Index No.:_____ AM05/I.24m

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

ADVANCED MATRICULATION LEVEL
2024 FIRST SESSION

SUBJECT:	**Biology**
PAPER NUMBER:	I
DATE:	7th May 2024
TIME:	9:00 a.m. to 12:05 p.m.

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	4	5	6	7	8	**Total**
Score									
Maximum	17	12	10	11	17	11	12	10	**100**

1. This question is about cellular function and organisation.

   a. Figure 1 shows an animal cell. Complete Table 1 by naming the organelles labelled A to E and briefly describe the main function of each of them.

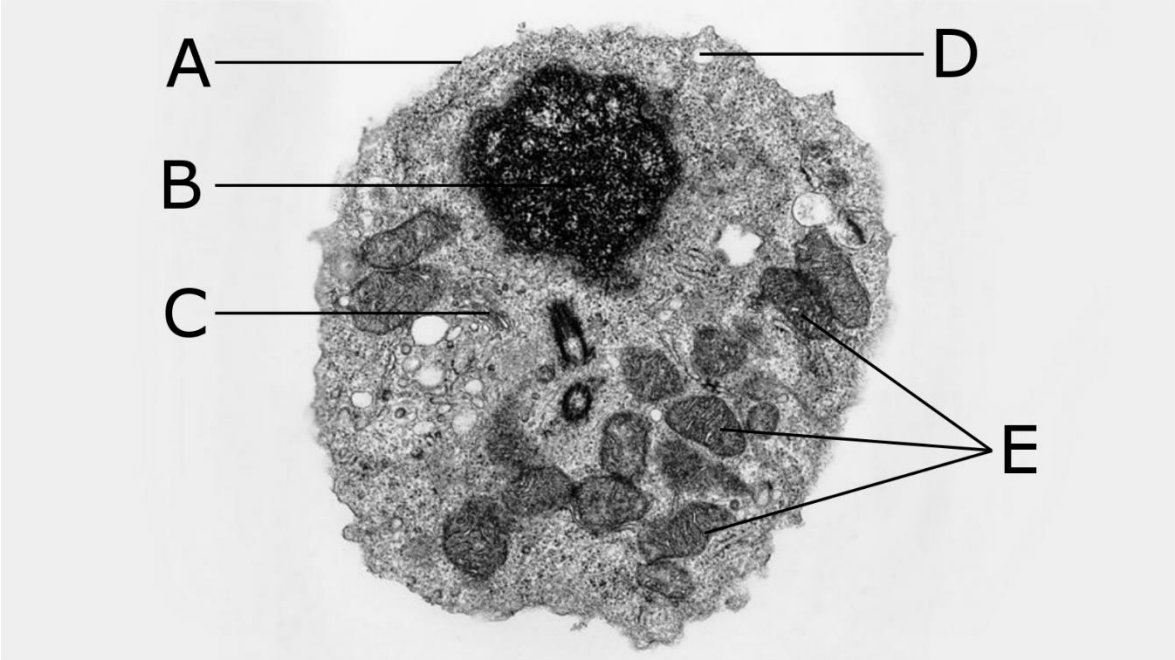

Figure 1: An electron micrograph of an animal cell.
(*Adapted from: https://www.bbc.co.uk)*

Table 1: Labelling the animal cell.

Label	Name of organelle	Main function of organelle
A		
B		
C	Golgi apparatus	
D	Lysosome	
E		

(4)

b. Briefly explain the following statements:

i. The evolution of compartmentalisation was a significant development in the specialisation of eukaryotic cells.

_____

_____

_____

_____ (2)

ii. The endoplasmic reticulum is a dynamic structure that serves many roles in the cell.

_____

_____

_____

_____

_____

_____

_____

_____ (4)

iii. Microtubules and the acrosome are essential for the proper functioning of human sperm cells.

_____

_____

_____

_____

_____

_____ (3)

Question continues on the next page.

iv. Peroxisomes are specialised for carrying out oxidative reactions.

_____

_____

_____

_____ (2)

c. Most plant cells are distinguished from animal cells by having chloroplasts. Describe **TWO** pieces of evidence supporting the idea that these organelles originated through endosymbiosis.

_____

_____

_____

_____ (2)

(Total: 17 marks)

2. This question is about cell cycles in humans.

a. Identify which phase of a typical human somatic cell cycle represents the processes below.

Process	**Phase when process occurs**
The incorrect incorporation of a nucleotide during the synthesis of a new DNA strand.	
Chromosomes align along the cell's equator.	
Chromosomes condense.	
Centrioles undergo duplication.	
Chromatids are pulled apart towards opposite poles of the cell.	
The nucleolus reforms within the daughter nuclei.	

(3)

b. Briefly explain why it is no longer possible to visually distinguish individual chromosomes after telophase.

_____

_____

_____ (2)

c. When scientists want to study chromosomes, they apply the colchicine to cells that are about to undergo mitosis. Colchicine stops the formation of microtubules in cells.

i. Briefly explain the function of microtubules during mitosis.

_____

_____

_____

_____

_____

_____ (3)

ii. Suggest why it may be helpful to add colchicine to cells during mitosis if scientists want to study chromosomes.

_____

_____

_____

_____ (2)

d. Describe **TWO** differences in the genetic material of spermatogonia and spermatids within the same individual.

Difference 1: _____

_____

Difference 2: _____

_____ (2)

(Total: 12 marks)

Please turn the page.

3. This question is about striated muscle in mammals.

a. Name the **TWO** protein filaments that form myofibrils.

_____ (1)

b. Name the ion associated with muscle contraction and identify the structure within striated muscle cells where it is stored.

Ion: _____ Storage structure: _____ (2)

c. Briefly explain how the proteins identified in your answer to part (a) contribute to muscle contraction.

_____

_____

_____

_____

_____

_____

_____

_____

_____ (4)

d. Explain how relaxation is achieved in striated muscles.

_____

_____

_____

_____

_____

_____ (3)

(Total: 10 marks)

4. Scientists use restriction endonucleases to cut out a specific gene from the DNA of one organism. Then, using other biotechnological techniques, they insert the cut sequence into the DNA of a different organism (the 'target' organism). Plasmid vectors are used to introduce the desired gene into the target organism.

   a. Restriction endonucleases are generally extracted from bacteria. Describe the main function that these molecules perform in bacteria.

_____

_____

_____ (1)

   b. Briefly describe **THREE** characteristics of plasmid vectors that make them suitable for this purpose.

