

(1)

A group of organisms with similar characteristics that can interbreed to produce fertile offspring.



(b) Describe how DNA profiling could be carried out to show that these snakes are different species.

(4)

Obtain DNA samples (e.g. from blood or skin cells) from both types of grass snake.

Amplify the DNA by PCR and cut it into fragments using restriction enzymes, producing fragments of different lengths (target regions of DNA).

Load the fragments into wells in an agarose gel and carry out gel electrophoresis by passing an electric current through the gel.

Gel electrophoresis separates the fragments of DNA by size, as shorter fragments move further towards the positive electrode.

Compare the patterns of bands: more differences in the pattern of bands would indicate that the snakes are different species, while similar patterns would indicate the same species.

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(c) Explain how these two species of snake could have arisen from a common ancestor.

(4)

Mutation produced variation within the population of the ancestral grass snakes, e.g.

snakes with different colours or markings.

By natural selection, the snakes which were better camouflaged in their surroundings

survived to reproduce and passed on their alleles.

Over many generations this gave rise to two populations with differing allele frequencies,

so separate gene pools developed.

The two populations became reproductively isolated (e.g. different mating behaviour) and

could no longer interbreed to produce fertile offspring.

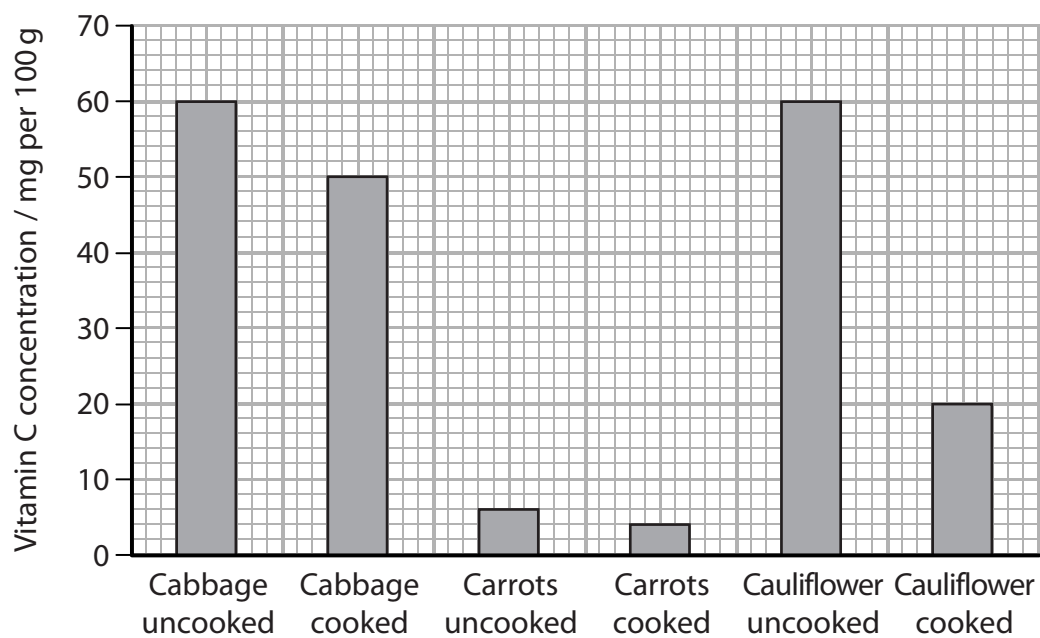
As both live in the same habitat in the south of England, this is sympatric speciation.

(Total for Question 3 = 9 marks)



- 4 Vitamin C has antioxidant properties. The human body cannot make or store vitamin C. A healthy diet must contain vitamin C.

The graph shows the concentration of vitamin C in a variety of cooked and uncooked vegetables.



- (a) (i) How many of the following conclusions are valid for these results?

- cooking destroys all of the vitamin C
- each vegetable contains less vitamin C when it is cooked than when it is uncooked
- cabbage contains the most vitamin C

(1)

- ☐ A 0
- ☒ B 1
- ☐ C 2
- ☐ D 3



(ii) The recommended daily value (DV) of vitamin C for men is 90 mg.

Calculate the mass of cooked cauliflower that would provide 90 mg of vitamin C.

