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SUBJECT: **Biology**  
 PAPER NUMBER: I  
 DATE: 30<sup>th</sup> August 2023  
 TIME: 9:00 a.m. to 12:05 p.m.

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### Directions to Candidates

- Write your index number in the space at the top left-hand corner of this page.
- Answer **ALL** questions. Write all your answers in the spaces provided in this booklet.
- The mark allocation is indicated at the end of each question. Marks allocated to parts of questions are also indicated.
- You are reminded of the necessity for good English and orderly presentation in your answers.
- In calculations you are advised to show all the steps in your working, giving your answer at **each** stage.
- The use of electronic calculators is permitted.

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### For examiners' use only:

Question	1	2	3	4	5	6	7	8	9	Total
Score										
Maximum	8	10	12	10	11	14	13	11	11	<b>100</b>

1. This question is about pathogenic activity.

The following diagram shows an example of a pathogenic particle.

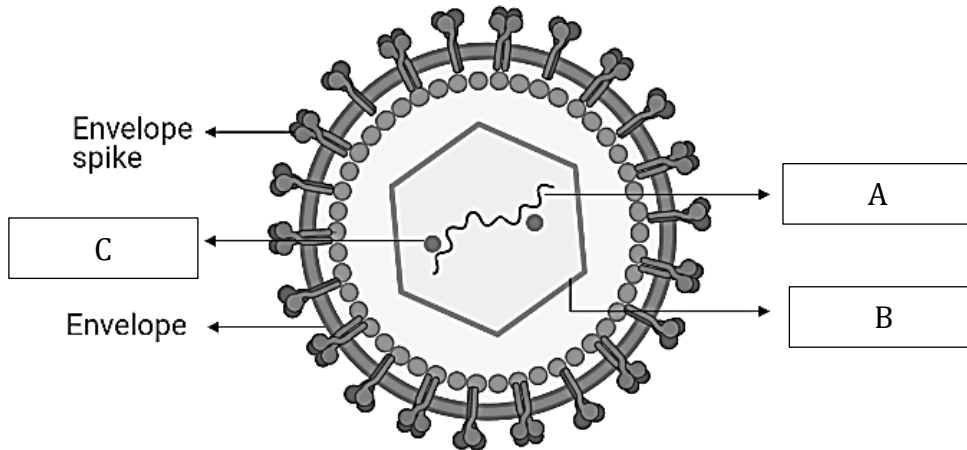


Figure 1: A schematic representation of the pathogen  
(Adapted from: <https://www.biorender.com>)

a. Define the term 'pathogen'.

\_\_\_\_\_ (1)

b. Identify the type of pathogen represented in Figure 1.

\_\_\_\_\_ (1)

c. Provide **TWO** reasons why this pathogen cannot be classified in any taxonomic kingdom.

\_\_\_\_\_  
\_\_\_\_\_ (2)

d. Identify structures A and B.

Structure A: \_\_\_\_\_ Structure B: \_\_\_\_\_ (1)

e. Structure C is an enzyme. Identify structure C and explain its role in the pathogenic activity of this particle.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ (3)

**(Total: 8 marks)**

2. Provide a brief explanation for the following observations:

a. Multicellularity was required for organisms to increase in size.

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(2)

b. Most sessile organisms do **not** exhibit bilateral symmetry.

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(2)

c. Acoelomates require a large body surface area to survive.

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(2)

d. Terrestrial organisms are characterized by internal respiratory surfaces.

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(2)

e. An arthropod's niche is influenced by its jointed appendages.

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(2)

**(Total: 10 marks)**

3. This question is about sugars.

Starch and glycogen are two polysaccharides that are insoluble in water, making them good storage molecules. As these two polysaccharides cannot move across membranes, they are first changed into smaller subunits before being moved to where the sugar is required.

a. Name the subunit that forms both starch and glycogen.

\_\_\_\_\_ (1)

b. Name the bond that allows for the branched polymerization of starch and glycogen.

\_\_\_\_\_ (1)

c. Name the type of reaction that breaks the bond mentioned in part (b), converting starch and glycogen to smaller units.

\_\_\_\_\_ (1)

d. By making reference to water potential, explain why starch and glycogen, being insoluble, make good storage molecules.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ (2)

e. Explain why starch and glycogen cannot move across a cell membrane.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ (2)

f. Sucrose is a non-reducing disaccharide composed of a glucose molecule bonded to a fructose molecule. In vascular plants, this disaccharide is transported from source to sink via the phloem.

i. Explain how sucrose is loaded into the phloem.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ (3)

ii. Suggest why in plants, sucrose is a better transporting molecule than glucose.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_ (2)

**(Total: 12 marks)**

4. This question is about responses to the environment.

a. Figure 2 shows the structure of a synapse. Fill in the table below by identifying the components labelled A – D and provide a brief definition for each component.

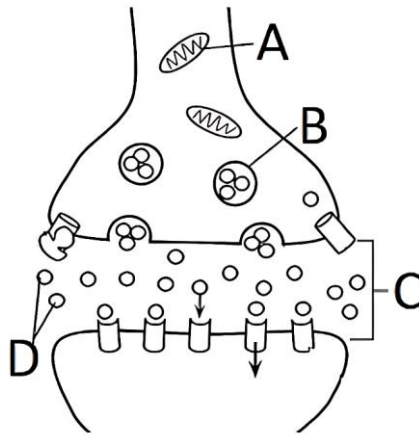


Figure 2: A diagrammatic representation of a synapse.  
 (Modified from <https://www.biologycorner.com>)

Label	Identification of component	Definition for the component
A		
B		
C		
D		

(4)

**Question continues on next page.**

b. In terms of structure and function, briefly explain how presynaptic membranes and postsynaptic membranes differ from each other.

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(2)

c. Briefly explain what happens when an electrical impulse is transferred from one cell to another.

