Index Number:_____ SEC04/1.23m

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

SECONDARY EDUCATION CERTIFICATE LEVEL
2023 MAIN SESSION

SUBJECT:	**Biology**
PAPER NUMBER:	I
DATE:	8th May 2023
TIME:	9:00 a.m. to 11:05 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.
- The mark allocation is indicated at the end of each question. Marks allocated to parts of questions are also indicated in brackets.
- You are reminded of the necessity for orderly presentation in your answers.
- The use of electronic calculators is permitted.

For examiners' use only:

Question	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
Score											
Maximum	**11**	**10**	**11**	**8**	**10**	**10**	**10**	**10**	**10**	**10**	**100**

1. a. This question is about bacteria and viruses. From the list below, choose the most appropriate term to fill in the blanks.

binary fission	decomposing	nitrogen fixing	host
prokaryotes	protein coat	reproduce	single-celled

Bacteria and viruses may not be visible with the human eye, but they are all around us in staggering numbers. Bacteria are _____ i.e. made up of simple cells, with free floating genetic material. A virus is not a living organism and can only grow and _____ in the cells of a _____. Viruses are not cellular.

Bacteria, by contrast, are _____ organisms that produce their own energy and can reproduce on their own. While both can cause disease, bacteria also serve other vital roles in nature. Many bacteria living in the human gut, help in digestion of food and absorption of the products formed, _____ and _____ organic material in soil. Bacteria reproduce mainly by _____ .

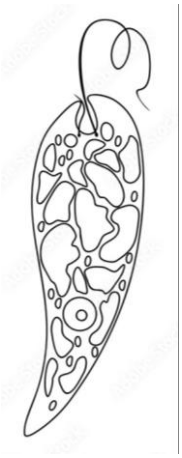
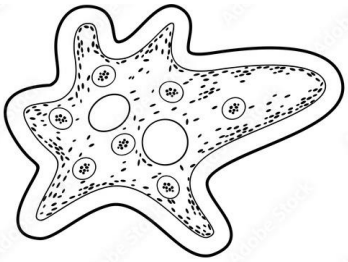
Viruses are an assembly of different types of molecules that consist of genetic material with a _____ and, sometimes enveloped with a layer of fat too. (4)

b. The table below shows some characteristics of plants and fungi. Fill in the missing characteristics.

Characteristic	**Plants**	**Fungi**
Reproduction	Some reproduce by seeds	None reproduce by seeds
Main carbohydrate stored		Glycogen
Cell wall is made up of	Cellulose	
Structure of organism		Mycelium and hyphae

(3)

c. In the table below, list **TWO** differences and **TWO** similarities between a plant-like protist and an animal-like protist.

Plant-like protist E.g. *Euglena* 	**Animal-like protist** E.g. *Amoeba*  *(Source: https://as1.ftcdn.net/v2/jpg)*
Differences	
i)	
ii)	
Similarities	
i)	
ii)	

(2,2)

(Total: 11 marks)

Please turn the page.

2. a. Figure 2.1 below shows two plants which have flowers that resemble human organs.

Lamprocapnos spectabilis

Celosia argentea var. cristata

Figure 2.1: Heart shaped and brain shaped flowers
(Source: Lamprocapnos spectabilis https://www.deviantart.com/finnisterre/ Celosia argentea https://www.pinterest.com/pin/)

i) Both plants have broad leaves with a network of veins. Use this information to deduce whether these flowering plants are dicots or monocots.

_____ (1)

ii) Based on your answer to part a i), predict the number of petals expected in **each** flower.

_____ (1)

b. *Dawsonia superba* is the tallest moss on Earth. Under optimum conditions it can grow up to 50 cm. It is found in certain regions of New Zealand and Australia.

i) Describe the habitat of this plant.

_____ (1)

ii) Explain why it is unusual that mosses grow to such heights.

_____

_____ (2)

iii) The leaves of mosses have a primitive type of cuticle. Explain the importance of the cuticle in leaves.

_____

_____ (2)

c. Figure 2.3 shows a part of Aleppo Pine (*Pinus halepensis*) including male and female cones.

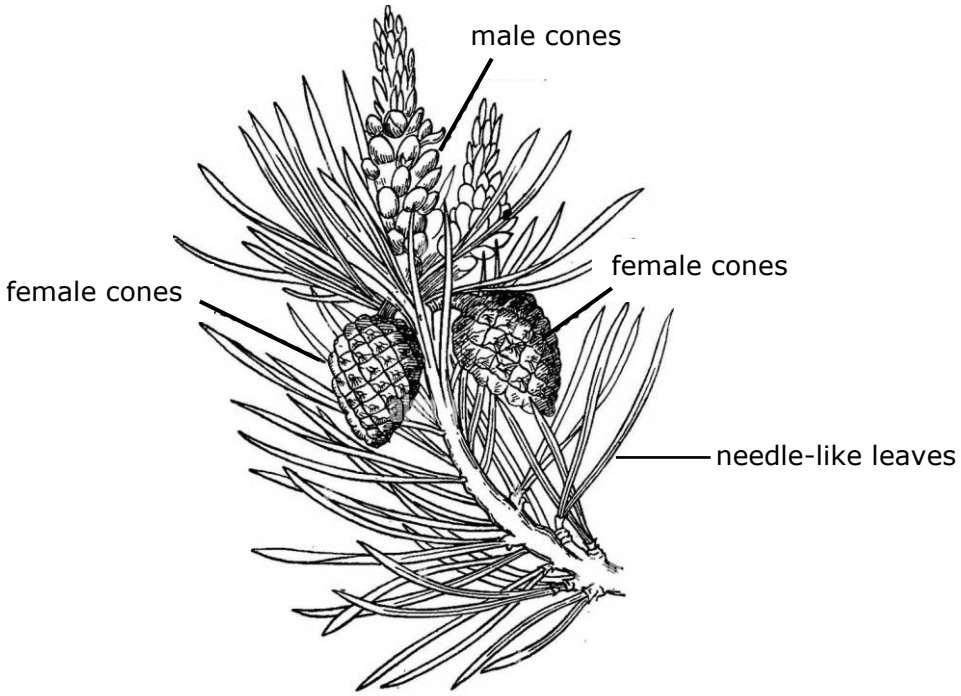


Figure 2.3: Male and female cones of the Aleppo Pine
(Source: https://c8.alamy.com/comp/)

i) Discuss the importance of the needle-like leaves of the Aleppo Pine.