(2)

Cooked cauliflower contains 20 mg per 100 g

$$90 \div 20 = 4.5$$

$$4.5 \times 100 \text{ g} = 450 \text{ g}$$

Answer *450 g*

(b) Devise a procedure that can be used to investigate the effect of cooking on the vitamin C content of cauliflower.

(4)

Weigh out two equal masses of cauliflower (e.g. 50 g each). Boil one for a set time (e.g. 10 minutes) and leave the other uncooked.

Grind each sample with the same volume of distilled water and filter, so the cooked and uncooked extracts are made from the same mass of cauliflower.

Put the same volume and concentration of DCPIP (e.g. 1 cm³ of 1%) into a test tube and titrate; add the cauliflower extract drop by drop from a burette until the blue DCPIP is decolourised. Record the volume of extract needed.

Repeat with vitamin C solutions of known concentration to plot a calibration curve, and use it to determine the vitamin C content of the cooked and uncooked cauliflower.

Repeat three times and calculate means.

(Total for Question 4 = 7 marks)



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- 5 The extent of decomposition is important in helping to determine the time of death of a mammal.

Body farms are outdoor laboratories where experiments take place to investigate the changes that take place after death in a range of conditions. Body farms use the bodies of pigs or donated human bodies.

The effects of factors such as temperature, moisture and position of the body on the rate of decomposition can be studied.

- (a) Explain the effect of ambient temperature on the rate of decomposition.

(3)

An increase in ambient temperature will increase the rate of decomposition (decay).

This is because molecules have more kinetic energy, so enzyme activity increases, both of the body's own enzymes and those of decomposers.

An increase in temperature also increases the growth rate and multiplication of decomposers such as bacteria and fungi.

Conversely, low temperatures decrease the rate, and very high temperatures may denature enzymes and decrease the rate of decomposition.

- (b) Describe the changes that occur inside a body in the first week after death.

(3)

Body temperature falls (algor mortis) until it reaches the ambient temperature.

Rigor mortis: stiffening of the muscles, which wears off after about 36 hours.

Autolysis: cells and tissues are broken down by the body's own enzymes.

Putrefaction by bacteria, causing discolouration of the skin and bloating due to the accumulation of gases.



(c) Body farms use the bodies of pigs to study the changes in insect species on a body after death.

(i) Describe how this study could be carried out.

(3)

Standardise the pigs studied, e.g. same breed, size, mass, age and sex, all killed at a known time.

Place the bodies outdoors in the same position and control or monitor abiotic factors such as temperature and humidity (e.g. using a data logger).

Record the presence of the different species of insects on each body, and their life cycle stages (eggs, larvae, pupae, adults).

Make the observations at regular intervals of time, e.g. every 24 hours.

(ii) Explain how the results of this study could be used to help to establish the time of death of a human.

(3)

Record which insect species are present on the human body.

Take into account which stages of the life cycle are present, e.g. the size or instar of the larvae.

Compare these with the results from the investigation on pigs, to identify the stage of succession reached and so determine the time of death.

Environmental variables at the scene, such as temperature, need to be taken into account, as they affect the rate of insect development and succession.

(Total for Question 5 = 12 marks)



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6 Electron microscopes have enabled scientists to view the ultrastructure of cells.

(a) (i) Which of the following structures is found in animal cells?

(1)

- ☐ A amyloplast
- ☐ B chloroplast
- ☐ C mesosome
- ☒ D ribosome

(ii) Which of the following structures is found only in plant cells?

(1)

- ☒ A amyloplast
- ☐ B Golgi apparatus
- ☐ C mesosome
- ☐ D vacuole

(iii) Which of the following structures is found in both animal and plant cells?

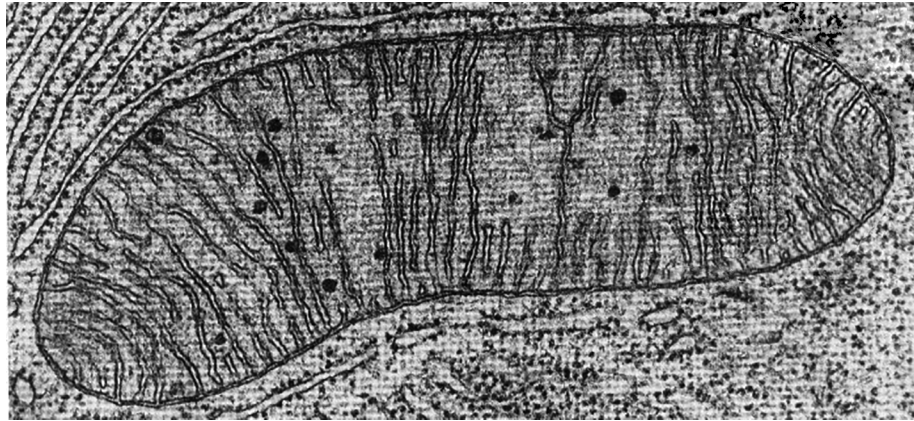
(1)