_____

_____

_____

_____

_____

_____

_____ (3)

   c. List **FOUR** methods used to introduce vector DNA into host cells.

_____

_____

_____

_____ (2)

   d. What term describes a DNA molecule composed of DNA sequences obtained from different species?

_____ (1)

Question continues on next page.

e. What is the term used to describe an organism that has foreign DNA artificially integrated into its own genetic material?

_____ (1)

f. The Polymerase Chain Reaction (PCR) is a method used to artificially produce multiple copies of a DNA sequence. This method involves a three-step process: first, the DNA is denatured; then, the primers anneal to the template DNA; and finally, the DNA is copied using an enzyme.

i. Name the enzyme used during PCR.

_____ (1)

ii. The enzyme utilized during PCR is derived from thermophilic bacteria. Provide an explanation for this.

_____

_____

_____ (2)

(Total: 11 marks)

5. This question is about transport systems.

As organisms evolved, they grew in size by increasing their cellular numbers rather than enlarging individual cells. This is mainly attributed to maintaining a high surface area to volume ratio, which impacts internal cellular transport. As cell numbers increase, gaseous exchange mechanisms prove to be insufficient, leading to the development of transport mechanisms in large multicellular organisms.

a. Use your knowledge of the surface area to volume ratio to explain how increasing cell size influences internal cellular transport.

_____

_____

_____ (2)

b. Briefly explain why the need for a mass transport system was necessary when increasing the number of cells in an individual.

_____

_____

_____ (2)

c. Mass transport systems rely on three main components: a pump or a source that causes a pressure differential, vessels, and a transportation medium.

Fill in the table below to denote some properties of different transport systems.

Transport system	**Pump/ pressure generator**	**Main vessel/s**	**Transportation medium**	**Type of pressure exhibited (positive or negative)**
Plant water transport system				
Mammal circulatory system				

(4)

d. Provide an explanation for the following statements related to transport systems.

i. Sources and sinks involved in translocation within plants vary by season.

_____

_____

_____

_____ (2)

ii. Most bryophytes do **not** exhibit transpiration.

_____

_____

_____

_____ (2)

Question continues on the next page.

iii. In the limbs of vertebrates, some veins are situated between skeletal muscles.

_____

_____

_____

_____ (2)

iv. Different blood vessels in the human circulatory system have different thicknesses.

_____

_____

_____

_____

_____

_____

_____

_____ (3)

(Total: 17 marks)

6. This question is about human reproduction.

The table below displays the typical range of sex hormone levels necessary for the proper functioning of the human reproductive system.

Table 2: Mean levels of sex hormones in males and females per mL of blood.

Hormone	**Typical range in males**	**Typical range in females**
Follicle stimulating hormone	1 – 12 mIU mL^{-1}	3 – 9 mIU mL^{-1}
Luteinising hormone	2 – 12 mIU mL^{-1}	2 – 10 mIU mL^{-1}
Progesterone	0.13 – 0.97 ng mL^{-1}	5 – 20 ng mL^{-1} (on day 21)
Oestrogen	10 – 40 pg mL^{-1}	27 – 161 pg mL^{-1}
Testosterone	2.70 – 10.70 ng mL^{-1}	0.15 – 0.70 ng mL^{-1}

(*Adapted from: invitra.com*)

a. Name **TWO** hormones secreted by the pituitary gland that play a role in regulating the menstrual cycle in females.

_____ (1)

b. Based on your knowledge of feedback mechanisms and hormonal levels, use the information provided in Table 2 to propose a possible explanation for the observations noted below.

i. A male exhibits testosterone levels higher than 10.70 ng mL^{-1} whilst both follicle stimulating hormone and luteinising hormone levels are below 0.5 mIU mL^{-1}.

_____

_____

_____

_____ (2)

ii. During days 13-14 of the menstrual cycle, a female's oestrogen levels spike to 300 pg mL^{-1}.

_____

_____

_____

_____ (2)

iii. On day 28 of her menstrual cycle, a female's progesterone level was 50 ng mL^{-1}.

_____

_____

_____

_____ (2)

c. In week 39 of pregnancy, oxytocin levels rise in the pregnant mother, while after childbirth, the levels of the hormone prolactin in the mother remain elevated.

i. Where in the body is oxytocin produced?

_____ (1)

Question continues on next page.

ii. What are the **TWO** primary functions of oxytocin during and after childbirth?

_____

_____ (2)

iii. What is the main role of prolactin in the body?

_____ (1)

(Total: 11 marks)

7. This question is about genetic diversity.

a. The Northern elephant seals (*Mirounga angustirostris*) were nearly hunted to extinction for their blubber. By the late 19th century, their population had declined to a few individuals, resulting in a reduction in the genetic diversity of the species.

i. What term is used to describe the drastic reduction in the genetic diversity of the Northern elephant seals?

_____ (1)

ii. Describe **TWO** other processes that would further prompt loss of genetic diversity when the population size drastically declines.

_____

_____

_____

_____ (2)

iii. Discuss how the loss of genetic variation may affect the species' ability to adapt to environmental changes or disease outbreaks in the future.

_____

_____

_____

_____ (2)

b. A small group of Galapagos finches established a new population on a small island, most likely as a result of being blown off course during a storm.

i. What term may be used to describe the establishment of a new population by a small subset of the original population?

_____ (1)

ii. How would you expect the genetic diversity of the newly established population to compare with that found on the nearby larger islands? Explain your answer.

_____

_____

_____ (2)

c. Northern spotted owls are known for their limited dispersal capabilities, often exhibiting fidelity to specific forested habitats for nesting and foraging. This behaviour makes this species susceptible to habitat fragmentation.

i. State what is meant by habitat fragmentation.

_____

_____ (1)

ii. Mention **ONE** human activity that may lead to habitat fragmentation for this species of owl.

_____ (1)

iii. Describe how habitat fragmentation may influence the gene pool of this species.

_____

_____

_____

_____ (2)

(Total: 12 marks)

Please turn the page.

8. The food web depicted below (Figure 2) illustrates a simplified food web from the Mediterranean Sea, with the primary producer being a species of alga that lives under similar conditions as those of the seagrass *Posidonia oceanica*.