_____

_____ (2)

ii) Name the gamete produced in the male cone.

_____ (1)

(Total: 10 marks)

Please turn the page.

3. A group of students investigated the effect of enzymes on proteins. They used different fruits that may or may not contain enzymes that break down protein. The students prepared a set of petri dishes with a different fruit in each petri dish. They then poured warm liquid gelatine (protein) in the petri dishes. Gelatine sets (solidifies) as it cools down.

   The students timed how long it took for the gelatine to set as it cooled down. The experiment was repeated twice.

   Table 3.1 shows the observations made and the results obtained.

Table 3.1: Observations and results of investigation

Type of fruit	**Observation**	**Time for gelatine to set (T_1) in hours**	**Time for gelatine to set (T_2) in hours**	**Average Time for gelatine to set in hours**
Control	Completely set	1	1	1
Banana	Completely set	1.5	1	1.25
Strawberry	Completely set	1.5	1.5	1.5
Apple	Mostly set, thin layer of liquid on surface	3	2.5	2.75
Lemon	Mostly set, thin layer of liquid on surface	3.5	4	3.75
Kiwi	Completely liquid: did not set	N/A	N/A	N/A
Pineapple	Completely liquid: did not set	N/A	N/A	N/A

(Source: http://www.youngscientist.com.au/pdf)

a. Using the graph paper provided, plot a bar chart of average time for gelatine to set in hours (y-axis) against the type of fruit. (4)

b. Give a scientific explanation why the gelatine in the petri dishes containing kiwi and pineapple did **not** set.

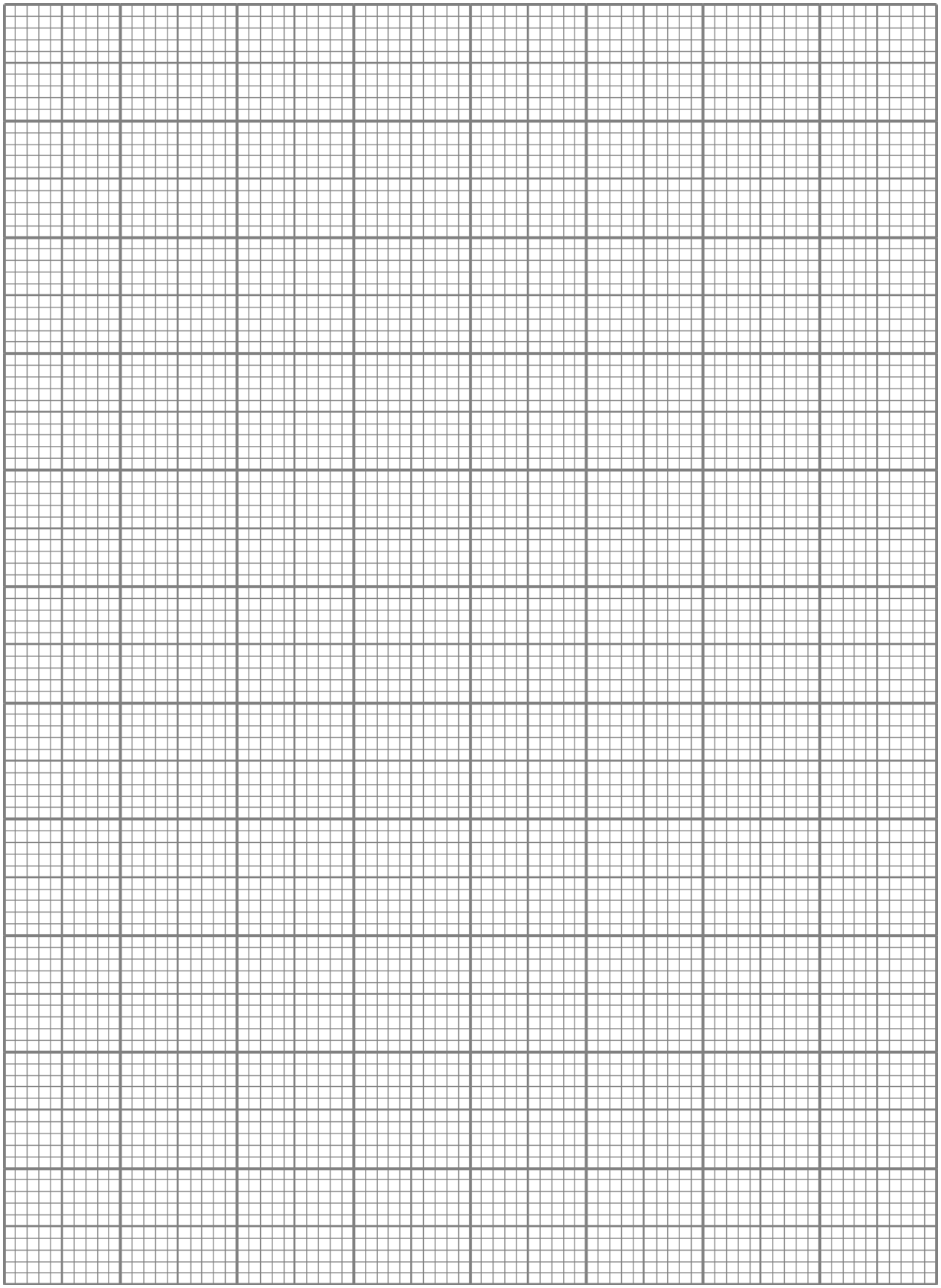
_____

_____ (2)

c. State **ONE** reason why the gelatine took long to set in the petri dishes containing lemon and apple.