- ☐ A amyloplast
- ☐ B cell wall
- ☐ C pili
- ☒ D smooth endoplasmic reticulum



P 5 6 7 1 0 A 0 1 5 3 2

(b) The photograph shows an electron micrograph of a mitochondrion from a liver cell.



Magnification $\times 20\,000$

Calculate the maximum actual length of this mitochondrion.

(2)

Length of mitochondrion in photograph = $116\text{ mm} = 116\,000\text{ }\mu\text{m}$

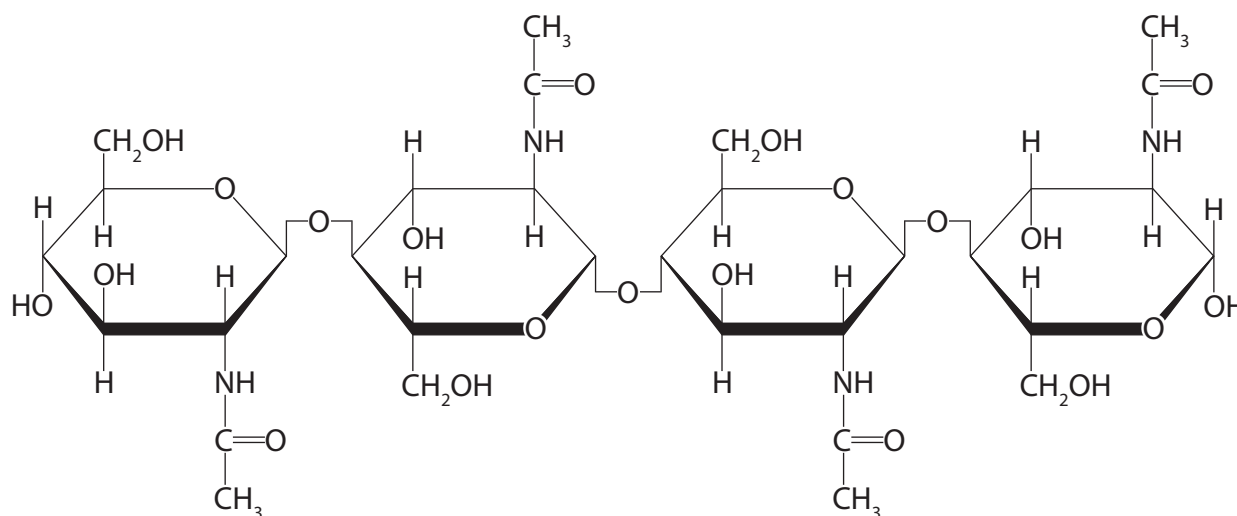
Actual length = image length $\div$ magnification

= $116\,000 \div 20\,000 = 5.8\text{ }\mu\text{m}$

Answer *5.8 μm*



- (c) The diagram shows part of a molecule of chitin, a modified polysaccharide found in fungal cell walls.



Compare and contrast the structure of chitin with that of a cellulose molecule.

(3)

Similarities: both are polymers whose monomers are joined by glycosidic bonds formed in condensation reactions.

In both, every other monomer is inverted (rotated through 180°), giving long, straight, unbranched chains.

Differences: the monomers of chitin have eight carbon atoms, whereas the monomers of cellulose (β-glucose) have six carbon atoms.

Chitin has an additional side chain (NHCOCH₃) containing nitrogen, an amide group, in place of an OH group, but cellulose does not contain nitrogen.

(Total for Question 6 = 8 marks)



P 5 6 7 1 0 A 0 1 7 3 2

7 Some species of bacteria have developed resistance to antibiotics.

This has led scientists to investigate many molecules for antimicrobial properties.

Peptides extracted from broad bean plants and cowpea plants have been studied.

(a) Describe how a peptide bond is formed.

(2)

A peptide bond is formed by a condensation reaction, in which a molecule of water is released.

