**Answer ALL questions.**

**Write your answers in the spaces provided.**

**1** Fungi break down dead plant and animal material in ecosystems.

Some types of fungi produce cellulase enzymes. These enzymes break down cellulose.

The breakdown of cellulose can be detected using Benedict's solution.
This solution turns red if monomers from the breakdown of cellulose are present.

(a) Give a reason why more cellulose is found in dead plant material than in dead animal material.

**(1)**

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(b) State the type of reaction catalysed by cellulase to break down cellulose.

**(1)**

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(c) Describe the structure of the monomer produced when cellulose is broken down.

**(2)**

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(d) Metal ions sometimes inhibit the activity of enzymes.

This inhibition occurs even if the metal ion concentration is low and the substrate concentration is high.

(i) Name the type of inhibition involved.

**(1)**

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(ii) Devise an experiment to test whether copper ions (Cu2+) inhibit cellulase activity.

**(5)**

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**(Total for Question 1 = 10 marks)**

**2** Chester Zoo has 12 000 animals from 400 different species.

Chester Zoo aims "to be a major force in conserving biodiversity worldwide".

(a) State **one** ethical reason and **one** economic reason for the conservation of biodiversity.

**(2)**

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(b) Chester Zoo has 10 black rhinoceros. The black rhinoceros is critically endangered due to being hunted for its horns.

One kilogram of rhinoceros horn can sell for more than £50 000.

The photograph shows a black rhinoceros.

The number of black rhinoceros fell from 70 000 in 1960 to 15 000 in the late 1970s.

All trade in black rhinoceros horn was prohibited under CITES in 1977.

However, hunting continued and fewer than 2 500 black rhinoceros were left by the year 2000.

(i) Explain why hunting continued after the black rhinoceros was listed in CITES.

**(2)**

(ii) Explain why the genetic diversity of the black rhinoceros has decreased between 1960 and 2000.

**(2)**

(c) Chester Zoo supports an *in-situ* rhinoceros conservation and monitoring project in Chyulu Hills National Park in Kenya.

It is difficult to find and count the black rhinoceros because they roam freely across a large area.

However, the DNA of a black rhinoceros can be obtained from its dung (faeces).

(i) Devise a method by which black rhinoceros dung could be used to estimate the number of black rhinoceros living in Chyulu Hills National Park.

**(5)**

(ii) DNA from dung indicated that 14 black rhinoceros were present in the park.

Explain why 14 black rhinoceros could be an underestimate of the population.

**(2)**

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**(Total for Question 2 = 13 marks)**

**3** Poliomyelitis is a serious disease that can lead to muscle weakness, paralysis and death. There is no cure.

Poliomyelitis is caused by poliovirus.

(a) The first poliovirus vaccine was tested in a study using 1.8 million children.

These children were divided into three groups.

Children in group 1 were treated with the vaccine.

(i) Devise suitable treatments for the children in group 2 and group 3.

**(2)**

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(ii) There are three types of poliovirus: PV1, PV2 and PV3. Each type causes poliomyelitis.

The table shows the results of the study for each type of poliovirus for children in group 1.

| Type of poliovirus | Effectiveness of vaccine (%) |
|---|---|
| PV1 | 60–70 |
| PV2 | >90 |
| PV3 | >90 |

A few children had a severe allergic reaction to the vaccine.

Comment on the extent to which this study supports the widespread use of this vaccine.

**(4)**

(b) Newer vaccines against poliovirus are now widely used.

In 1980, there were an estimated 400 000 cases of poliomyelitis worldwide.

In 2012, there were 291 recorded cases in a few countries.

Calculate the percentage decrease in cases from 1980 to 2012.

**(1)**

Answer ..... %

(c) Pakistan still has cases of poliomyelitis. The population of Pakistan is 196 million people.

After vaccination, 95% of people successfully develop immunity.

Herd immunity is achieved when 85% of the population is immune.

Calculate the number of people in Pakistan, to the nearest million, who must be vaccinated in order to achieve herd immunity.

**(2)**

Answer .....

(d) One type of vaccine contains inactivated poliovirus.

A scientist took blood samples from people who had received this vaccine. The blood samples contained antibodies to poliovirus.

Explain how treatment with inactivated poliovirus cause the body to produce antibodies to poliovirus.

**(4)**

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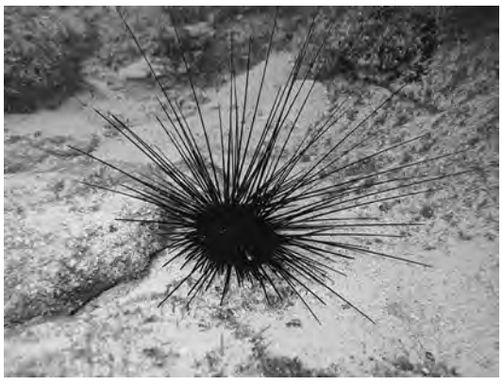
**(Total for Question 3 = 13 marks)**

**4** A sea urchin is an invertebrate animal that lives on the seabed.

The photograph shows a sea urchin.