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(4)

**(Total: 10 marks)**

5. This question is about digestion in humans.

a. Figure 3 is a diagrammatic representation of the human digestive system.

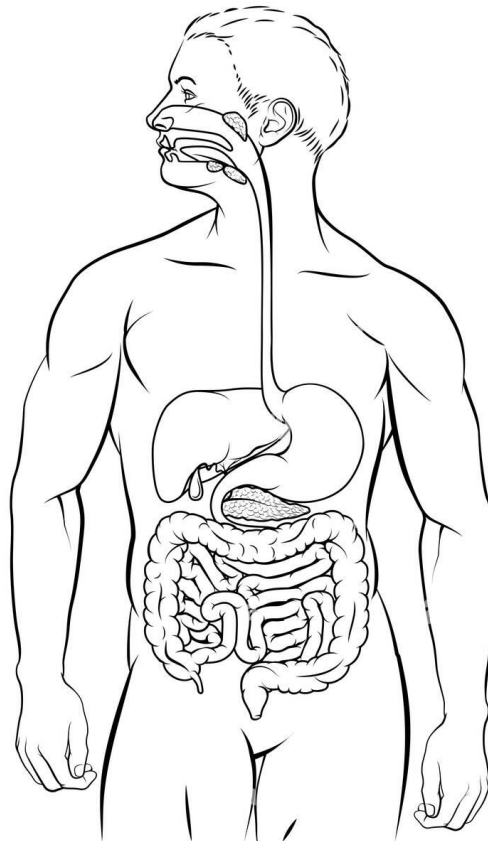


Figure 3: A diagram of the human digestive system.  
(Taken from <https://www.123rf.com>)

- i. On Figure 3, label **THREE** organs that secrete digestive enzymes. (3)
- ii. For **each** of the organs labelled in part a (i), list **ONE** enzyme secreted by the organ and explain its mode of action on a substrate.

Name of organ as identified in part a (i)	ONE enzyme secreted by the organ	Mode of action of enzyme

(3)

- b. The ileum is responsible for the uptake of the end-products of digestion. Explain how the ileum is structurally adapted for the efficient absorption of nutrients.

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(3)

- c. Explain the function of the large intestine in terms of the symbiotic relationship which occurs in this organ.

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(2)

**(Total: 11 marks)**

6. This question is about cell division.

a. Indicate the type of cell division required for each situation mentioned below.

Statement	Type of cell division
After fracturing a bone, the doctor told me that it takes around two months for bone to heal.	
Yeast reproduces by budding.	
Angiosperms produce pollen.	
In mosses, female gametophytes produce eggs.	

(4)

b. Mitosis produce genetically identical daughter cells. Explain **ONE** advantage and **ONE** disadvantage of producing clones as offspring during reproduction.

Advantage: \_\_\_\_\_  
 \_\_\_\_\_ (1)

Disadvantage: \_\_\_\_\_  
 \_\_\_\_\_ (1)

c. In humans, a spermatogonium produces four sperm cells, each having a different genetic constitution. Name and briefly explain **TWO** processes that can give rise to this genetic variation.

Process 1: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

Process 2: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_ (6)

d. Explain the biological significance of the variation mentioned in part (c).  
 \_\_\_\_\_  
 \_\_\_\_\_ (2)

**(Total: 14 marks)**



7. This question is about genetic inheritance.

- a. A heterozygous woman with blood group B and a heterozygous man with blood group A could have four children, all with a different blood group. Explain this observation, using a genetic cross to illustrate your answer.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_ (5)

- b. A homozygous plant with pink petals and a hairless pedicel (a small stalk that supports a single flower) was crossed with a homozygous plant with blue petals and a hairy pedicel. The F<sub>1</sub> seeds were collected and germinated. All F<sub>1</sub> plants had flowers with blue petals and a hairy pedicel.

Note: for this question assume that the colour of the petals and the hairiness of the pedicel are controlled by two different genes, each having only two alleles.

Answer the questions that follow, using the symbols below.

Symbol	Allele
A	dominant allele for petal colour
a	recessive allele for petal colour
B	dominant allele for hairiness of pedicel
b	recessive allele for hairiness of pedicel

- i. What are the genotypes of the parent plants?

Genotype of parent plant 1 (pink petals and a hairless pedicel) \_\_\_\_\_

Genotype of parent plant 2 (blue petals and a hairy pedicel) \_\_\_\_\_ (2)

- ii. List the genotype/s of the F<sub>1</sub> seedlings.

\_\_\_\_\_ (1)

**Question continues on next page.**

- iii. A member of the F<sub>1</sub> generation was self-pollinated. Using a genetic cross, explain what the expected phenotypic ratios of the offspring are.

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(5)

**(Total: 13 marks)**

- 8. This question is about reproduction.
  - a. Briefly explain why under certain environmental conditions, it is advantageous for some animals to switch from sexual to asexual reproduction.

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(3)

- b. Briefly explain why lizards transfer gametes through internal fertilization, while frogs are able to do so through external fertilization.

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(3)

c. List **THREE** methods that prevent self-pollination in plants.

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(3)

d. Explain the evolutionary advantage of avoiding self-pollination.

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(2)

**(Total: 11 marks)**

9. This question is about evolution.

a. Figure 4 is a diagrammatic representation illustrating the two theories of how a morphological trait changes with time.