_____

_____ (1)



This question continues on next page.

d. List **ONE** variable you would control in this investigation.

_____ (1)

e. The group of students then tried the investigation using boiled kiwi and pineapple.

i) Predict the observation result that would have been made by the students.

_____ (1)

ii) Give a biological explanation to the result given in part e i).

_____

_____

_____ (2)

(Total: 11 marks)

4. Figure 4.1 shows part of the endocrine system in a man.

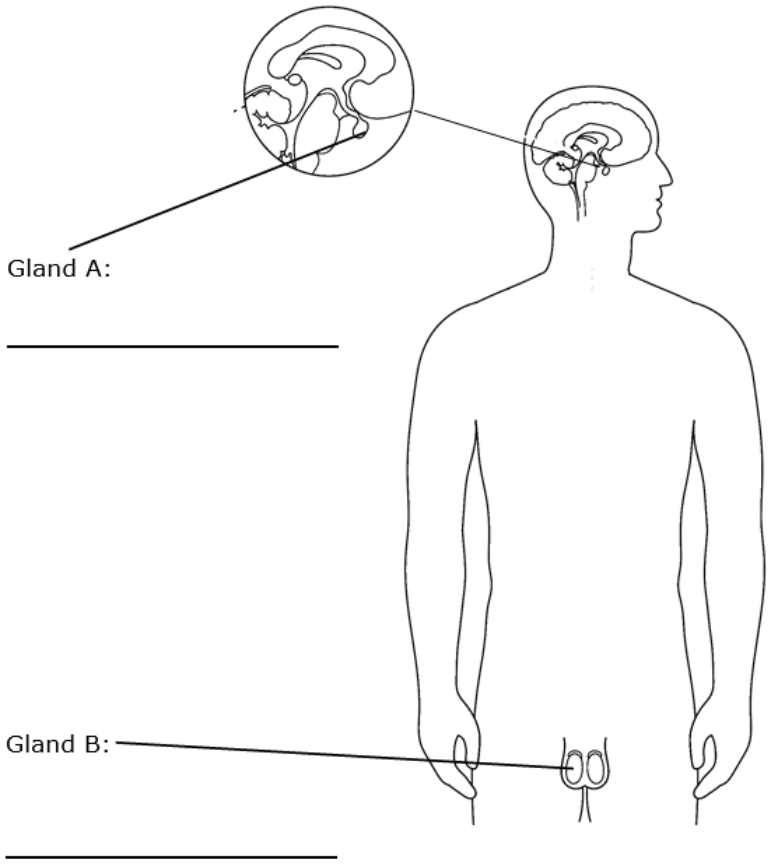


Figure 4.1: Part of the endocrine system in a man
(Adapted from: https://upload.wikimedia.org/wikipedia/)

a. On Figure 4.1 label glands A and B. (2)

b. Figure 4.2 shows gland C. (The gland is not drawn to scale.)

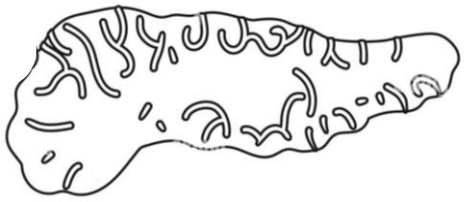


Figure 4.2: Endocrine gland C

(Source adapted from: https://c8.alamy.com/)

i) Identify endocrine gland C.

Gland C: _____ (1)

ii) Mark and label clearly the position of gland C on Figure 4.1. (Do not draw the gland itself.) (1)

c. Table 4.1 gives the hormone secreted by glands B and C and their functions. Fill in the missing information in the table. (2)

Gland	Hormone secreted	Function
B		Stimulates secondary sexual characteristics in males.
C	Insulin	

Table 4.1: Hormones secreted by glands B, C and D and their functions.

d. Endocrine disorders result from the improper functioning of the endocrine system, which includes the glands that secrete hormones and the receptors that respond to hormones. At any one of these points, dysfunction can occur and cause wide-ranging effects on the body.

The hypothalamus and gland A in Figure 4.1 play important roles as they act as the coordinating centres of the endocrine system.

i) State **ONE** other cause of an endocrine disorder other than the glands that secrete hormones.

_____ (1)

ii) The brain coordinates the endocrine system. What happens if this coordination fails?

_____

_____ (1)

(Total: 8 marks)

5. Figure 5.1 shows a diagram of a dissected flower.

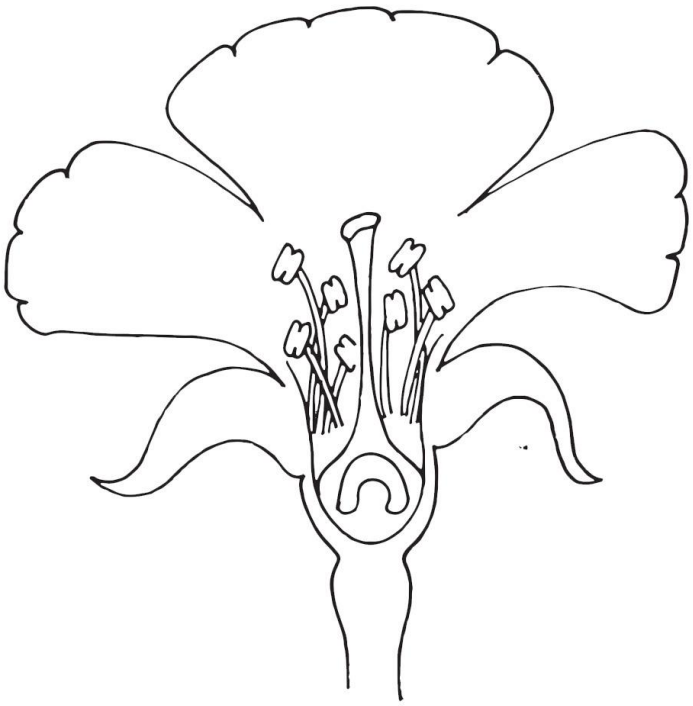


Figure 5.1: A diagram of a dissected flower
(Source: https://o.quizlet.com/Sy0Oa.FotXFEqCiKSHuLfw_b.jpg)

a. On figure 5.1 label the following parts:
   i) sepals; (1)
   ii) petals. (1)

b. On figure 5.1 label:
   i) the part where pollen is made with a letter A; (1)
   ii) the structure that supports the part where pollen is made with a letter B; (1)
   iii) the part where eggs are made with a letter C. (1)

c. State the type of pollination that occurs in this flower. Refer to the diagram to give **TWO** reasons for your answer.