It forms between the amine group (NH_2) of one amino acid and the carboxyl group (COOH) of an adjacent amino acid.

(b) The effects of these plant extracts were tested on pathogenic bacteria. It was found that each extract had an effect on its own, but the effect was greater when used together.

Devise a procedure that scientists may have used to measure the effects of these extracts on pathogenic bacteria.

(4)

Spread a culture of the pathogenic bacteria evenly over sterile nutrient agar plates to produce a bacterial lawn, using aseptic technique.

Soak sterile filter paper discs of equal size in the same volume and concentration of: broad bean extract, cowpea extract, both extracts combined, and distilled water as a control.

Place the discs on the agar plates, tape the lids and incubate at 37°C for 48 hours.

Measure the diameter of the zone of inhibition around each disc and calculate its area.

Repeat and compare the mean sizes of the zones: the larger the zone of inhibition, the more effective the antimicrobial properties.



(c) A bacteriostatic antibiotic works by

(1)

- ☐ A destroying bacteria
- ☐ B destroying viruses
- ☒ C preventing the multiplication of bacteria
- ☐ D preventing the development of antibiotic resistance

(d) Hospitals have developed practices in response to the increase in hospital acquired infections.

Describe the infection control practices hospitals have introduced.

(3)

Hand wash stations and antibacterial alcohol gel (hand sanitisers) at the entrance to wards and by beds, for staff and visitors.

Doctors and nurses are not allowed to wear ties, watches or long sleeves (bare below the elbows).

Testing patients for the presence of antibiotic resistant bacteria such as MRSA before admission, and isolation of infected patients.

Increased washing of bedding (or use of disposable bedding) and disinfection of beds and surfaces.

(Total for Question 7 = 10 marks)



P 5 6 7 1 0 A 0 1 9 3 2

8 Thrombophilia is a condition that increases the risk of blood clots forming.

This condition increases the risk of venous thromboembolism (VTE), a condition where a blood clot forms in a vein. Thrombophilia due to the production of overactive factor V can be inherited.

Factor V is involved in the conversion of prothrombin to thrombin.

- (a) (i) Describe the role of thrombin in blood clotting.

(3)

Thrombin is an enzyme.

It catalyses the conversion of the soluble plasma protein fibrinogen into insoluble fibrin.

A mesh of fibrin fibres traps platelets and red blood cells to form a clot.

- (ii) Explain why a mutation in the gene coding for the protein factor V may increase the risk of VTE.

(3)

The mutation in the gene changes the sequence of amino acids (primary structure) in the factor V molecule, changing its tertiary structure so it is overactive.

Overactive factor V will increase the conversion of prothrombin into thrombin, so more thrombin is produced.

More fibrinogen is converted into fibrin, increasing blood clotting, so a clot is more likely to form in a vein.



- (b) A study was carried out to determine the incidence of VTE in people of different ages. Those who developed VTE were then tested for the factor V gene mutation.

The results of this study are shown in the table.

Age range	Percentage incidence of VTE in the study group (%)	Percentage of VTE patients with factor V mutation in the study group (%)
less than 20 years of age	1.3	49.3
over 70 years of age	34.0	20.9

Deduce the relative impact of the genotype and environmental factors on the development of VTE.

(4)

The percentage incidence of VTE is much higher in people older than 70 (34.0%) than in people under 20 (1.3%).

However, in younger people a larger percentage of the VTE patients have the factor V mutation (49.3%) than in older people (20.9%).

Therefore genotype has a greater influence on the incidence of VTE in younger people.

Therefore the greater incidence of VTE in older people is probably a result of environmental factors, such as immobility, obesity, smoking or surgery, which have a greater impact than genotype in this age group.

(Total for Question 8 = 10 marks)



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- 9 An experiment was carried out to determine the effect of temperature on the activity of the enzyme catalase in yeast cells.

The substrate was hydrogen peroxide. A suspension of yeast cells was added to hydrogen peroxide.

The volume of oxygen produced during the initial two minutes was recorded. This was repeated at a range of temperatures.

The results are shown in the table.

Temperature / °C	Mean volume of oxygen / mm ³
20	80
30	240
40	540
50	320
60	120

- (a) (i) Calculate the temperature coefficient (Q_{10}) for this reaction between 20°C and 30°C.