Sea urchin embryos are often used to study embryonic development.
In the early stages of embryonic development, a sea urchin embryo is similar to a mammalian embryo.

(a) A scientist observed a fertilised sea urchin egg during the first few day after fertilisation.

Explain how this fertilised egg became a hollow structure.

**(3)**

(b) The scientist found that 128 cells were present after a few days.

Calculate the number of rounds of cleavage that had taken place.

**(1)**

Answer .....

(c) The scientist carefully removed one of the 128 cells from the hollow structure and injected fluorescent dye into its cytoplasm

She replaced this cell in a new position on the opposite side of the hollow structure.

The embryo then developed normally. The repositioned cell formed healthy tissue, appropriate to its new position.

The tissue formed by an embryonic cell is called the 'fate' of the cell.

(i) Explain how the scientist could identify the fate of the repositioned cell.

**(2)**

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(ii) The scientist found that repositioning this cell changed its fate.

Explain the scientist's finding.

**(4)**

(d) Explain why the use of sea urchin embryos was approved by an ethics committee.

**(2)**

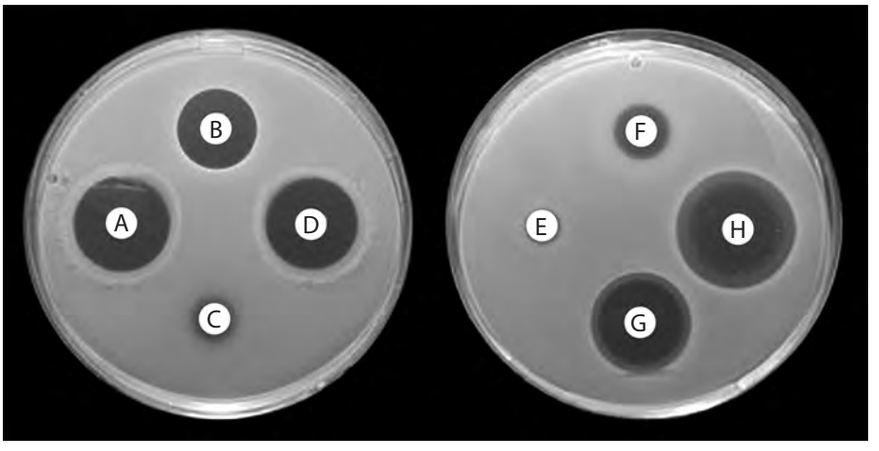
**(Total for Question 4 = 12 marks)**

**5** A student read that more than half of raw chickens on sale in supermarkets are contaminated with bacteria from the genus *Campylobacter*.

Some species of *Campylobacter* cause food poisoning in humans.

The student carried out an experiment to test the effectiveness of various antibiotics against *Campylobacter*.

The photograph shows the student's agar plates at the end of the experiment.




The white circles labelled A–H are filter paper discs. These discs were soaked in different antibiotics then placed on the surface of the agar.

(a) Explain how the student's method could ensure that the results from the two agar plates can be compared.

**(3)**

(b) One of the antibiotics the student used was penicillin.
Describe the effect of penicillin on bacterial cells.

**(3)**

(c) The student concluded that fresh chickens should be sprayed with antibiotic H before being packaged for sale in supermarkets.

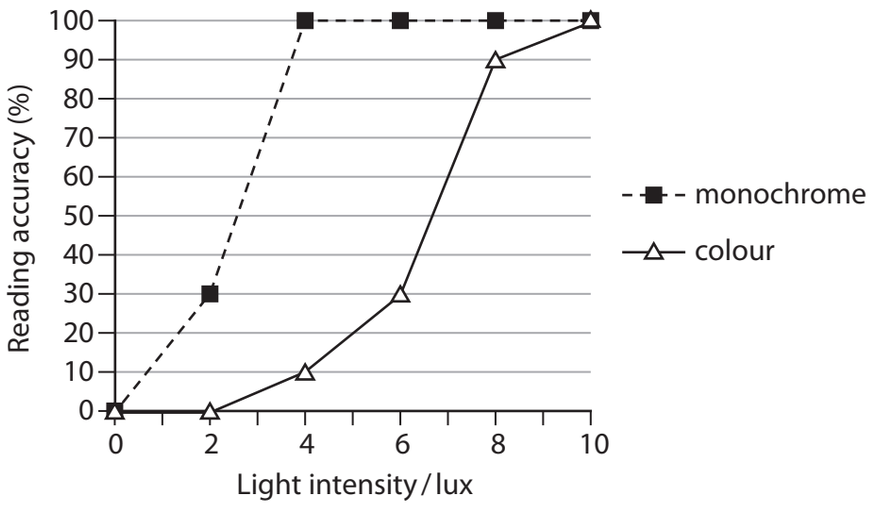
Evaluate the student's conclusion.