Pollination type: _____ (1)

Reasons: _____

_____

_____ (2)

d. Figure 5.2 shows a spider plant reproducing asexually by a method known as vegetative propagation.

Figure 5.2: A diagram of a spider plant reproducing asexually

(Source: https://cdn.hswstatic.com/)

State if the offspring plants produced are genetically identical or genetically different from the parent plant. Give a reason for your answer.

Offspring is: _____ (1)

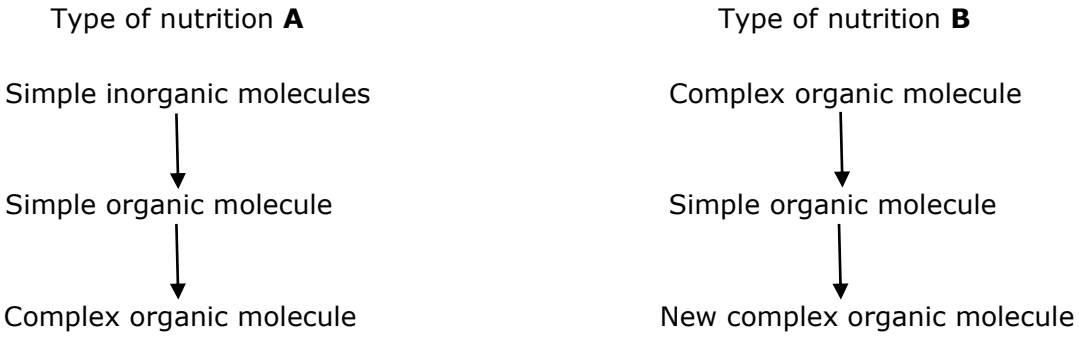
Reason: _____ (1)

(Total: 10 marks)

Please turn the page.

6. Nutrition is an essential process in all living organisms.

The flow charts below show two types of nutrition:



a. Identify the **TWO** types of nutrition:

Nutrition A: _____ (1)

Nutrition B: _____ (1)

b. If the complex organic molecule in nutrition B is starch, deduce the name of:

i) the simple organic molecule: _____ (1)

ii) the new complex organic molecule: _____ (1)

c. On the flow charts above, write down the following terms near the appropriate arrow;

i) light needed; (1)
ii) digestion; (1)
iii) assimilation. (1)

d. A lichen is an organism that arises from a symbiotic relationship between a fungus and a photosynthetic alga. A student wrote:

'Lichens show both nutrition type A and nutrition type B.'

State if the statement written by the student is correct or incorrect. Give a reason for your answer.

Statement is (correct / incorrect): _____ (1)

Reason: _____

_____ (2)

(Total: 10 marks)

7. In an investigation on the air content of soil, a student obtained two samples of soil by pushing an empty 100 ml can in soil until it became full. Each of the soil samples was then poured in a measuring cylinder containing 100 ml of water. Air bubbles were allowed to escape and the new volume was measured. Table 7.1 shows the results obtained:

Table 7.1: Results of an investigation on the air content of soil

	Soil sample A	Soil sample B
Initial volume in measuring cylinder (ml)	100.0	100.0
Final volume in measuring cylinder (ml)	199.3	198.1
Volume of air (ml)		

a. Using the information in Table 7.1, calculate the volume of air in sample A and sample B. Write your answer in the table. The space below can be used for the calculations. (1, 1)

b. State which of the two soil samples A or B is sandy soil. _____ (1)

c. State **TWO** reasons why it is important for air to be present between soil particles.

_____

_____

_____ (2)

d. One main problem with sandy soil is that water drains out of this soil quickly.

i) State **ONE** cause of the above-mentioned characteristic.

_____ (1)

ii) List **TWO** explanations why the quick draining affects plant growth.

_____

_____

_____ (2)

e. Waterlogged soil can also harm plant growth. Explain why.

_____

_____ (2)

(Total: 10 marks)

8. Entomophagy is the human consumption of insects. Edible insects are an abundant source of proteins and fats as well as rich in several mineral ions needed by the human body. Table 8.1 below shows the nutritional value of three different insects.

Table 8.1: Nutritional value of three edible insects

Nutritional value per edible 100 g	Mealworm beetle (larva)	Cricket (adult)	Silkworm (pupa)
Energy (in kJ)	1033	640	536
Protein (in g)	19.4	20.1	14.8
Fat (in g) Inc. saturated fats	12.3 2.9	5.1 2.3	8.3 3.6
Calcium (in mg)	16.9	75.0	15.0
Iron (in mg)	2.06	54.00	3.10

(Source: https://juniperpublishers.com/nfsij/NFSIJ.MS.ID.555638.php)

a. From the table, identify the best food source and give the reason why, that would help a person suffering from:
   i) weight loss;

Food source: _____ (1)

Reason: _____ (1)

   ii) anaemia (lacking adequate number of red blood cells).

Food source: _____ (1)

Reason: _____ (1)

b. The proteins of the edible insects in Table 8.1 contain all the essential (needed by the human body and cannot be produced) amino acids.

   i) List the **FOUR** elements that make up amino acids.

