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| Total Marks |
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Biology B
Advanced
PAPER 3: General and Practical Principles in Biology

Time: 2 hours 30 minutes

In the boxes below, write your name, centre number and candidate number.

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| Surname | | | | | |
| Other names | | | | | |
| Centre Number | | | | | |
| Candidate Number | | | | | |

YOU MUST HAVE

Scientific calculator, writing and drawing equipment, ruler

YOU WILL BE GIVEN

Diagram Booklet

INSTRUCTIONS

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.

You may use a scientific calculator.

In question(s) 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.

INFORMATION

The total mark for this paper is 120.

The marks for EACH question are shown in brackets – use this as a guide as to how much time to spend on each question.

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.

Answer ALL questions.

Write your answers in the spaces provided.

1 Nerve impulses are transmitted along neurones.

- (a) (i) In the time period between two nerve impulses, the potential difference across the membrane is -70 mV .**

**State the term given to this potential difference.
(1 mark)**

(continued on the next page)

1 continued.

- (ii) When the neurone is stimulated, an action potential may occur in the axon, due to the change in permeability of the membrane to ions.**

Look at the graph for Question 1(a)(ii) in the Diagram Booklet. It shows an action potential.

Describe what happens in the axon membrane to cause the change in potential difference between 0.55 ms and 0.80 ms.

(4 marks)

(continued on the next page)

Turn over

1 continued.

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1 continued.

- (b) Scientists investigated the effect of stimulating an axon with different voltages and measured the response.**

Look at the table for Question 1(b) in the Diagram Booklet. It shows the results of this investigation.

Analyse the data to describe the conclusions which can be drawn.

(2 marks)

(Total for Question 1 = 7 marks)

Turn over

- 2 A student investigated the number of dividing cells in an onion root tip.**

Look at the table for Question 2(a) in the Diagram Booklet. The student made a root tip squash and counted the number of cells at each stage of the cell cycle. The table shows the results.

- (a) (i) Calculate the mitotic index for these results using the formula
(2 marks)**

$$\text{Mitotic index} = \frac{\text{number of actively dividing cells}}{\text{total number of cells}} \times 100$$

Answer _____

(continued on the next page)

2 continued.

- (ii) The mitotic index depends on the distance from the root tip.**

Look at the graph for Question 2(a)(ii) in the Diagram Booklet. It shows the relationship between the mitotic index and the distance from the root tip.

**Explain the relationship shown in the graph.
(2 marks)**

2 continued.

(b) The student used the following method to prepare the root tip squash.

- 1. Cut a small piece from the tip of a growing onion root and place it in weak acid.**
- 2. Transfer the root tip to a microscope slide.**
- 3. Add a drop of stain.**
- 4. Use a mounted needle to flatten the piece of root and place a coverslip on top.**
- 5. View using low power objective lens of a microscope.**
- 6. Count the cells at each stage of the cell cycle.**

**Justify two improvements to this method.
(2 marks)**

(continued on the next page)

Turn over

2 continued.

(Total for Question 2 = 6 marks)

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

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

Look at the table for Question 3(a) in the Diagram Booklet. It shows the colour of the indicator when it contains different concentrations of carbon dioxide.

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

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

(continued on the next page)

3 continued.

Look at the table for Question 3(a) in the Diagram Booklet. It shows the results.

- (a) (i) Describe two control tubes that should be used in this investigation.
(2 marks)**

(continued on the next page)

3 continued.

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

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3 continued.

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

**Describe how the method could be modified to give valid, quantitative results.
(3 marks)**

(continued on the next page)

Turn over

3 continued.

(Total for Question 3 = 8 marks)

4 Look at the diagram for Question 4 in the Diagram Booklet. Fruit flies, **Drosophila melanogaster**, are often used in genetics investigations. The diagrams show male and female flies.

- (a) Give one feature, visible in the diagrams, that you could use to distinguish between male and female flies and state how it differs between them.
(1 mark)

Feature

Difference

(continued on the next page)

4 continued.

(b) A scientist investigated the inheritance of several genes in fruit flies.

(i) A grey-bodied fly was crossed with a black-bodied fly.

All the offspring in the F_1 generation were grey-bodied.

Two of the grey-bodied flies from the F_1 generation were then crossed.

On page 20 determine the expected ratio of phenotypes of the offspring in the resulting F_2 generation by using a genetic diagram.

(2 marks)

(continued on the next page)

4 continued.

Answer _____

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4 continued.

- (ii) Normal fruit flies have long wings but some flies have very short wings called vestigial wings.**

The allele for long wing (L) is dominant to the allele for vestigial wing (l).

The gene for wing length is located on chromosome 2.

The allele for normal antennae (A) is dominant to the allele for bushy antennae (a).

The gene for antennae shape is located on chromosome 3.

Two flies which are heterozygous for both characteristics are crossed.

On pages 22 and 23 determine the ratio of phenotypes that you would expect in the next generation, using a genetic diagram.

(3 marks)

(continued on the next page)

4 continued.

4 continued.

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4 continued.

- (iii) The allele for red eyes (R) is dominant to the allele for white eyes (r).**

The scientist investigated the inheritance of eye colour.