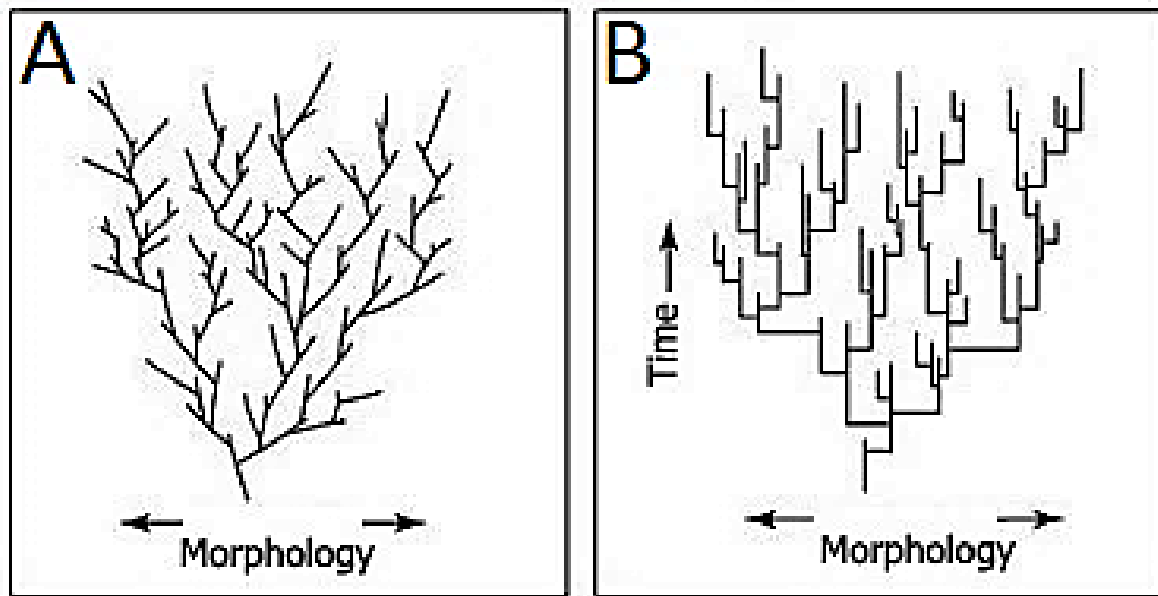


Figure 4: Two ways of representing evolution.  
(Obtained from <https://thebrain.mcgill.ca>)

**Question continues on next page.**

Identify and explain which image represents a gradualistic and which one represents a punctuated equilibrium mode of evolution.

Image A: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Image B: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ (3)

- b. Malaria parasites invade normal red blood cells, and this can be fatal for homozygotes that have two alleles for 'haemoglobin A'. Sickle cell disease is caused by having two alleles for 'haemoglobin S', which distorts the shape of red blood cells into a sickle shape. Heterozygotes for this condition carry a typical 'haemoglobin A' allele and a 'haemoglobin S' allele. These individuals are said to have the sickle cell trait, but not the disease.

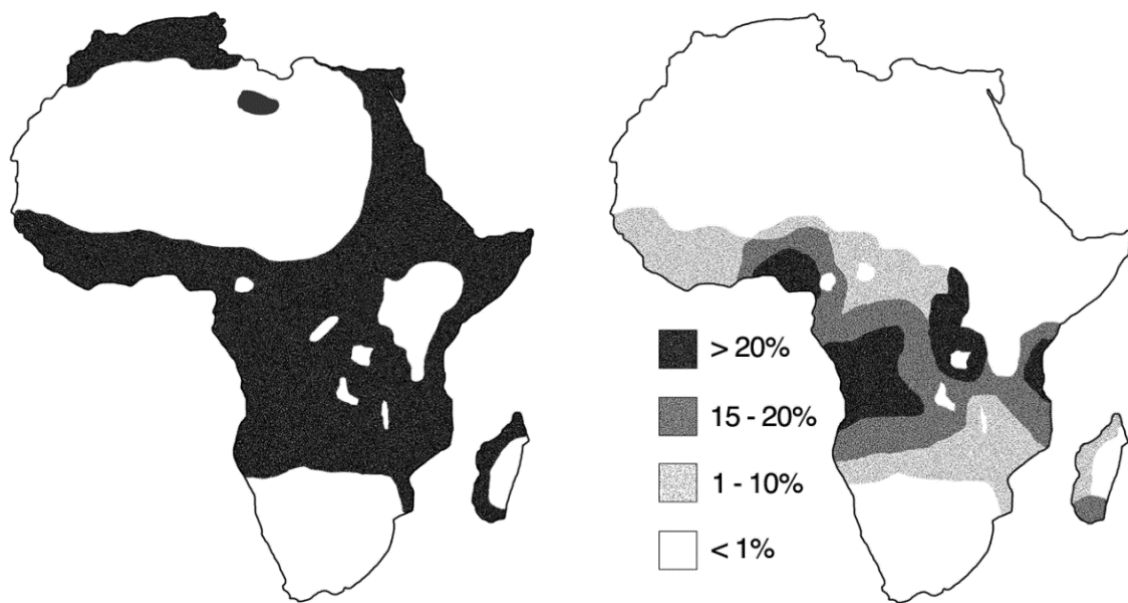


Figure 5: Prevalence of malaria (left) and sickle cell trait (right) in Africa.  
(Obtained from <https://owlcation.com>)

- i. Indicate the relationship between the prevalence of malaria and the sickle cell trait in Africa as illustrated in Figure 5.

\_\_\_\_\_  
\_\_\_\_\_ (1)

- ii. Briefly discuss how this polymorphism can be advantageous for surviving in areas where malaria is present.

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(4)

- c. Fill in the following table by identifying **ONE** type of isolating mechanism depicted in each scenario.

Scenario	Isolating mechanism
i. Mules are the sterile hybrid offspring of a male donkey and a female horse.	
ii. Male fireflies use specific light patterns to attract females.	
iii. The hybrid embryos of sheep and goats die in the early developmental stages before birth.	
iv. If a female of one species of snail tries to mate with the male of another species, their reproductive organs will not match and the two species cannot mate.	
v. Two species of frog live in the same region, but one species breeds in fast-moving streams and the other breeds in permanent ponds.	
vi. The western spotted skunk and the eastern spotted skunk cannot mate because the former breeds in autumn and the latter breeds in late winter.	