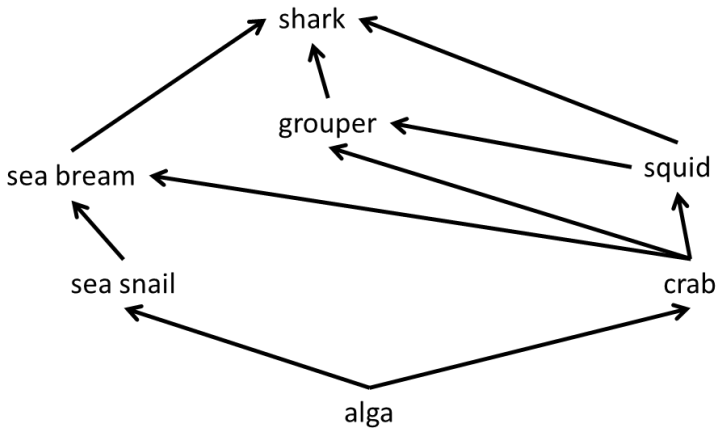

Figure 2: A simplified marine food web from the Mediterranean Sea.

a. Which coastal zone would the species at the first trophic level inhabit?

_____ (1)

b. Identify the phylum in which the following animals are classified.

Crab: _____ Sea snail: _____ (1)

c. Based on Figure 2, would you expect the fundamental niche of the crab to change should the sea bream go extinct? Provide a reason for your answer.

_____

_____

_____

_____ (2)

d. Give **ONE** example of a secondary consumer from Figure 2, and explain how the removal of the top predator would influence its realised niche.

_____

_____

_____

_____

_____ (3)

e. The populations of sharks in the Mediterranean Sea are small compared to the population of the animals they feed on. Using only information related to the food web shown in Figure 2, explain why the populations of sharks are small.

_____

_____

_____

_____

_____

_____ (3)

(Total: 10 marks)

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MATRICULATION AND SECONDARY EDUCATION CERTIFICATE
EXAMINATIONS BOARD

ADVANCED MATRICULATION LEVEL
2024 FIRST SESSION

SUBJECT:	**Biology**
PAPER NUMBER:	II
DATE:	7th May 2024
TIME:	4:00 p.m. to 7:05 p.m.

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.

The Power of Poison

The cosmetic use of botulinum toxin, often encountered under the trade name 'Botox', has mushroomed in recent years. However, it has a diverse and important range of clinical uses, especially in the treatment of neuromuscular disorders and chronic pain.

The story starts with a fairly typical microorganism, which most bacteriologists will never encounter and which is only ever handled in specialist laboratories. *Clostridium botulinum* is a typical endospore-forming, obligatory anaerobic, Gram-positive rod that grows at an optimal temperature of 30–40°C.

Under appropriate circumstances, and depending on the bacterial strain, *C. botulinum* can produce 7 distinct forms of neurotoxic proteins, types A–G. Four of these (types A, B, E and rarely F) cause human botulism, while types C, D and E cause illness in other mammals, birds and fish.

It is these toxins that produce the food-poisoning condition known as botulism. This involves the ingestion of the toxins through improperly preserved food, for example, through improper canning or bottling. Prolonged boiling can destroy these toxins.

Clostridium botulinum is commonly found in soil and also lives in the intestinal tract of animals, namely ruminants, where the ingested bacteria produce only minor adverse effects. This bacterium only occasionally causes animal botulism, usually from consumption of contaminated carcasses.

It was the German physician Justinus Kerner who, in 1820, discovered botulism in a group of musicians affected after eating contaminated ham. Symptoms of botulism, which typically develop after more than 12 hours, include muscle weakness and may extend to the muscle cells of the respiratory system, negatively impacting the victim's ability to inhale.

The biochemical mechanism of botulinum toxin is well understood. The toxins are produced as single-chain polypeptides that are activated by the bacterium's own proteolytic enzymes, forming a two-chain structure held together by a disulfide bridge. This modified form is absorbed directly through the gut wall, transported via the bloodstream, and eventually binds to the terminals of cholinergic neurons, that is nerve cells that use the neurotransmitter acetylcholine.

From the neuronal terminals, the toxin is transported into the cell's cytoplasm. Here, it cleaves the proteins that help release acetylcholine resulting in that part of the nervous system being unable to secrete the neurotransmitter, leading to paralysis.

(Adapted from: Feld, DR & Grünewald, RA (2018) The power of poison, The Biologist 65(2): 14-17).

a. *Clostridium botulinum* is a Gram-positive bacterium (line 6). What determines the Gram-staining result in bacteria? (2)

b. Considering that *Clostridium botulinum*'s optimal growth temperature ranges between 30–40°C (line 7), state how temperature may influence the prevalence of botulism outbreaks. (1)

c. Why does canning and bottling of food (lines 13–14) provide the optimal environmental conditions for the growth of *C. botulinum*? (2)

d. The neurotoxins produced by *C. botulinum* are destroyed by boiling (line 14). Explain how high temperature may destroy these neurotoxins. (2)

e. Suggest how the diversity of toxins produced by this bacterium (lines 8–11) may impact approaches to treatment. (1)

f. Describe how the proteolytic enzymes mentioned in line 24 may transform the single-chained polypeptide. (2)

g. Name **FOUR** types of bonding or interactions that may hold multiple polypeptides together in a protein structure. (2)

h. Name the neurotransmitter mentioned in the text. (1)

i. The neurotransmitter mentioned in the text is stored in nerve cells until it is released. Explain the action of this neurotransmitter once it diffuses across the synaptic cleft. (4)

j. Explain how the botulinum toxin may cause muscle weakness. (2)

k. In line 16, the authors indicated that these bacteria apart from being in soil, may also occur in the intestinal tract of ruminants. Give an example of a species that is a ruminant. (1)

l. Ruminants' guts are home to several bacterial species. Briefly explain the symbiotic relationship between ruminants and the bacteria that occur in their rumen. (3)

m. Name **TWO** roles of intestinal bacteria in the human digestive system. (2)

(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. Discuss the role of the human kidney in osmoregulation and excretion.

2. Nucleotides and proteins are required for enzyme production. Discuss this statement.

3. Reduced coenzymes are essential for cellular respiration. Discuss this statement.

4. Give a comparative account of isolating mechanisms and their impact on evolution.

(Total: 50 marks)

SECTION C
Answer ONE question from this section.