**(5)**

**(Total for Question 5 = 11 marks)**

**6** A student investigated the effect of light intensity on reading accuracy in humans.

The graph shows the student's results for both monochrome (black and white) and colour vision.




(a) Devise a method that the student could use to obtain these results.

**(4)**

(b) Explain the student's results using your knowledge of the light-sensitive cells in the human eye.

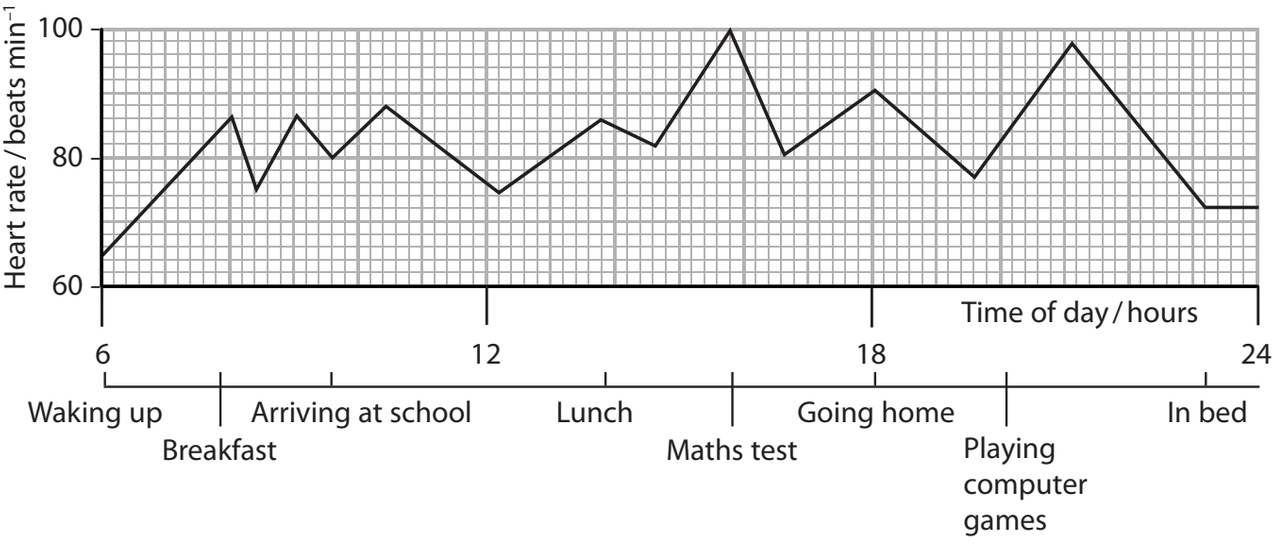
**(4)**

**(Total for Question 6 = 8 marks)**

**7** A student was interested to find out how his heart rate would vary throughout the day.

He wore a heart rate monitor from the time he woke up until the time he went to bed.

The graph shows the data collected and some of the student's activities during the day.




(a) Calculate the rate of increase in the student's heart rate between 6 am and 8 am.

**(2)**

Answer .....

(b) Explain why the student's heart rate changed at the time of his maths test.

**(5)**

(c) The student noticed that the graph showed a change in his heart rate while he was playing computer games.

He designed an investigation to find out how different computer games affect heart rate.

The student played one computer game and recorded the increase in his heart rate.

He then played four other different computer games and again recorded the increase in his heart rate.

He repeated this on six different occasions throughout the week.

(i) Explain how the design of the student's investigation could be improved.

**(4)**

(ii) Sketch a suitable graph that the student could use to present the results of his investigation.

**(2)**

**(Total for Question 7 = 13 marks)**

**8** ATP is involved in a wide variety of biological processes such as active transport and muscle contraction.

A typical adult human body has a mass of 62 kg.

It contains approximately 250 g of ATP and has approximately $3.7 \times 10^{13}$ cells.

(a) (i) Calculate the mean mass of ATP in one cell of a typical human.

Express your answer in standard form.

**(2)**

Answer ..... g

(ii) Explain why this calculation does **not** give an accurate estimate of the mass of ATP in a nerve cell.

**(2)**

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(b) Scientists have calculated that a typical person synthesises their own body mass in ATP every 24 hours.

(i) Calculate the mean rate of ATP production in grams per second in a person with a body mass of 62 kg.

**(2)**

Answer .....

(ii) Explain why people do not double their body mass in 24 hours due to ATP production.