(3)

**(Total: 11 marks)**

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SUBJECT:	<b>Biology</b>
PAPER NUMBER:	II
DATE:	31 <sup>st</sup> August 2023
TIME:	9:00 a.m. to 12:05 p.m.

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### **Directions to Candidates**

- Answer the question in Section A, any **TWO** questions from Section B and **ONE** question from Section C. Write all your answers in the separate booklet provided.
  - If more than two questions from Section B are attempted, only the first two answers shall be taken into consideration.
  - If more than one question from Section C is attempted, only the first answer shall be taken into consideration.
  - The mark allocation is indicated at the end of each question. Marks allocated to parts of questions are also indicated.
  - You are reminded of the necessity for good English and orderly presentation in your answers.
  - In calculations you are advised to show all the steps in your working, giving your answer at each stage.
  - The use of electronic calculators is permitted.
-

**SECTION A**

1. Read the following extract carefully, and using the information provided and your knowledge of biology, answer the questions that follow. The numerals in the left-hand margin are the line numbers.

**Extinction on Selmunett Islands**

The phenomenon of extinction is not a new concept in Malta. Take the case of *Podarcis filfolensis kieselbachi*. There is no doubt that a large population originally existed on Selmunett Islands with an estimated population of 1000 individuals for the whole of Selmunett which has an approximate area of 0.1 km<sup>2</sup> and occurs around 90 m away from the main land. The highest number of lizards  
5 observed in a study in 2001 was 127 in 11 hours of observation in August, which is much lower than the estimated pre-year 2000 population density. Population density declined during the period 1999–2007, reaching almost zero in 2006 and 2007.

Only a couple of individuals were spotted in 2006 and a few captive individuals were released back on the island in 2007. Whether the population would have recovered from such low numbers  
10 depended on many factors, especially on the gender of the individuals left and their reproductive potential.

Selective predation by rats seems to be the most likely cause of the decline in the *Podarcis filfolensis kieselbachi* population on Selmunett Islands. It is thought that the interaction between rats and lizards contributed heavily to the lizard's population decline as rats predominantly  
15 targeted smaller individuals (juveniles and females) which may explain why the six lizards were captured in 2004, these were all large individuals, a feature predominantly exhibited by males.

Human interference may have also been a potential cause for the population's decline. In particular, the islands became popular with boat owners as a bathing and barbeque spot, and as more people started owning boats during the 1990s human presence on the island increased.  
20 This had an impact on both the rats' and the lizards' niches which resulted in an increase in the rat population. Apart from this, human interference had also impacted the lizard's habitat.

Since 2012, *Podarcis filfolensis kieselbachi* has been categorised as extinct. A lesson can be learnt from such events. Endemic species, especially those living on small islands need to be monitored for conservation purposes perhaps more so than those living on mainland.

*(Adapted from: Conservation status of the St Paul's Island wall lizard)*

- a. Explain why the technique of observation was better to implement instead of belt or line transect to estimate the population size of *Podarcis filfolensis kieselbachi*? (2)
- b. Why was it better to conduct studies on this species in summer rather than winter? (1)
- c. During their studies, the researchers would have noted certain behavioural patterns. Briefly suggest behavioural patterns that could have been associated with thermoregulation in *Podarcis filfolensis kieselbachi*. (2)
- d. What is the term used to describe a species with a high risk of extinction? (1)
- e. Give a brief explanation of why population recovery of *Podarcis filfolensis kieselbachi* was dependent on the reproductive potential of the species (lines 10 – 11). (3)
- f. Explain why selective predation (line 12) had a profound effect on the population of lizards. (3)
- g. Determine the type of speciation exhibited by *Podarcis filfolensis kieselbachi*. Use information from the text to justify your answer. (3)
- h. Explain how human interference had favoured the population increase of rats. (2)
- i. Which type of interspecific interaction was observed between humans and *Podarcis filfolensis kieselbachi*? Give a reason for your answer. (2)
- j. Determine whether the lizard's population is influenced by density dependent factors or density independent factors or both. Give reasons for your answer. (3)
- k. Why do endemic species populations inhabiting small islands need to be monitored more than those living on mainland? (3)

**(Total: 25 marks)**

## **SECTION B**

**Answer any TWO questions from this section; your answers should take the form of essays. Each question carries 25 marks.**

- 1. In humans, the innate and adaptive mechanisms operate together as a coordinated defence system. Discuss.
- 2. Discuss the importance of osmosis in plants.
- 3. Discuss applications of modern recombinant DNA biotechnology. In your account make reference to advantages and disadvantages associated with this technology.
- 4. Discuss how the different types of skeletons in animals solve problems associated with mechanical support.

**(Total: 50 marks)**

**SECTION C**

**Answer ONE question from this section.**

1. Use your knowledge of biology to explain the following statements:
  - a. Hydrogen bonding gives water its thermoregulatory properties. (5)
  - b. Some protein structures are brought about by hydrogen bonding. (5)
  - c. Free hydrogen ions ( $H^+$ ) and free hydroxyl ions ( $OH^-$ ) in water may affect the productivity of enzymes. (5)
  - d. Hydrogen bonding needs to be broken and reformed whilst phosphodiester bonding needs only to be reformed during DNA replication. (5)
  - e. Base pairing is important during protein synthesis. (5)

**(Total: 25 marks)**

**OR**

2. Use your knowledge of biology to explain the following statements:
  - a. Angiosperms produce diploid zygotes nourished by triploid endosperm. (5)
  - b. Angiosperms have coevolved with animals. (5)
  - c. In humans, the male sexual function is controlled by several hormones. (5)
  - d. Popular vegetables, such as broccoli, cauliflower, cabbage, kale, kohlrabi, and brussels sprouts, are all representatives of a single mustard species, *Brassica oleracea*. (5)
  - e. Hardy-Weinberg equilibrium constitutes a model in which allele frequencies do not change across generations. However, several conditions must be met for a population to be at Hardy-Weinberg equilibrium. (5)

**(Total: 25 marks)**




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SUBJECT:	<b>Biology</b>
PAPER NUMBER:	III
DATE:	1 <sup>st</sup> September 2023
TIME:	9:00 a.m. to 10:35 a.m.