1. Use your knowledge of biology to explain the following statements:

   a. Conformational change in rhodopsin is important in mammalian vision. (5)

   b. Drugs that influence the human central nervous system have the ability to mimic the body's own chemical signals. (5)

   c. The humoral immune system relies on antigen recognition to initiate an appropriate immune response. (5)

   d. Insulin and glucagon play crucial roles in regulating blood glucose levels. (5)

   e. Physiological changes in mammals contribute to the maintenance of a constant body temperature. (5)

(Total: 25 marks)

OR

2. Use your knowledge of biology to explain the following statements:

   a. Both the brown alga *Cystoseira* and the bryophyte *Funaria* lack a true vascular system, yet, despite this similarity, they are classified in different kingdoms. (5)

   b. Heterosporous plants are capable of adapting to a broader set of environmental conditions than homosporous plants. (5)

   c. Some plants are capable of reproducing both asexually and sexually. (5)

   d. The sporophyte stage of Fabaceae has a different morphology from that of Poaceae. (5)

   e. In angiosperms, both the embryo and its nutritive tissue are produced via a specialised reproductive process. (5)

(Total: 25 marks)

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MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

ADVANCED MATRICULATION LEVEL
2024 FIRST SESSION

SUBJECT:	**Biology**
PAPER NUMBER:	III
DATE:	8th May 2024
TIME:	9:00 a.m. to 10:35 a.m.

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	20	17	**50**

1. This question is about the variety of living organisms.

   a. Identify the phylum in which each of the four organisms shown in Figures 1 to 4 is classified.

Figure 1
(obtained from: https://www.carolina.com)

PHYLUM: _____

Figure 2
(obtained from: https://www.britannica.com)

PHYLUM: _____

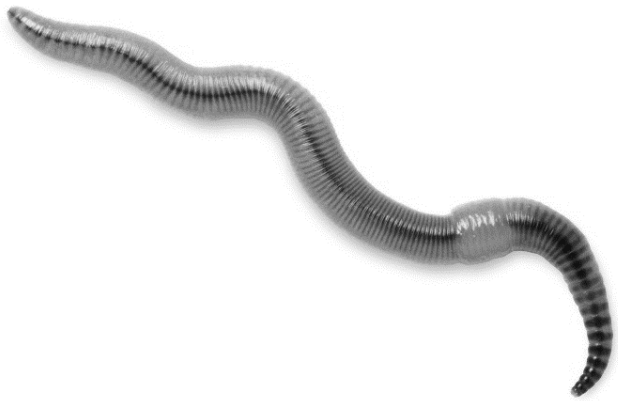

Figure 3
(obtained from: https://res.cloudinary.com/)

PHYLUM: _____

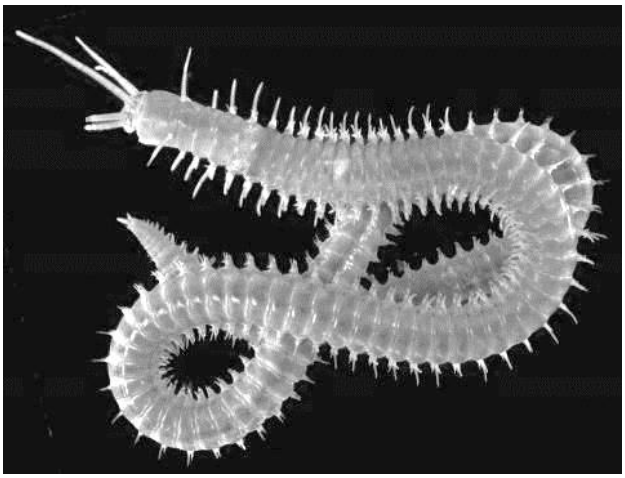

Figure 4
(obtained from: https://i.pinimg.com)

PHYLUM: _____

(4)

b. Name a taxon, below the rank of phylum, within which the organisms in Figure 3 and Figure 4 are classified.

Figure 3: _____

Figure 4: _____ (2)

c. Using only visible morphological features, construct a dichotomous key to distinguish between the four organisms shown in Figures 1 to 4.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____ (5)

d. The organism in Figure 2 is a triploblastic acoelomate. Briefly explain the terms *triploblastic* and *acoelomate*.

Triploblastic: _____

_____

Acoelomate: _____

_____ (2)

(Total: 13 marks)

2. A spirometer, as shown in Figure 5, was used to measure the lung capacity of a 25-year-old male (the 'experimental subject') both at rest and just after exercise. The experimental subject had been fasting from food for three hours before the experiment and was not a smoker.

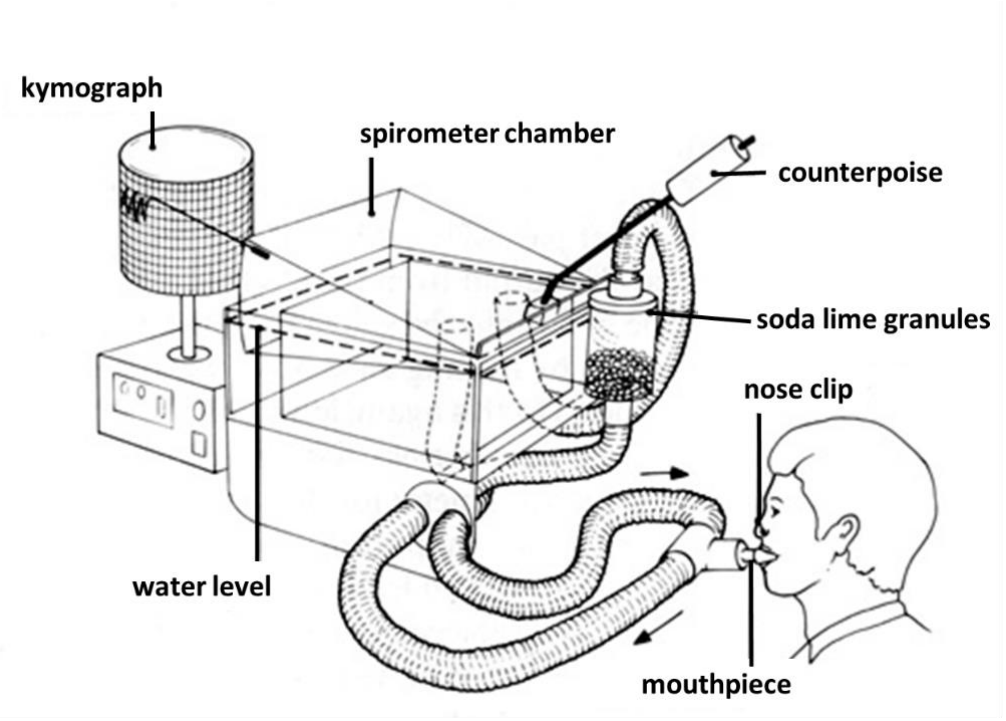

Figure 5: Spirometer setup.

(Adapted from: https://practicalbiology.org/images/pbiol/img/)

a. Explain why the experimental subject was wearing a nose-clip during this investigation.