_____ (2)

   ii) Give **ONE** importance of proteins in the human body.

_____ (1)

c. A person suffering from heart disease was asked to follow a diet low in saturated fats. Saturated fats are converted into cholesterol that sticks to the arterial walls. Explain why the heart muscle is damaged when cholesterol sticks to the coronary artery walls.

_____

_____

_____ (2)

d. In Table 8.1, the stage of metamorphosis of the insect best for human consumption is found in brackets next to the common name. In the boxes below, state the stages of complete metamorphosis in chronological order.

(1)

(Total: 10 marks)

9. A class of students investigated if yeast cells take up Congo red dye by passive or active transport.

a. Fill in the table to distinguish between passive and active transport. Draw a tick (✓) if the statement is correct and a cross (✗) if it is incorrect. (3)

	Passive Transport	**Active Transport**
Occurs in both non-living and living systems.		
Substances move from a low to a high concentration.		
Needs ATP.		

In the investigation the students placed 10 ml of yeast culture in each of two test tubes. The yeast culture in one of the test tubes was boiled. The test tube was labelled 'Boiled'. The other test tube was labelled 'Live'. A few drops of Congo red dye were placed in each sample.

Yeast cells from each sample were placed on a microscope slide and the slides observed under the microscope.

The 'boiled' yeast cells appeared red, the 'living' yeast cells did not.

b. i) State whether boiled yeast cells take up Congo red dye by passive or active transport. Give a reason for your answer.

_____

_____

_____

_____

_____ (3)

This question continues on next page.

ii) Explain how this result shows that living yeast cells pump out the Congo red dye by active transport.

_____

_____

_____

_____ (3)

c. Some of the yeast cells in the test tube labelled 'live' still did **not** pump out the Congo red dye. Give a reason for this observation.

_____

_____ (1)

(Total: 10 marks)

10. The table includes a list of terms and definitions used in ecology. Complete the table by filling in the missing terms or definitions.

Biological term	**Definition**
Ecology	
Ecosystem	
	The place where a community of organisms lives.
Community	
	A group of organisms of the same species living in the same area at the same time.
Producers	
	Feed directly on producers.
Secondary consumers	
	A diagram showing several interconnected feeding pathways through which the energy flows within an ecosystem.
	A linear feeding pathway showing the flow of food materials and energy in a series of organisms.

(Total: 10 marks)

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

SECONDARY EDUCATION CERTIFICATE LEVEL
2023 MAIN SESSION

SUBJECT:	**Biology**
PAPER NUMBER:	IIA
DATE:	9th May 2023
TIME:	4:00 p.m. to 6:05 p.m.

Write your answers on the booklet provided. Write down the number of the questions you answer on the front page of your answer booklet.
Please note that for question 2 of this paper you need the graph paper in the booklet.

SECTION A: Answer ALL questions in this section. This section carries 25 marks.

1. Read the following passage and then answer the questions that follow.

Tardigrades

Tardigrades are small animals classified in the phylum Tardigrada. They are a terrestrial species that live in damp environments; other species are found in fresh or salt water. They are commonly known as water bears and most people say tardigrades are the cutest invertebrates.

Tardigrades are about half a millimetre long. Due to their small size, tardigrades survive without a circulatory or a gas exchange system.

The tardigrade body has five sections, a well-defined head and four body segments, each of which has a pair of short, stubby legs fitted with claws. These legs are used for grasping and slow-motion acrobatics rather than for walking. Tardigrades are covered with a rugged but flexible cuticle that must be shed as the organism grows. They are related to Arthropods.

Tardigrades have an anatomy and physiology like that of larger animals, including a full alimentary canal and digestive system. Mouth parts lead to an oesophagus, stomach, intestine and anus. They feed on the fluids of plant cells, animal cells, and bacteria. They are prey to amoebas, nematodes, and other tardigrades. Some species are entirely carnivorous!

Normally, there are both male and female tardigrades and reproduce sexually. A female tardigrade will lay anywhere between 1 and 30 eggs, then a male will then come along, and fertilize the eggs by depositing sperm. However, there are some species where it is reported that there are no males at all. In this case the unfertilized eggs give rise to new individuals. There are no larval stages in tardigrades.

Tardigrades are divided into two classes, Eutardigrada and Heterotardigrada. As a rule, the members of Eutardigrada have a smooth cuticle without plates, whereas the Heterotardigrada have a cuticle with plates.

When exposed to dry periods, tardigrades curl up into a little ball called a tun. Tun formation requires the synthesis of a protective sugar known as trehalose, which moves into the cells and replaces lost water. While in a tun, their metabolism decreases by 99.9% of normal. Tardigrades can survive as tuns for years. In 1983, a team of Japanese scientists on a journey through Antarctica collected some tardigrades and put them in a deep freeze for thirty years. When the tardigrades unfroze in May 2014, they walked around on a plate of agar gel like nothing had happened. And then they reproduced.

(Adapted from: Miller W. R, Tardigrades; in American Scientist https://www.americanscientist.org/article/tardigrades)

a. Explain why tardigrades are invertebrates. (1)

b. Tardigrades are related to Arthropods.
   i) Describe **ONE** way how tardigrades are structurally related to Arthropods. (1)
   ii) Describe **ONE** way how tardigrades are structurally related to Insects. (1)
   iii) Describe **ONE** way how tardigrades are structurally different from Insects. (1)

c. Explain why the small size of tardigrades allows them to survive without a gas exchange or a circulatory system. (2)

d. State whether tardigrades show external or internal fertilization. Support your answer with evidence from the text. (2)

e. Explain why tardigrades curl up into a tun to survive dry conditions. (2)

f. In the tun state, tardigrades decrease their metabolism by 99.9%. Explain how this allows tardigrades to survive for long periods of time. (2)

(Total: 12 marks)

2. An experiment is carried out to investigate the effect of light intensity on the rate of photosynthesis. A plant is kept at constant temperature and the rate of photosynthesis is measured at two different carbon dioxide concentrations: 0.04% and 0.4%. Table 2.1 shows the results of the experiment.