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### Directions to Candidates

- Write your index number in the space at the top left-hand corner of this page.
  - Answer **ALL** questions. Write all your answers in the spaces provided in this booklet.
  - The mark allocation is indicated at the end of each question. Marks allocated to parts of questions are also indicated.
  - You are reminded of the necessity for good English and orderly presentation in your answers.
  - In calculations you are advised to show all the steps in your working, giving your answer at each stage.
  - The use of electronic calculators is permitted.
- 

### For examiners' use only:

Question	1	2	3	Total
Score				
Maximum	13	19	18	<b>50</b>

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1. This question is about microscopy.

a. What is the main difference between a temporary slide and a permanent slide?

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(1)

b. A student was provided with a thinly cut transverse section of a plant stem in preparation for a temporary slide. Outline the procedure that needs to be followed to prepare a stained temporary slide of the sample provided.

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(4)

c. How does the method described in part (b) differ from that used in preparation of a root tip squash?

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(3)

d. The root tip squash technique is a simple and effective method, widely used to study cell division. Explain.

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(2)

- e. The microscope images in Figures 1 and 2 represent two species from the same taxonomic kingdom.

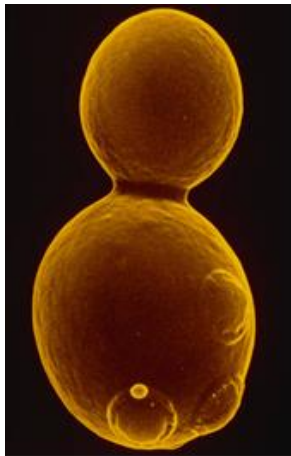


Figure 1  
<https://sciencephotogallery.com>

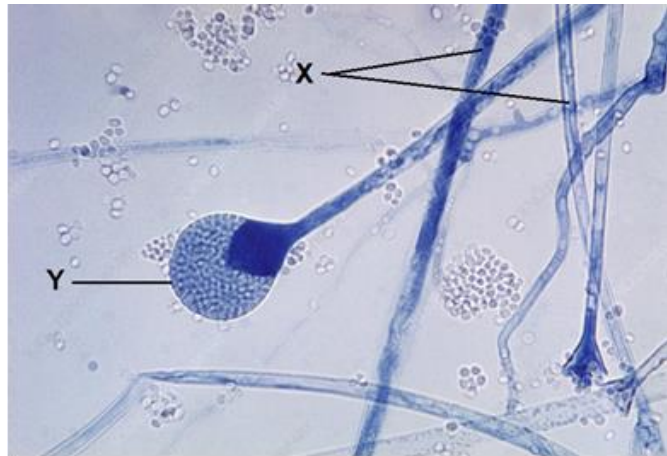


Figure 2  
<https://media.sciencephoto.com>

- (i) Identify the kingdom in which these two species are classified. \_\_\_\_\_ (1)
- (ii) Name **ONE** contrasting diagnostic structural feature that can be easily used to tell the two species apart. \_\_\_\_\_ (1)
- (iii) Provide a label for structures X and Y shown in Figure 2.  
Structure X: \_\_\_\_\_  
Structure Y: \_\_\_\_\_ (1)

**(Total: 13 marks)**

2. This question is about experiments related to photosynthetic pigments and photosynthesis.
- a. In this experiment, paper chromatography was used to separate the photosynthetic pigments present in a spinach leaf.
- (i) Suggest how these pigments can be extracted from the spinach leaf through the use of a small volume of an organic solvent such as acetone. \_\_\_\_\_ (1)

***This question continues on next page.***

A pencil was used to mark a line 2 cm above the edge of the filter paper. This line marks the starting point where the drop of the leaf extract will be placed.

- (ii) Suggest why a pencil, rather than a pen, was used to mark the starting line.

\_\_\_\_\_ (1)

Using a pipette, a drop of the leaf extract was placed on the centre of the line. The absorbent paper was left to dry and then another drop was added on the same spot of the filter paper and allowed to dry again. This was repeated four times.

The following chromatography chamber (Figure 3) was set up.

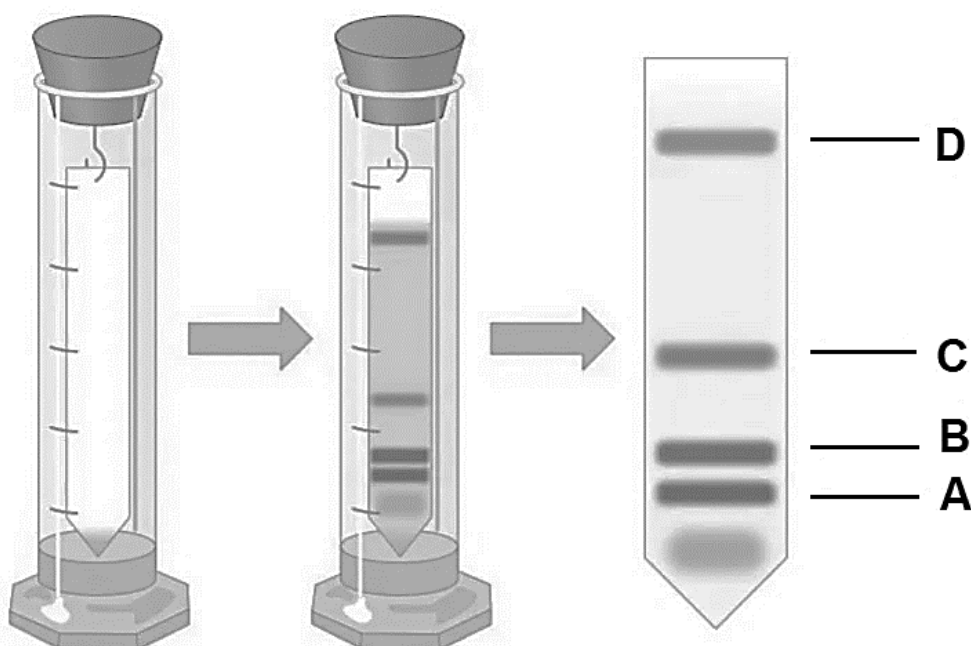


Figure 3: Chromatography chamber and results obtained  
<https://microbiologynote.com>