The crosses used were:

CROSS 1 – a red-eyed female fly was crossed with a white-eyed male fly: half of the offspring were red-eyed females and half were red-eyed males

CROSS 2 – a white-eyed female fly was crossed with a red-eyed male fly: half of the offspring were red-eyed females and half were white-eyed males.

On pages 25 and 26 explain the results of these crosses.

(4 marks)

(continued on the next page)

4 continued.

4 continued.

(Total for Question 4 = 10 marks)

- 5 (a) Look at the image for Question 5(a) in the Diagram Booklet. It shows a germinating pollen grain as seen through a light microscope.

The actual length of this pollen tube is $136\mu\text{m}$.

Calculate the magnification of this image.
(2 marks)

Answer _____

(continued on the next page)

5 continued.

- (b) (i) Look at the diagram for Question 5(b)(i) in the Diagram Booklet. It shows a pollen grain that has begun to germinate after landing on the surface of the stigma of a flower.**

**Identify the structures labelled A and B.
(2 marks)**

A _____

B _____

(continued on the next page)

5 continued.

(ii) Describe the process of double fertilisation in flowering plants.
(3 marks)

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**(c) Devise an investigation to determine the effect of pH on the rate of growth of pollen tubes.
(5 marks)**

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(Total for Question 5 = 12 marks)

Turn over

- 6 Fritillaria delavayi** is a small plant (height 7 cm), that grows on rocky slopes on mountains in China. It has bright green leaves and bright yellow flowers.

For at least 2000 years, this plant has been collected and used in Chinese medicine. It is not known to be eaten by animals.

In less accessible regions, where few humans go, the plants are bright green with bright yellow flowers.

In locations where bulbs are collected in high numbers, most plants have greyish-brown leaves and flowers.

Scientists believe that the greyish-brown plants are the same species as the brightly-coloured plants.

- (a) Explain why most of the plants in areas where bulbs are collected in high numbers have greyish-brown leaves and flowers.
(4 marks)

(continued on the next page)

Turn over

6 continued.

[illegible]

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6 continued.

- (b) (i) Describe how scientists can use gel electrophoresis to show that these plants belong to the same species.
(4 marks)**

(continued on the next page)

Turn over

6 continued.

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6 continued.

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

(Total for Question 6 = 10 marks)

7 Plants require mineral ions from the soil for healthy growth.

**(a) (i) Describe how mineral (inorganic) ions are taken up by active transport.
(3 marks)**

7 continued.

- (ii) Describe the function of a named mineral ion that is vital for the growth of plants.
(2 marks)**

Mineral ions

Function

(continued on the next page)

Turn over

7 continued.

- (b) **Galium verum** (Lady's bedstraw), is a plant that grows in meadows, hedges, road verges and sand dunes.

This plant grows to between 15 cm and 60 cm in height.

A student investigated whether **Galium verum** growing in meadows was taller than **Galium verum** growing on sand dunes.

- (i) Give a suitable null hypothesis for this investigation.
(1 mark)

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7 continued.

**(ii) Devise a method that can be used to collect valid results to test this null hypothesis.
(5 marks)**

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7 continued.

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7 continued.

- (iii) Explain which statistical test would be most suitable to test this null hypothesis.
(2 marks)**

(Total for Question 7 = 13 marks)

8 The activity of enzymes is affected by a number of factors.

(a) Explain why increasing the temperature of an enzyme-controlled reaction changes the rate of reaction.

(3 marks)

(continued on the next page)

Turn over

8 continued.

(continued on the next page)

8 continued.

- (b) A student investigated the activity of the enzyme catalase in potato.**

This enzyme is found in potato cells. It catalyses the conversion of hydrogen peroxide to oxygen and water.

Look at the diagram for Question 8(b) in the Diagram Booklet. It shows the apparatus used to collect the data.

- (i) Describe how two named variables, other than the potato, can be controlled in order to obtain valid results.**
(4 marks)

(continued on the next page)

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8 continued.

- (ii) Look at the graph for Question 8(b)(ii) in the Diagram Booklet. It shows the results of the investigation.**

**Determine the initial rate of reaction from this graph.
(1 mark)**

Answer _____

(continued on the next page)

8 continued.

**(iii) Explain why the rate of reaction decreases over time.
(2 marks)**

(continued on the next page)

8 continued.

- (c) The student used this apparatus to investigate the effect of using increasing numbers of potato cubes on the rate of reaction.

The potato was cut into 1 cm^3 cubes to be used in five trials.

In the first trial, one cube was added to the flask and the volume of oxygen produced in 30 seconds was measured.

The hydrogen peroxide was then replaced.

This was repeated in the other four trials using 2, 3, 4 and 5 cubes of potato.

Explain the results you would expect from this investigation.
(3 marks)

(continued on the next page)

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8 continued.

(Total for Question 8 = 13 marks)

- 9 Water moves through xylem vessels in a plant during transpiration.

Phloem tissue is responsible for transport of organic materials such as sucrose.

- (a) Compare and contrast the structure of xylem tissue and phloem tissue.
(3 marks)

(continued on the next page)

Turn over

9 continued.