(1)

$$Q_{10} = \text{rate at } 30^\circ\text{C} \div \text{rate at } 20^\circ\text{C}$$

$$= 240 \div 80 = 3$$

Answer 3.....



- (ii) Explain the effects of a temperature increase from 20 °C to 30 °C on the initial rate of activity of catalase in the yeast cells.

(3)

Between 20 °C and 30 °C the enzyme and substrate molecules have more kinetic energy.

Therefore there will be more frequent collisions between catalase and hydrogen peroxide.

So more enzyme-substrate complexes are formed, increasing the initial rate of activity.

The Q_{10} value of 3 indicates that the activity triples with the 10 °C temperature rise.

- (iii) Explain what happens to the Q_{10} value between 40 °C and 50 °C.

(2)

The Q_{10} value is less than 1.0 ($320 \div 540 = 0.59$), as the rate decreases.

This is because the enzyme is denatured: the active site changes shape, so the substrate no longer fits the active site and fewer enzyme-substrate complexes are formed.



P 5 6 7 1 0 A 0 2 3 3 2

(b) Leaf rust is a disease caused by a species of fungus. Leaf rust affects cereal crops such as wheat.

Leaf rust yeast spreads through cereal crops when the humidity is high.

Discuss the possible impact of climate change on the effects of leaf rust on the yield of wheat crops.

(4)

Climate change could result in increased temperature, increased humidity, changes in rainfall patterns or periods of drought.

An increase in temperature could increase the growth and reproduction of the leaf rust fungus.

Increased rainfall and increased humidity could increase the spread of the leaf rust through the wheat crop.

However, a period of drought (low humidity) could reduce the spread of leaf rust.

If leaf rust spreads and grows more, less leaf area is available for photosynthesis, so the yield of wheat would decrease; if its spread is reduced by drought, less yield would be lost to leaf rust.

(Total for Question 9 = 10 marks)



10 The Intergovernmental Panel on Climate Change (IPCC) has issued the following statement:

"Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems."

(a) Explain why anthropogenic emissions of greenhouse gases are affecting the climate.

(3)

Human activities such as burning fossil fuels, deforestation, cattle ranching and landfill increase the concentration of greenhouse gases such as carbon dioxide and methane in the atmosphere.

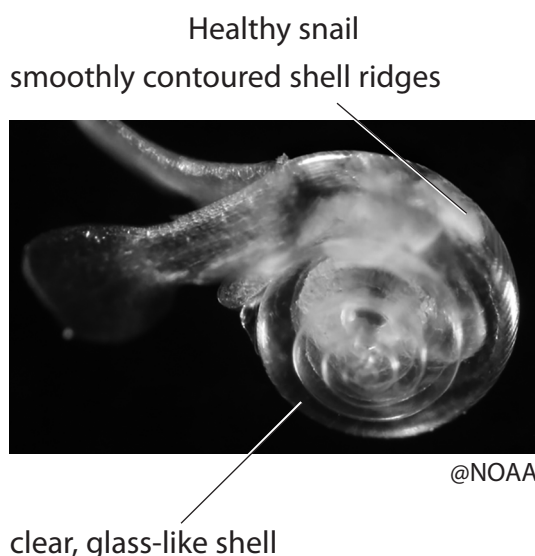
Therefore more heat energy (infrared radiation) re-radiated from the Earth's surface is trapped in the atmosphere.

This causes a mean increase in surface and atmospheric temperature (global warming), which changes the climate.

*(b) Pteropods are small free-swimming snails found in oceans throughout the world. They are a food source for a variety of fish including salmon, mackerel and herring.

In 2011, the health of these snails was studied in the ocean around Hawaii. A sample of these snails showed that 53% of them had damaged shells.