The solvent was allowed to move up the chromatography paper. Once the solvent front stopped moving, the paper was removed from the chamber and allowed to dry. Four pigments, labelled A to D, were identified. The distance travelled by the solvent front and the distance moved by each pigment were measured and recorded in Table 1.

Different pigments have different  $R_f$  (retention factor) values that could be estimated using the equation represented below.

$$R_f = \frac{\text{Distance travelled by pigment}}{\text{Distance travelled by solvent front}}$$



- (iii) Using the information provided in Table 1, calculate the  $R_f$  values for pigments A to D. Give your answers to 2 decimal places. Use the lines below the table to show your working.

Table 1: Table of results obtained from the paper chromatography of spinach leaf pigments.

Pigment Band	Band colour	Distance travelled by pigment (cm)	Distance travelled by solvent front (cm)	$R_f$ value
A	Light green	5.0	11	
B	Dark green	7.1	11	
C	Yellow	7.8	11	
D	Yellow-orange	10.5	11	

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(2)

- (iv) By making reference to the  $R_f$  values obtained in part (iii), indicate which pigment is retained most during its movement up the filter paper.

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(1)

- (v) Using the information from Table 1, identify the names of pigments A to D from the following list of pigments:

Carotene, Chlorophyll a, Chlorophyll b and Xanthophyll

Pigment A: \_\_\_\_\_

Pigment B: \_\_\_\_\_

Pigment C: \_\_\_\_\_

Pigment D: \_\_\_\_\_

(2)

***This question continues on next page.***

- (vi) Suggest **ONE** limitation of paper chromatography when used in the analysis of photosynthetic pigments.

(1)

- b. A second experiment was set to establish the relationship between the rate of photosynthesis of the aquatic plant *Elodea* and light.

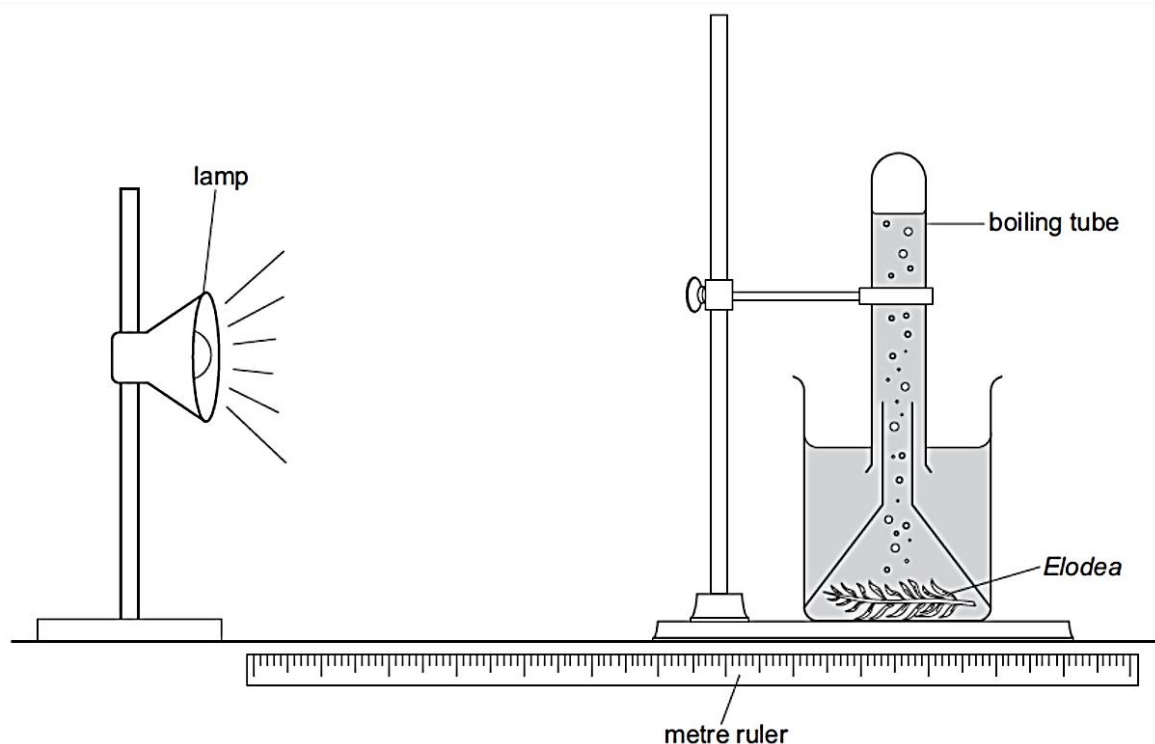


Figure 4: Experimental setup  
<https://www.eduqas.co.uk>

In this experiment the scientist placed a piece of *Elodea* in a beaker containing a solution of sodium hydrogencarbonate ( $\text{NaHCO}_3$ ). This chemical releases carbon dioxide into the solution.

During the experiment *Elodea* produced oxygen that was collected in an inverted boiling tube. The volume of oxygen collected gave the scientist an indication on the rate of photosynthesis.

- (i) Suggest why during this experiment *Elodea* is submersed in a solution of  $\text{NaHCO}_3$  rather than water.