Table 2.1 The rate of photosynthesis at different carbon dioxide concentrations

Light intensity (arbitrary units)	**Rate of photosynthesis at 0.04% CO_2 (arbitrary units)**	**Rate of photosynthesis at 0.4% CO_2 (arbitrary units)**
0	0	0
300	40	95
600	80	190
900	95	230
1200	102	240
1500	103	245
1800	103	245
2100	103	245

a. On the graph paper provided (use the 2 mm grid scale), draw a graph to show the effect of light intensity on the rate of photosynthesis at 0.04% CO_2 concentration. Plot light intensity on the x-axis. Using the same pair of axes, plot a graph to show the effect of light intensity on the rate of photosynthesis at 0.4% CO_2 concentration. (6)

b. i) Describe the relationship between the rate of photosynthesis and light intensity from 0 arbitrary units to 600 arbitrary units. (1)
   ii) Explain why the rate of photosynthesis at a light intensity of 1500 arbitrary units is higher than the rate at 600 arbitrary units. (1)
   iii) The rate of photosynthesis remains constant and maximum at light intensities above 1500 arbitrary units. Explain why. (2)

c. Farmers burn paraffin in greenhouses to collect more crops. Explain how this experiment supports this statement. (3)

(Total: 13 marks)

Section B: Answer any THREE questions from this section. Each question carries 25 marks.

3. a. The following statements on the carbon cycle are incorrect. Explain why each statement is incorrect.
   i) Aerobic respiration removes carbon dioxide from the atmosphere. (3)
   ii) The process of fermentation by yeast cells and by some bacteria, reduces carbon dioxide in the atmosphere. (5)

   b. Give a biological explanation for the following:
   i) Decomposers release carbon dioxide in the atmosphere. (3)
   ii) Increasing levels of carbon dioxide cause global warming. (4)

   c. The following statements describe the nitrogen cycle. Use the statements to summarise the nitrogen cycle in the form of a cyclic diagram. (8)

   - Nitrogen in air is converted into nitrogen compounds.
   - Nitrogen-fixing bacteria in the roots of legumes provide these nitrogen compounds to the plants.
   - Lightning and the engines of motor vehicles during combustion also convert nitrogen into nitrogen compounds.
   - The nitrogen compounds such as nitrates are absorbed through the roots and are used by plants to produce proteins.
   - Consumers feed on the producers and use the food to build their own proteins.
   - When the plants and animals die, decomposers break down the protein into nitrogen compounds such as ammonium salts. Animal egested products are also decomposed.
   - Nitrifying bacteria convert the ammonium salts to nitrates.
   - Denitrifying bacteria convert the nitrates and ammonium salts back to atmospheric nitrogen.

   d. Use the nitrogen cycle to explain why compost is used to fertilise the soil. (2)

(Total: 25 marks)

4. When members of an endangered species have not been seen for some time, they are declared as extinct. At times, after several years, sometimes centuries, these species are rediscovered.
   a. i) Define the term species. (2)
   ii) List **TWO** factors that might make a species endangered or extinct. (2)

   b. The Top-shell *Steromphala nivosa,* found only in Maltese coastal waters, was observed from 1851 to 1978 but no sightings were made until 2006. It was declared as extinct till 2006 and is now registered as endangered.
   i) Other than a shell, these organisms have a soft unsegmented body. State the phylum of this species. (1)
   ii) Give the genus name of the Top-shell. (1)
   iii) Previous research had identified the seagrass *Posidonia oceanica* as the main habitat of the Top-shell. This sea grass is a monocot. Describe **THREE** characteristics of monocotyledonous plants. (3)

c. In 2022, some species were rediscovered. Among these were the rose-veiled fairy wrasse (fish), the tapir frog (amphibian) and the Principe scops owl (bird).
   i) State **ONE** characteristic common to **all** three species. (1)
   ii) Distinguish between the skin characteristics of the three mentioned classes. (3)
   iii) Write **ONE** common characteristic between fish and amphibians. Describe and explain how this characteristic is different in birds. (1, 3)

d. Another discovery was the identification of a maned sloth (mammal) through genetic and physical analysis. The new species was confirmed through structural and genetic analysis.
   i) State **TWO** structural characteristics of mammals. (2)
   ii) Scientists use Deoxyribonucleic acid (DNA) sequences for genetic analysis. Describe a DNA molecule. (3)

e. *Lamarckdromia beagle* is a crustacean species discovered in Western Australia this year. This is a spongy crab that keeps sponges on its shell. Sponges are primitive animals.
   i) Give the phylum of the *Lamarckdromia beagle*. (1)
   ii) State the number of jointed limbs of this crab. (1)
   iii) The sponges offer camouflage and protection to the crab, while the crab provides a food source to the sponge on its shell. Identify the type of relationship between the crab and the sponge. (1)

(Total: 25 marks)

5. Central precocious puberty is an inherited condition that causes early puberty in boys and girls. Boys and girls start developing secondary sexual characteristics before the age of 9 and 8 respectively.

   a. List **TWO** secondary sexual characteristics in boys. (2)

   b. The cause of this condition is a mutation of a gene found on chromosome 15. The normal allele produces a protein that directs puberty to start at the right time. The mutated allele does not produce a functional protein and so puberty is initiated early. Usually, both copies of the gene are active in all cells. The activity of this gene depends on which parent it was inherited from. The allele inherited from a person's father <u>is active</u> (can produce proteins) while that inherited from the mother is not active.