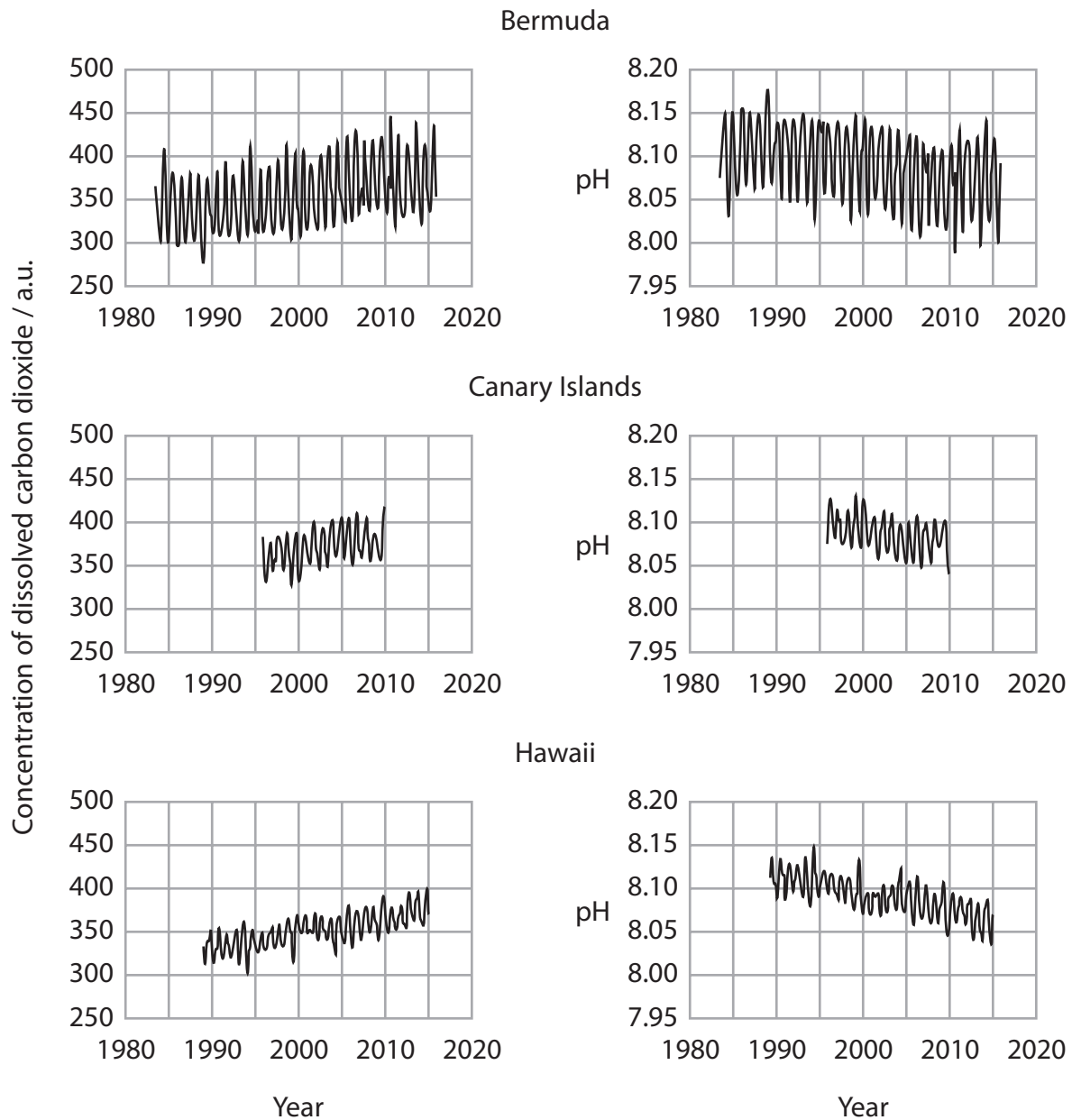
The photographs show a healthy snail and a snail with a damaged shell found in the ocean around Hawaii.



The pH of sea water affects shell formation in these snails. The changes in carbon dioxide concentration and pH have been recorded in oceans surrounding several islands.



These records are shown in the graphs.



Analyse the data to discuss the likely impact of increased carbon dioxide emissions on fish populations in these oceans.

(6)

Human activity, such as burning fossil fuels (coal, oil and gas), is increasing the level of carbon dioxide in the atmosphere, and this carbon dioxide then dissolves in the oceans.

The graphs show that dissolved carbon dioxide has increased at all three islands, e.g. at Hawaii from about 330 a.u. in 1988 to about 385 a.u. in 2015, and at Bermuda from about 340 to 380 a.u.

Over the same time the pH of the oceans has decreased, e.g. at Hawaii from about 8.11 to 8.07, so as carbon dioxide levels increase the pH decreases (carbon dioxide forms carbonic acid).

The reduction in pH affects shell formation, increasing the percentage of snails with damaged shells; at Hawaii 53% of the snails already had damaged, dissolving shells.