_____

_____ (1)

b. Explain the function of the soda lime granules in the set-up shown in Figure 5.

_____

_____ (1)

The breathing capacity of the person under study was measured while at rest. While sitting down, the person was asked to breathe normally for approximately 70 seconds, followed by one maximum inhalation and one maximum exhalation. The person then continued with normal breathing until reaching 180 seconds. The first 100 seconds are represented in Figure 6, and the entire pattern is shown in Figure 7.

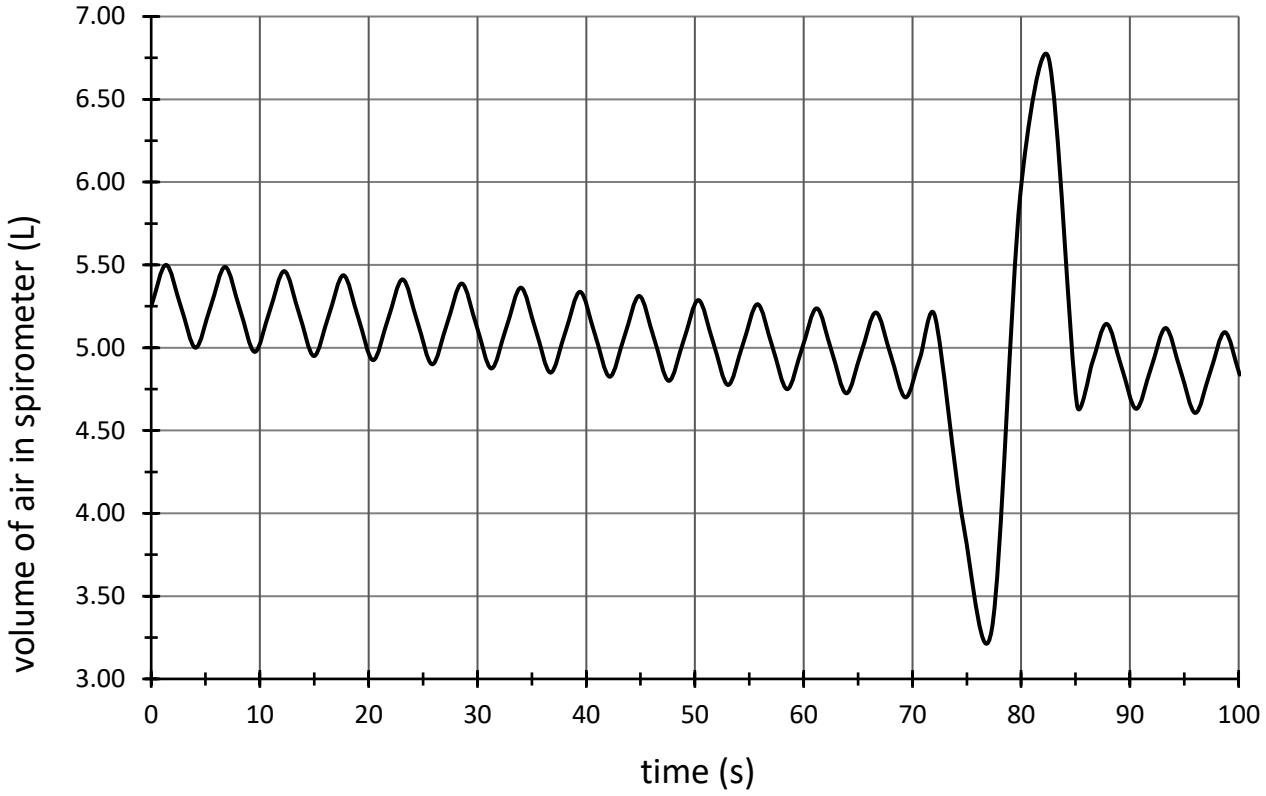

Figure 6: Spirogram for the person when at rest, showing variation in the volume of air during the first 100 s.

c. Using the spirogram in Figure 6, determine the value of the following for the person at rest.

i. The number of breaths during the first minute.

_____ (1)

ii. The tidal volume, that is the volume of air exchanged during normal breathing.

_____ (1)

iii. The vital capacity, that is the maximum volume of air exhaled after maximum inhalation.

_____ (1)

iv. The volume of carbon dioxide the person produced during the first minute.