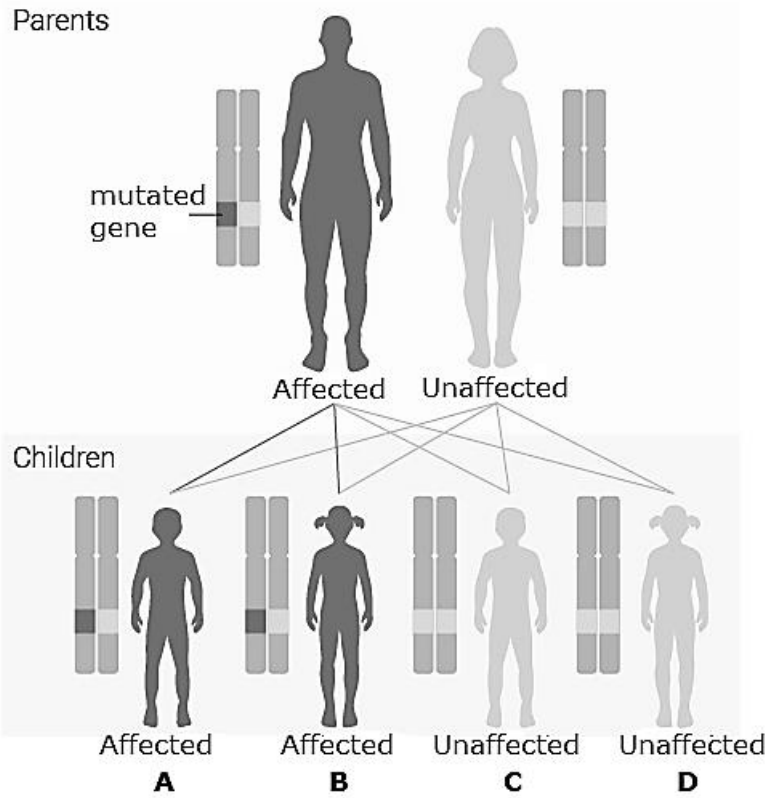


Figure 5.1 Inheritance of precocious adolescence
(Source: https://medlineplus.gov/genetics/condition/central-precocious-puberty/#inheritance)

Children A and B, in Figure 5.1 are both affected as they get the mutated allele from their father.

i) From the above statement, is the inheritance shown in Figure 5.1 autosomal or sex-linked? Give **ONE** explanation for your answer. (1, 2)
ii) Person A has children with a genotypically unaffected partner. Use a genetic diagram to determine the probability that the child is born unaffected. Take the mutated allele to be dominant. (6)
iii) Use the information and the diagram to explain why person B will not have any children that are affected. (1)

c. The onset of menstruation is one of the secondary sexual characteristics in girls.
i) Name the hormone produced by the ovary that stimulates puberty. (1)
ii) The onset of menstruation indicates that the female is now fertile. Describe the development within the ovary until ovulation occurs. Name the hormone/s involved in this development and from where they are secreted. (7)
iii) Describe what happens in the ovary and the uterus if fertilisation does **not** occur. (5)

(Total: 25 marks)

Please turn the page.

6. This question is about gas exchange.

a. Define the term gas exchange. (2)

b. Figure 6.1, diagram A shows the gas exchange surfaces in a fish and diagram B shows the gas exchange surface in an insect.

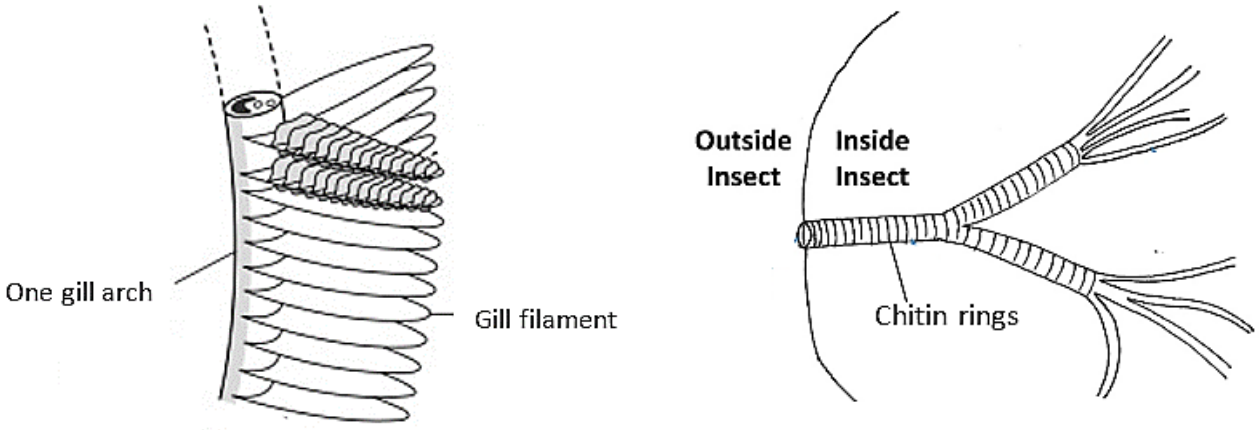


Diagram A Diagram B

Figure 6.1 The gas exchange surfaces in a fish and an insect

(Sources: https://ars.els-cdn.com/content/ https://dragonflywoman.files.wordpress.com/)

i) Copy the diagram of the gas exchange surface of an insect and label the following structures: trachea, tracheole, spiracle. (3)

ii) Explain why some of the tubes in the tracheal system in an insect are supported with chitin rings. (2)

iii) Refer to Figure 6.1 to describe how **both** gas exchange surfaces increase the surface area for efficient gas exchange. (2)

iv) When a fish is pulled out of water, the gill filaments collapse on each other, and the fish dies. Explain why. (3)

c. Water flows through gills in the opposite direction of blood. Table 6.1 gives the percentage concentration of oxygen in water and in blood in part of a gill.