Snails with damaged shells will not survive, so there will be fewer pteropods and less food available for fish such as salmon, mackerel and herring, affecting food chains and food webs in the oceans.

There may be an initial increase in fish populations, as snails with weak shells are more vulnerable to predation, but as snail numbers fall there will be a reduction in fish populations.



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(c) Climate change can also affect the life cycle of organisms.

The effect of temperature on the lifespan of fruit flies (*Drosophila melanogaster*) was investigated.

The results are shown in the table.

Temperature / °C	Lifespan / days
15	130.3
21	86.3
27	41.6
30	20.4

Determine the relationship between the increase in temperature and the change in lifespan.
(2)

There is an inverse relationship (negative correlation): as temperature increases, the lifespan decreases.

From 15 °C to 30 °C the lifespan decreases by 109.9 days (130.3 – 20.4), an 84% decrease, which is a decrease of about 7.3 days per 1 °C increase in temperature.

(Total for Question 10 = 11 marks)



11 Batten disease is a rare, inherited disorder of the nervous system. It usually begins in childhood. It is a recessive disorder.

(a) Explain what is meant by an inherited recessive disorder.

(2)

A recessive disorder is caused by a faulty allele that is inherited from the parents, which is only expressed in the homozygous condition (bb), i.e. in the absence of a normal allele.

(b) (i) Parents without Batten disease have a child with Batten disease.

Which of the following describes the genotype of the parents?

(1)

- ☐ A bb and Bb
☒ B Bb and Bb
☐ C BB and BB
☐ D BB and bb

(ii) Draw a genetic diagram to show the probability of their future children developing Batten disease.

(2)

Parents: Bb x Bb

Gametes: B, b B, b

	<i>B</i>	<i>b</i>
<i>B</i>	<i>BB</i>	<i>Bb</i>
<i>b</i>	<i>Bb</i>	<i>bb</i>

Offspring genotypes: BB, Bb, Bb, bb

bb = Batten disease

Probability of Batten disease = 1 in 4 (25% or 0.25)



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- *(c) Genetic testing can be used to identify individuals who have genetic disorders such as Batten disease.

The table shows examples of some types of genetic screening and examples of where they may be used.

Type of screening	Method	Example
Blood test to identify risk of a disease	DNA from a blood sample is examined	Identifying presence of BRCA1 and BRCA2 mutations where there is a family history of breast cancer
Blood test to identify carriers of a genetic disease	DNA from a blood sample is examined	Establishing if a person is heterozygous for a recessive condition such as cystic fibrosis (CF)
Amniocentesis	Fetal DNA from amniotic fluid is tested	Identifying genetic disorders in the fetus
Chorionic villus sampling (CVS)	Fetal DNA from placental tissue is tested	Identifying genetic disorders in the fetus
Non-invasive prenatal diagnosis (NIPD)	Analysis of fetal DNA fragments from blood samples from the mother	Identification of chromosomal disorders and a small number of single gene disorders in the fetus
Pre-implantation genetic diagnosis (PGD)	Combined with IVF to test embryo at 8-cell stage	Ensures only embryos without a genetic disorder such as CF are implanted



Assess the advantages and disadvantages of these types of screening for genetic disorders.

(6)

Blood tests to identify risk, such as for BRCA1 and BRCA2 mutations, allow people to make choices, e.g. extra breast cancer screening or a preventative mastectomy. But people may not want to know, relatives learn information they may not want, and it may affect life insurance.

Carrier testing (e.g. CF) lets both partners be tested so the risk to their children is known and family planning choices can be made. But tests only detect the most common CF mutations, so there may be false negatives.

Amniocentesis and CVS prepare parents for a child with a disease, which may be life limiting, or give the choice of abortion. CVS can be carried out earlier in pregnancy, but both are invasive and increase the risk of miscarriage, especially CVS. The disease cannot be cured and abortion is not acceptable to everyone. False positives could lead to abortion of a healthy fetus.

NIPD is non-invasive, with no increased risk of miscarriage, but is only available for chromosome disorders such as Down's syndrome and a few single gene disorders.

PGD means only healthy embryos are implanted, so there is no decision about abortion. But it needs IVF, which is traumatic, has about a 30% success rate and is seen as unethical as embryos are discarded. Overall, blood tests on adults are better, as their disadvantages have less impact than those of testing embryos and fetuses.

(Total for Question 11= 11 marks)

TOTAL FOR PAPER = 100 MARKS



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