(1)



Briefly explain the biology behind the pattern noted.

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(3)

(iv) The scientist wanted to try another experiment to see the effect of different wavelengths on the rate of photosynthesis. Suggest how slight modifications to the setup in Figure 4 may allow for such study.

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(2)

**(Total: 19 marks)**

3. This question is about histology of plants.

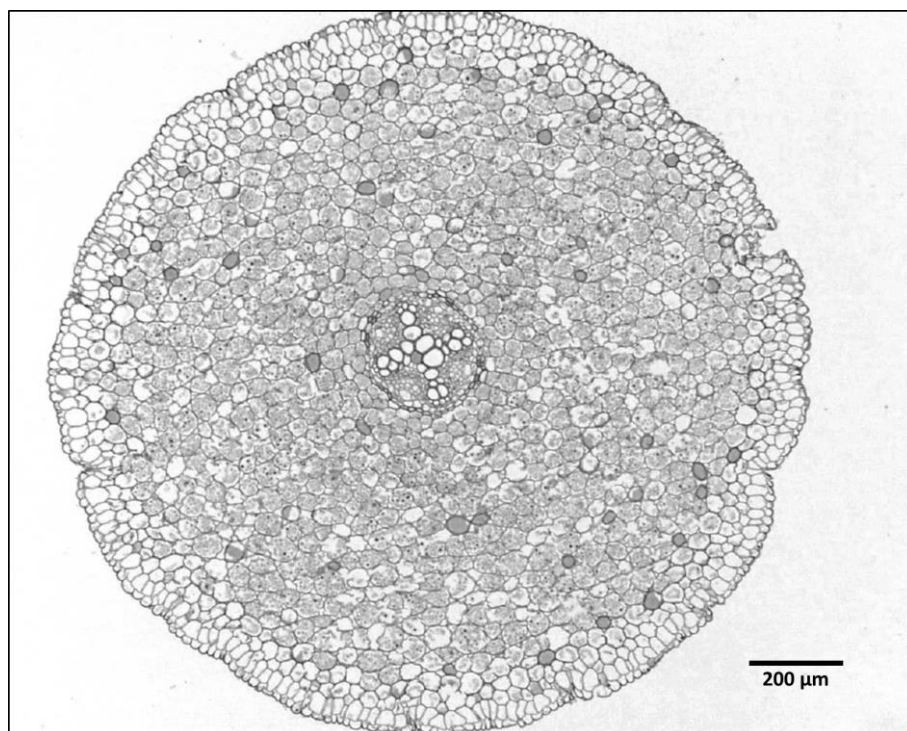


Figure 6: Transverse section of a root (plant 1)  
Adapted from: <https://biology4isc.weebly.com>

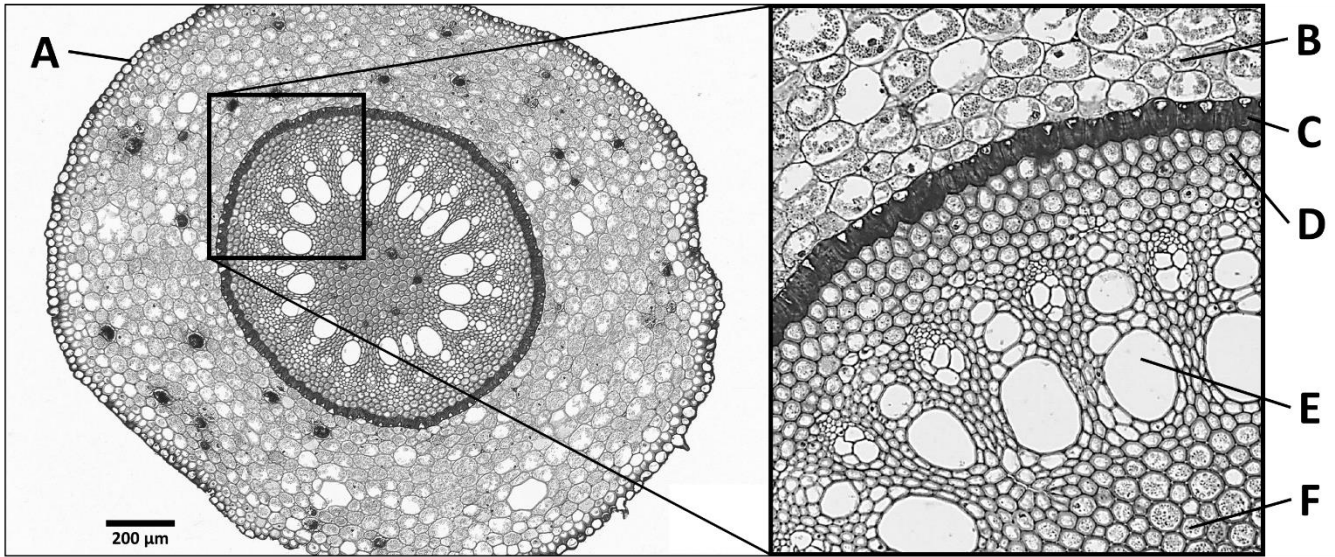


Figure 7: Transverse section of a root (plant 2)  
 Adapted from: <https://schulte.faculty.unlv.edu>

a. Figures 6 and 7 show a transverse section through the root of two different plants. Which one of the two figures represents a section from a dicot root? Briefly explain the reasoning behind your answer.

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(2)

b. Identify tissues A to F in Figure 7 and provide an annotation for each one.

Label	Tissue	Annotation
A		
B		
C		
D		
E		
F		

(9)

***This question continues on next page.***

- c. Figure 8 shows a small part from a transverse section through a dicot stem as seen under the high power of a light microscope.