**(2)**

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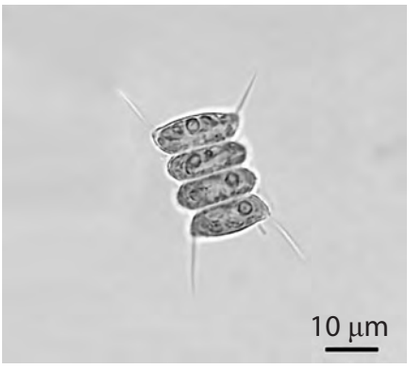
(c) Compare and contrast the way in which ATP is synthesised in mitochondria and in chloroplasts.

**(5)**

**(Total for Question 8 = 13 marks)**

**9** The green alga, *Scenedesmus quadricauda,* lives in fresh water.
Each cell has a single chloroplast.

The photograph shows some *Scenedesmus* cells.




Photosynthesis can be measured if these algae are placed in a solution containing hydrogen carbonate indicator.

When the carbon dioxide concentration is the same as that of atmospheric air, the hydrogen carbonate indicator is red.

As the carbon dioxide concentration decreases, the hydrogen carbonate indicator changes colour from red to pink and then to purple.

(a) Explain why the carbon dioxide concentration of the solution decreases when the algae carry out photosynthesis.

**(2)**

(b) A student investigated the effect of light on the rate of photosynthesis in *S. quadricauda*.

He used different coloured filters to vary the wavelength of the light.

The algae were added to a solution of hydrogen carbonate indicator in a test tube.

The test tube was sealed and placed under a lamp with a red filter.

After 30 minutes, the student noted the colour of the hydrogen carbonate indicator.

He then shook the open test tube until the indicator returned to its original colour.

He repeated this procedure with yellow, green and blue filters, using the same algae and the same indicator solution.

The student's results are shown in the table.

| colour of filter | wavelength of light / nm | colour of indicator after 30 minutes |
|---|---|---|
| red | 640 | reddish pink |
| yellow | 580 | pink |
| green | 520 | pinky purple |
| blue | 460 | dark purple |

(i) Analyse the data to explain what conclusion may be drawn from these results.

**(2)**

(ii) The student repeated the method using fresh hydrogen carbonate indicator and a new sample of *S. quadricauda*.

This time he used the blue filter first, then green, then yellow, then red.

The results are shown in the table.

| colour of filter | wavelength of light / nm | colour of indicator after 30 minutes |
|---|---|---|
| blue | 460 | reddish pink |
| green | 520 | pink |
| yellow | 580 | pinky purple |
| red | 640 | dark purple |

*Evaluate the student's investigation.

**(9)**

**(Total for Question 9 = 13 marks)**

**10** Sickle cell anaemia is caused by a mutation in the β-globin gene which codes for part of haemoglobin.

The diagram shows the first 10 amino acids in this part of haemoglobin, in a healthy person and in a person with sickle cell anaemia.

**Healthy person:** val – his – leu – thr – pro – glu – glu – lys – ser - ala

**Person with sickle cell anaemia:** val – his – leu – thr – pro – val – glu – lys – ser – ala

(a) Explain why the haemoglobin in a person with sickle cell anaemia will fold differently from the haemoglobin of a healthy person.

**(4)**

(b) The allele that leads to sickle cell anaemia is known as HbS.

From 1990 to 1996, all newborn infants in California were screened for the presence of the HbS allele.

The data in the table show the ratio of individuals with and without the HbS allele, in various ethnic groups.

| **Ethnic group** | **HbS allele : no HbS allele** |
|---|---|
| African American | 1:14 |
| Asian | 1:1336 |
| Caucasian | 1:625 |
| Hispanic | 1:183 |
| Middle Eastern | 1:360 |
| Native American | 1:176 |

A chi squared test was used to analyse the raw data.

The null hypothesis was: "There is no difference between the frequency of the HbS allele in African Americans and in all other ethnic groups combined."

The calculated value of chi squared was 450 615.

The table shows some critical values for the chi squared distribution, with one degree of freedom.

| **probability, *p*** | 0.005 | 0.010 | 0.025 | 0.050 | 0.100 |
|---|---|---|---|---|---|
| **critical value** | 7.879 | 6.635 | 5.024 | 3.841 | 2.706 |

Explain the conclusion that can be drawn from this chi squared test.

**(3)**

(c) People who are homozygous for the HbS allele develop sickle cell anaemia.

People who are heterozygous for HbS produce both forms of haemoglobin. These individuals have some sickled red blood cells.

People with the HbS allele are less likely to get malaria.

(i) You are provided with a blood sample from a patient with malaria and a blood sample from a healthy individual.

Devise a method that would allow you to distinguish between the two blood samples.

**(3)**

(ii) Malaria is a major cause of death in Africa.

Assess the effect that this might have on the frequency of the HbS allele in African populations.

**(4)**

**(Total for Question 10 = 14 marks)**

**TOTAL FOR PAPER = 120 MARKS**