_____ (1)

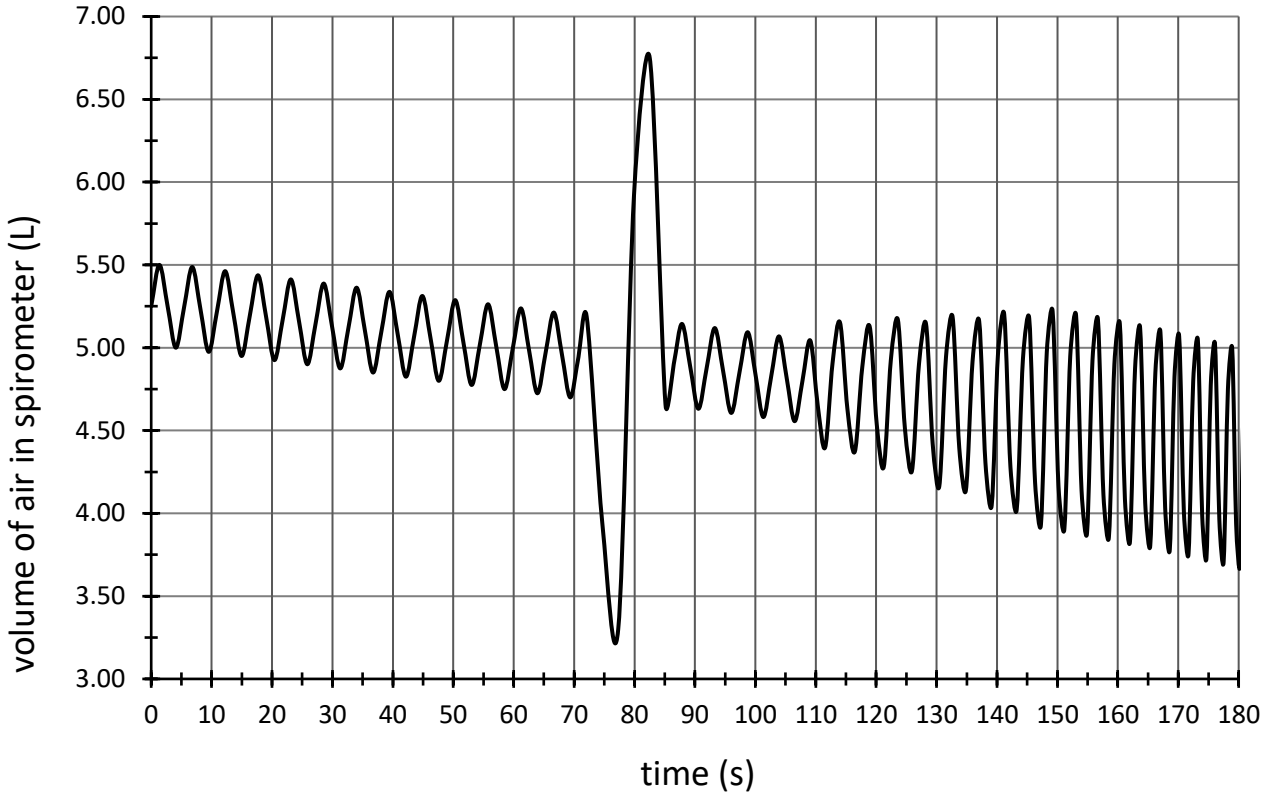

Figure 7: Spirogram for the person when at rest, showing variation in the volume of air during the first 180 s.

d. Using the spirogram shown in Figure 7, explain how the pattern observed during the third minute differs from that observed during the first minute.

_____

_____

_____ (1)

e. Suggest why there were differences between the third minute and first minute, even though the person was at rest during the entire period.

_____

_____

_____ (2)

f. From the data on the spirogram one cannot determine the residual volume. Explain the term 'residual volume'.

_____

_____ (1)

In a second experiment, the breathing was analysed for 40 seconds after a short period of physical exercise. The spirogram is shown in Figure 8.

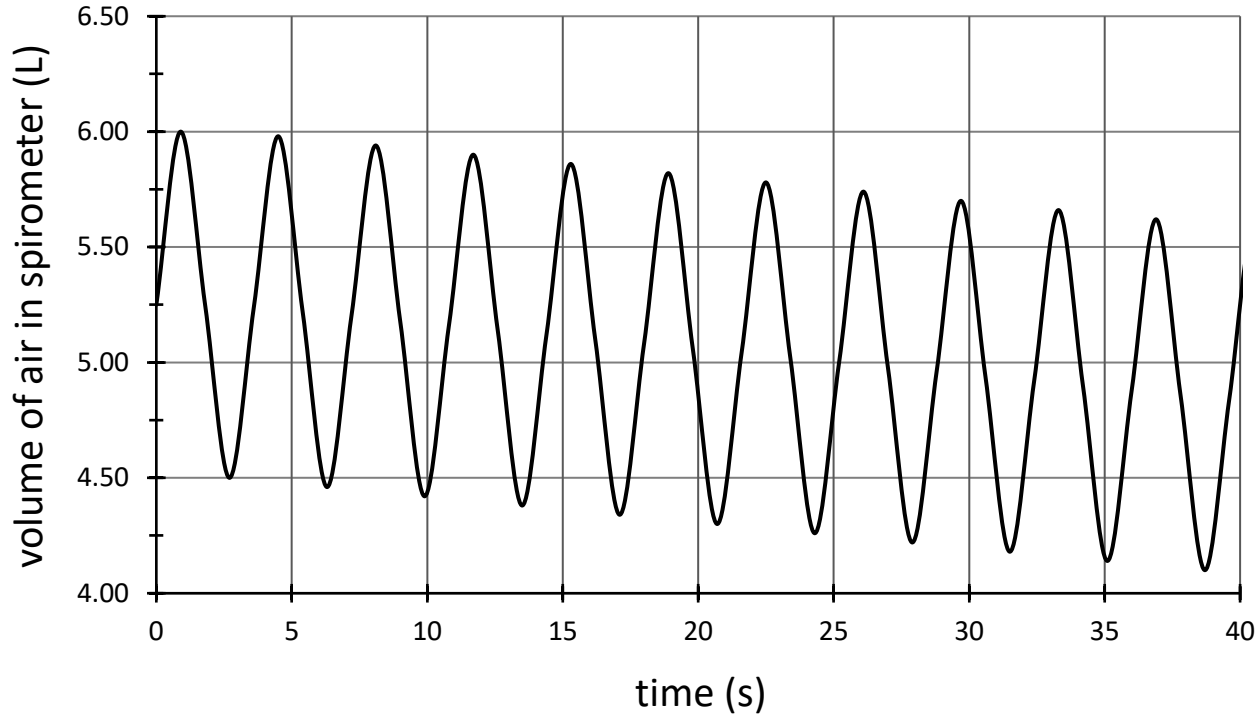

Figure 8: Spirogram for the person after undergoing exercise, showing data for 40 s.

g. By referring to differences noted between the plots in Figure 6 and Figure 8, explain how:

i) breathing patterns change after exercise.

_____

_____

_____

_____ (2)

ii) the demand for oxygen changes after exercise.

_____

_____

_____

_____ (2)

h. The experimental subject was asked to fast for at least 3 hours before the experiment. Considering the person at rest (Figure 6), how would you expect the breathing volumes and patterns to change, if at all, had the person consumed a full meal 30 minutes prior to the investigation? Explain your answer.

_____

_____

_____

_____ (2)

i. Considering the person at rest (Figure 6), how would you expect the breathing pattern of the person under study to differ, if at all, had the person been a heavy smoker? Provide an explanation for your answer, bearing in mind that smoking alters the structure of the alveoli.

_____

_____

_____ (2)

Asthma is a respiratory condition that affects the airways in the lungs. In asthmatic individuals, the airways can become inflamed and constricted, hindering exhalation. In a separate study, two individuals, one suffering from chronic asthma and the other a non-asthmatic, were asked to inhale and exhale as hard and fast as possible into a spirometer. This was done to measure their volume of exhaled air, as shown in Figure 9.