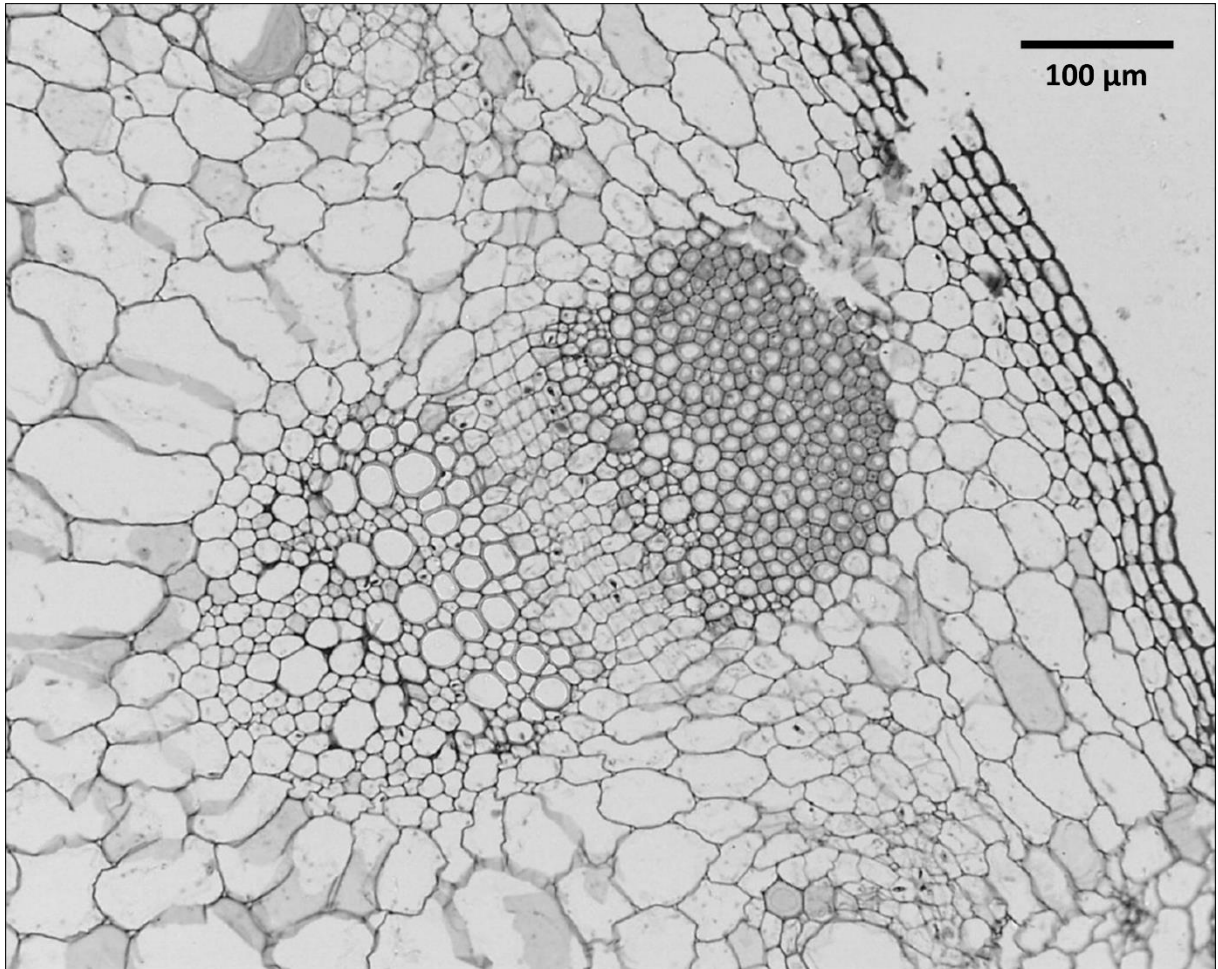



Figure 8: Transverse section through a dicot stem  
<https://schulte.faculty.unlv.edu>

In the space provided on the following page, draw and label a low power plan for the section shown in Figure 8.



(7)

**(Total: 18 marks)**

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ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE  
EXAMINATIONS BOARD

**ADVANCED MATRICULATION LEVEL  
2023 SECOND SESSION**

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SUBJECT: **Biology**  
PAPER NUMBER: IV – *Practical*  
DATE: 29<sup>th</sup> August 2023  
TIME: 1 hour 35 minutes

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### Directions to Candidates

- Write your index number in the space at the top left-hand corner of this page.
  - Answer **ALL** parts of the question. Write all your answers in this booklet. Drawings of biological material and graphical representations of data are to be made on the appropriate pages within this booklet.
  - The marks allotted to parts of question are indicated.
  - You are reminded of the necessity for good English and orderly presentation in your answers.
  - In calculations you are advised to show all the steps in your working, giving your answer at each stage.
  - The use of electronic calculators is permitted.
- 

### For examiners' use only:

Question	Total
Score	
Maximum	40

1. The vacuole of beetroot (*Beta vulgaris*) cells contains a number of pigments, collectively known as betalains. Certain chemicals may damage membranes, and in the case of beetroot, when membranes are damaged betalains leak out of the cell.

You are required to devise and implement an experimental procedure to comparatively investigate the effect of different concentrations of ethanol on the release of betalains from the cells of *Beta vulgaris*.

You are provided with the following materials:

- Beetroot strips (*Beta vulgaris*);
- 40% solution of ethanol;
- A sheet of white paper;
- Other laboratory apparatus as required.

**It is recommended that solutions of 10 mL are used during this experiment.**

- a. What is the aim of your biological investigation?

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(1)

- b. Suggest a suitable null hypothesis for this investigation.

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(1)

- c. Suggest **ONE** suitable alternative hypothesis for this investigation.

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(1)





**Carry out the investigation that you devised in part (e) and record your results in part (g).**

g. Record your results in the space below. *Marks will be awarded for the structure and the organisation of the results obtained.*

(5)

h. Describe any trend that emerges from your results.

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(3)



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