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9 continued.

- (b) Look at the diagram for Question 9(b) in the Diagram Booklet. A student used the potometer shown in the diagram to investigate the rate of water uptake in a leafy shoot.**

The student investigated the effect of a combination of environmental conditions on the rate of water uptake.

Look at the table for Question 9(b) in the Diagram Booklet. It shows the results of this investigation.

- (i) The internal diameter of the capillary tubing is 0.3 mm.**

The volume of a cylinder is calculated using the formula

$$\pi r^2 h$$

On page 54 calculate the mean rate of water uptake for the shoot in moving air, in the light.

(continued on the next page)

9 continued.

Give your answer in $\text{mm}^3 \text{min}^{-1}$ to two significant figures.
(3 marks)

Answer _____ $\text{mm}^3 \text{min}^{-1}$

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9 continued.

(ii) Analyse the data to explain the results of this investigation.
(3 marks)

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9 continued.

(iii) Describe how this investigation could be modified to make a valid comparison of water loss from the upper and lower surfaces of the leaves.

(4 marks)

[illegible]

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9 continued.

(Total for Question 9 = 13 marks)

10 Grassland is an important habitat for grazing animals such as cattle.

(a) Fields used for grazing cattle must have a high gross primary productivity.

State what is meant by the term gross primary productivity and include the units in which it is measured.

(2 marks)

(continued on the next page)

Turn over

10 continued.

(b) Cattle graze on the plants on grassland.

Describe what happens to the energy in the plants that are not eaten by cattle.

(2 marks)

(continued on the next page)

10 continued.

- *(c) When grazing animals such as cattle, sheep and horses are kept in fields, their faeces are left on the ground, and are known as dung.**

The dung is eaten by dung beetles, which in turn are eaten by other animals.

Dung beetles bury dung up to one metre underground in tunnels they have made. This removes the dung from the surface of the field.

A cow can produce over eight tonnes of dung per year.

There are around 60 species of dung beetle in the UK. In 2016, 50% of these were identified as being scarce or threatened.

Scientists believe factors causing the decline of dung beetles include:

- farmers using more land to grow crops, and using more land for building and development**
- keeping some grazing animals in sheds over the winter, rather than them spending the winter in fields**
- fewer habitats for dung beetles, leading to populations of dung beetles becoming isolated and preventing outbreeding**
- grazing animals routinely being treated with anti-parasitic drugs that can kill dung beetles.**

10 continued.

Some scientists have stated that farming practices need to change to conserve the species of dung beetle, and to maintain biodiversity and the stability of ecosystems.

**Discuss the validity of this statement.
(9 marks)**

(continued on the next page)

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10 continued.

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10 continued.

(Total for Question 10 = 13 marks)

- 11 Yeast, *Saccharomyces cerevisiae*, is a single-celled organism used in brewing and baking.

Yeast cells can be seen using a light microscope.

A student counted the number of yeast cells, at 90-minute intervals, growing in a liquid culture at 30°C.

Look at the graph for Question 11(a)(i) in the Diagram Booklet. It shows the results.

- (a) (i) Calculate the percentage increase in the number of yeast cells from 2 hours to 6 hours.
(2 marks)

Answer _____%

(continued on the next page)

11 continued.

- (ii) Look at the graph for Question 11(a)(ii) in the Diagram Booklet. Predict the number of cells per cm^3 of the culture at 12 hours.**

Assume that the culture continues to grow at the same rate.

(1 mark)

Answer _____ $\times 10^2$ per cm^3

(continued on the next page)

11 continued.

- (b) Describe two precautions that would prevent the yeast culture becoming contaminated with bacteria.
(2 marks)**

(continued on the next page)

11 continued.

- (c) The student counted the yeast cells using a haemocytometer.**

This is a slide with chambers containing a known volume of liquid. The yeast cells are counted when viewed using a light microscope.

Any yeast cells totally within the counting square should be counted, along with those which overlap the top or left-hand side of the square.

- (i) Look at the image for Question 11(c)(i) in the Diagram Booklet. The volume of liquid in the counting square shown is 0.004 mm^3 .**

Calculate the number of yeast cells per mm^3 .

**Give your answer in standard form.
(2 marks)**

Answer _____ per mm^3

11 continued.

- (ii) Identify two causes of inaccuracy in this method of counting cells.
(2 marks)**

(continued on the next page)

11 continued.

(d) Look at the table for Question 11(d) in the Diagram Booklet. It shows the number of cells counted using a haemocytometer.

(i) The student calculated the standard deviations using the following formula.

$$\text{SD} = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$$

**On page 74 calculate the standard deviation for the sample at 3 hours.
(3 marks)**

(continued on the next page)

11 continued.

$$SD = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$$

Answer _____

(continued on the next page)

Turn over

11 continued.

- (ii) The student concluded that the yeast population doubles every 90 minutes.**

**Comment on the validity of this conclusion.
(3 marks)**

(continued on the next page)

Turn over

11 continued.

(Total for Question 11 = 15 marks)

TOTAL FOR PAPER = 120 MARKS
END OF PAPER