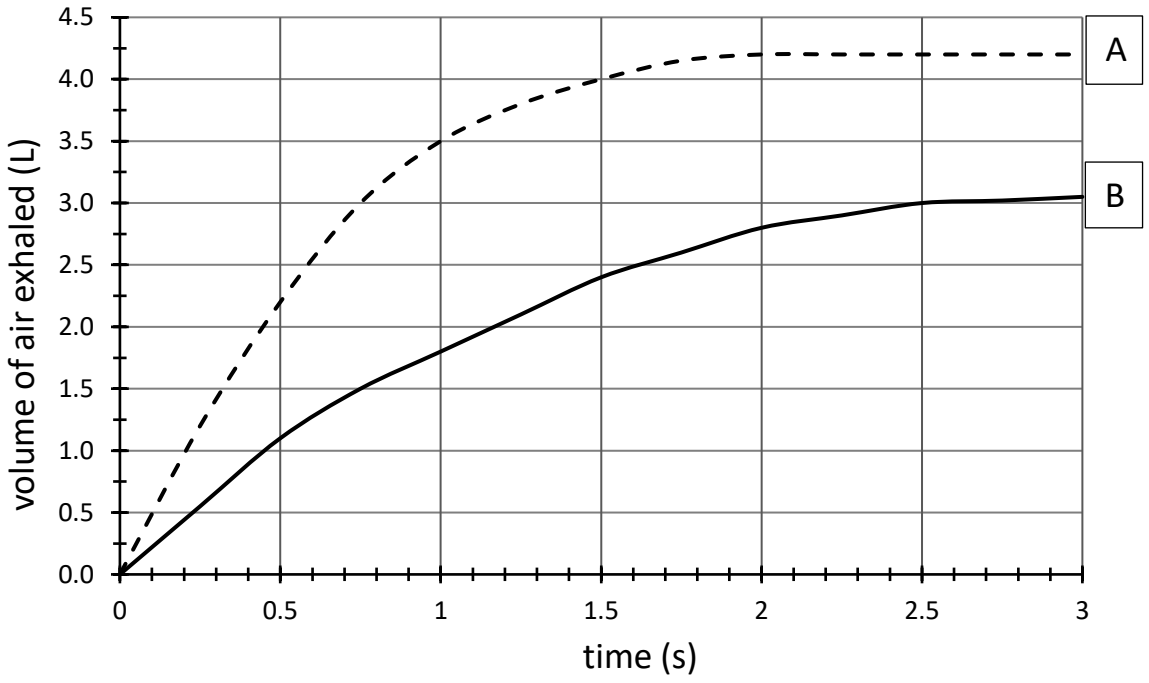

Figure 9: The volume of air exhaled by the two individuals (persons A and B).

j. Which of the two individuals, person A or person B, was asthmatic? Provide an explanation for your answer.

_____

_____

_____

_____ (2)

(Total: 20 marks)

3. A study was carried out to estimate the population size (N) of a cave-dwelling cricket inhabiting a cave in central Italy. The study was conducted over a period of two years, using two methods in parallel to determine the population size. N_Q represents the population size calculated by the quadrat method, while N_{CR} values were estimated using the capture-mark-recapture technique. The Lincoln Index calculation, used for estimating N_{CR} values, is shown below.

The Lincoln Index Equation

$$N_{CR} = \frac{n_a \times n_b}{m}$$

N_{CR} = total population size estimated using capture-mark-recapture technique.
n_a = number of individuals captured and marked in the first sampling event.
n_b = number of individuals captured in the second sampling event.
m = number of marked individuals captured during the second sampling event.

a. Outline how the quadrat method may be used to estimate the population size of the species.

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_____ (3)

b. Explain how the capture-mark-recapture method may be used to estimate the population size of the species.

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_____ (4)

Table 1: Sampling date and the population size estimates using the quadrat method (N_Q) and the capture–mark–recapture method (N_{CR}).

(n_a, n_b and m represent the variables in the Lincoln Index equation)

Sampling date	**N_Q**	**n_a**	**n_b**	**m**	**N_{CR}**
26.05.21	529	73	72	11	478
27.09.21	781	88	79	16	435
15.01.22	379	81	103	15	556
30.05.22	423	96	85	26	314
01.10.22	495	108	146	34	
14.01.23	491	132	166	49	
08.04.23	309	129	157	42	
Mean		n/a	n/a	n/a	

c. Using the equation for the Lincoln Index, calculate the population size (N_{CR}) of crickets for the last three sampling dates. Use the space provided below for your calculations, and record your answers in Table 1. Give your answers to the nearest whole number.

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_____ (3)

d. Calculate the mean values for both N_Q and N_{CR}, respectively. Use the space provided below for your calculations, and record your answers in Table 1. Give your answers to 1 decimal place.

_____

_____

_____

_____ (1)

The ecologist conducting this study wanted to determine the reliability and accuracy of the results obtained from the two sampling methods used in this research. She sought to verify whether the observed difference in population size values for N_Q and N_{CR} was statistically significant and not merely due to chance. She opted for statistical analysis of the data using the two-tailed t-test for null hypothesis testing and to assess statistical significance. A t-score of 0.522 was obtained.

e. Propose a suitable null hypothesis for this test.

_____

_____

_____ (1)

f. How many degrees of freedom are associated with the t-test conducted by the researcher?

_____ (1)

Table 2: T-distribution table of critical values

Degrees of freedom	Level of significance					
	0.20	**0.10**	**0.05**	**0.02**	**0.01**	**0.001**
1	3.078	6.314	12.71	31.82	63.66	636.62
2	1.886	2.920	4.303	6.965	9.925	31.599
3	1.638	2.353	3.182	4.541	5.841	12.924
4	1.533	2.132	2.776	3.747	4.604	8.610
5	1.476	2.015	2.571	3.365	4.032	6.869
6	1.440	1.943	2.447	3.143	3.707	5.959
7	1.415	1.895	2.365	2.998	3.499	5.408
8	1.397	1.860	2.306	2.896	3.355	5.041
9	1.383	1.833	2.262	2.821	3.250	4.781
10	1.372	1.812	2.228	2.764	3.169	4.587
11	1.363	1.796	2.201	2.718	3.106	4.437
12	1.356	1.782	2.179	2.681	3.055	4.318
13	1.350	1.771	2.160	2.650	3.012	4.221
14	1.345	1.761	2.145	2.624	2.977	4.140
15	1.341	1.753	2.131	2.602	2.947	4.073

(Adapted from: https://www.ttable.org)

g. Using the information in Table 2, determine the critical t-value for a significance level of P = 0.05.

_____ (1)

h. Based on the t-value obtained by the researcher and the critical t-value identified in your answer to part (g), should the researcher accept or reject the null hypothesis at a significance level of P = 0.05? Provide an explanation for your answer.

_____

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_____ (2)

i. Explain what your answer to part (h) suggests about the two sampling methods used in this study.

_____

_____

_____ (1)

(Total: 17 marks)

Index No.:_____ AM05/IV.24m

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

ADVANCED MATRICULATION LEVEL
2024 FIRST SESSION

SUBJECT:	**Biology**
PAPER NUMBER:	IV – *Practical*
DATE:	6th June 2024
TIME:	1 hour 35 minutes

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. Catalase is an enzyme that protects cells from damage caused by reactive oxygen compounds. Through its catalytic activity, it decomposes hydrogen peroxide (the substrate) into water and oxygen, as shown in the equation below.

In laboratory procedures, the height of the foam formed during the reaction can be used to estimate the enzyme's activity. You are required to devise and implement an experimental procedure to investigate the effect of different catalase concentrations on the rate of enzyme activity.

You are provided with the following materials:
- soap solution (labelled as **soap**) and a dropping pipette;
- hydrogen peroxide solution (labelled as **substrate**);
- catalase solution (labelled as **enzyme**);
- distilled water;
- other laboratory apparatus as required.

a. Suggest a suitable null hypothesis for this investigation.

_____

_____

_____ (1)

b. The catalase solution (labelled as **enzyme**) is buffered. Provide and explain **ONE** reason for using a buffer in the enzyme solution.

_____

_____

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_____ (2)

c. Describe the function of soap during the experiment.

_____

_____

_____ (1)

d. You are provided with a 0.04% catalase solution (labelled as **enzyme**) and distilled water. By filling the table below, show how you would prepare three 4 mL solutions having a concentration of 0.03%, 0.02% and 0.01% catalase solution, respectively.

Final catalase concentration	Volume of 0.04% catalase solution (mL)	Volume of distilled water (mL)	Total volume (mL)
0.03%			4
0.02%			4
0.01%			4

(3)

Prepare the 4 mL catalase solutions as indicated in part (d). Use the provided syringes to measure volumes and place the prepared solutions in the small cups provided.

e. Using the materials provided, devise and describe an experimental procedure, including a suitable control, that can be used to investigate the effect of different catalase concentrations on the rate of enzyme activity.

It is recommended to use:

- one drop of the soap solution (using the dropping pipette provided), 1 mL of the substrate solution, and 1 mL of enzyme solution during this experiment;
- follow the sequence outlined above for the addition of chemicals.

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Question continues on next page.

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_____ (10)

f. List and justify **TWO** precautions that should be taken during the experiment.

Precaution 1: _____

_____

_____

_____ (2)

Precaution 2: _____

_____

_____

_____ (2)

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. Draw a graph to represent your results on the graph paper provided on the following page. (6)

Question continues on next page.

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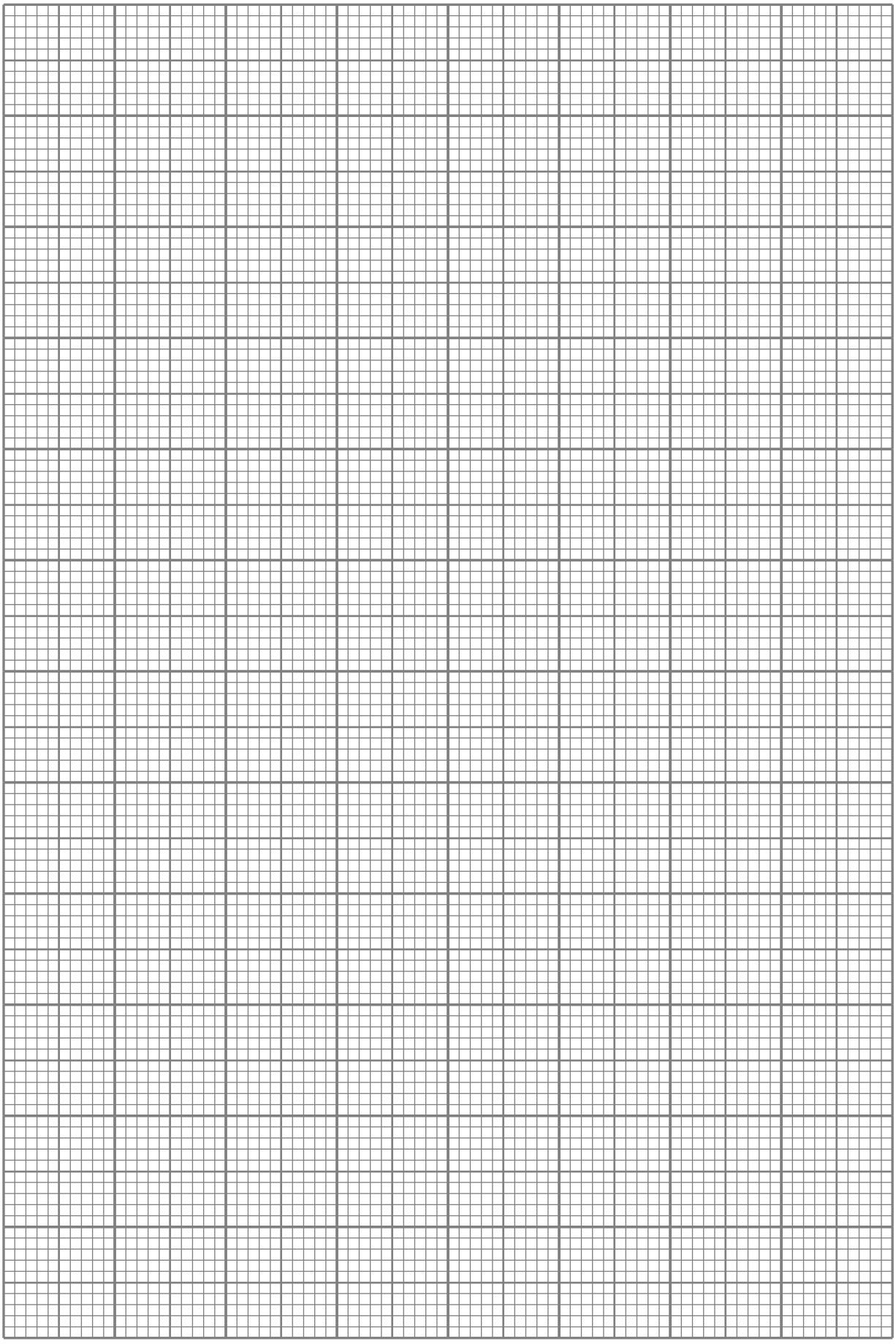

i. Describe any pattern that emerges from your results.

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_____ (2)

j. Use your knowledge of biology to interpret your results.

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_____ (4)

k. List **TWO** sources of error that may have occurred during your investigation.

Source of error 1: _____

_____ (1)

Source of error 2:

_____

_____ (1)

(Total: 40 marks)

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