Table 6.1 Percentage concentration of oxygen in water and in blood in part of a gill

Direction of flow of water	→				
% of oxygen in water	100	70	50	30	10
% of oxygen in blood	80	60	40	20	5
Direction of flow of blood	←				

i) Compare the concentration of oxygen in water with the concentration of oxygen in blood at any point along the gill. (2)

ii) Explain how this pattern of water and blood flow ensures efficient gas exchange in fish. (2)

d. During the day, gaseous exchange between a plant and the environment is different than between an insect and the environment. However, during the night, it is the same. State whether this statement is correct or incorrect. Explain your choice. (5)

e. Stomatal density refers to the number of stomata per unit area in a leaf.
   i) Describe the role of stomata in gas exchange in a plant. (1)
   ii) Predict the effect of a high stomatal density on the rate of gas exchange in a plant. Give a reason for your answer. (3)

(Total: 25 marks)

7. Figure 7.1 shows a section through the mammalian heart.

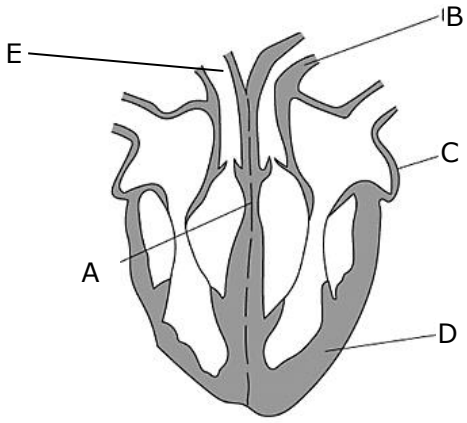


Figure 7.1 Cross section through a human heart.
(Source: https://www.savemyexams.co.uk/a-level/biology)

a. i) Name the parts labelled A, B and C. (3)
   ii) If structure A does not develop properly in the womb, it can result in an abnormality which can cause serious health problems. The baby may be born with a gap between the lower pumping chambers of the heart. It is sometimes called 'a hole in the heart'. Predict what happens if the 'hole in the heart' does **not** close shortly after birth. (3)

b. i) Explain why the muscle in the wall of chamber D is much thicker than that in the wall of the chamber C. (2)
   ii) Explain why the blood vessel E receives blood at a lower pressure than blood vessel B. (1)

c. Write a paragraph about veins. In the paragraph use the following key terms: deoxygenated blood, pulmonary vein, valves, backflow. (4)

This question continues on next page.

d. A person's heart rate was monitored during periods of exercise and periods of rest. The graph in Figure 7.2 shows the result of one 50-minute test.

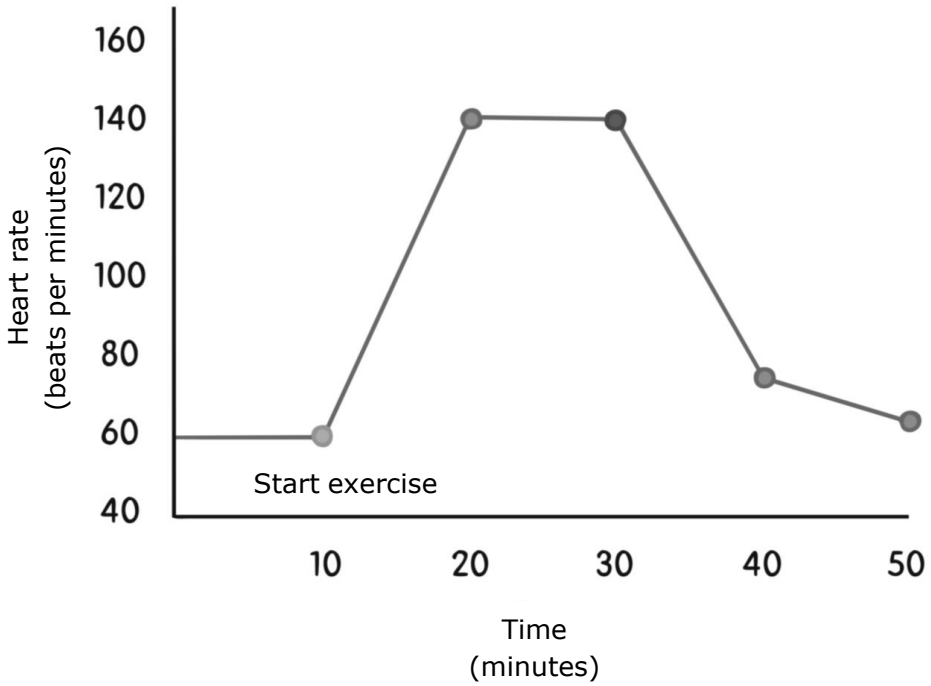


Figure 7.2: Changes in heart rate in 50 minutes
(Source: https://www.twinkl.com.mt/illustration/)

Use the graph to:

i) Determine the heart rate at the start of the test. (1)

ii) Determine the maximum heart rate reached during the test. (1)

iii) Describe the changes in the heart rate as the person continued exercising. (2)

iv) Determine the time when the person stopped exercising. Give a reason for your answer. (2)

v) Write a general conclusion about the effect of exercise on the heart. (3)

e. Having an increased heart rate is not a health condition in and of itself; rather, it is a symptom caused by any number of lifestyle factors. It may be a reaction to something that is happening in one's life.
List and explain **TWO** common reasons for an increased heart rate which is **not** related to health conditions. (2)

f. There is overwhelming evidence that some lifestyle factors, such as obesity, are leading risk factors for heart disease. Identify **ONE** example of lifestyle practices which help reduce risk factors for heart disease. (1)

(Total: 25 marks)

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

SECONDARY EDUCATION CERTIFICATE LEVEL
2023 MAIN SESSION

SUBJECT:	**Biology**
PAPER NUMBER:	IIB
DATE:	9th May 2023
TIME:	4:00 p.m. to 6:05 p.m.

Write your answers on the booklet provided. Write down the number of the questions you answer on the front page of your answer booklet.
Please note that for question 5 of this paper you need the graph paper in the booklet.

Answer FOUR questions from this paper. Each question carries 25 marks.

1. a. Figure 1.1 below shows a diagram of the carbon cycle.

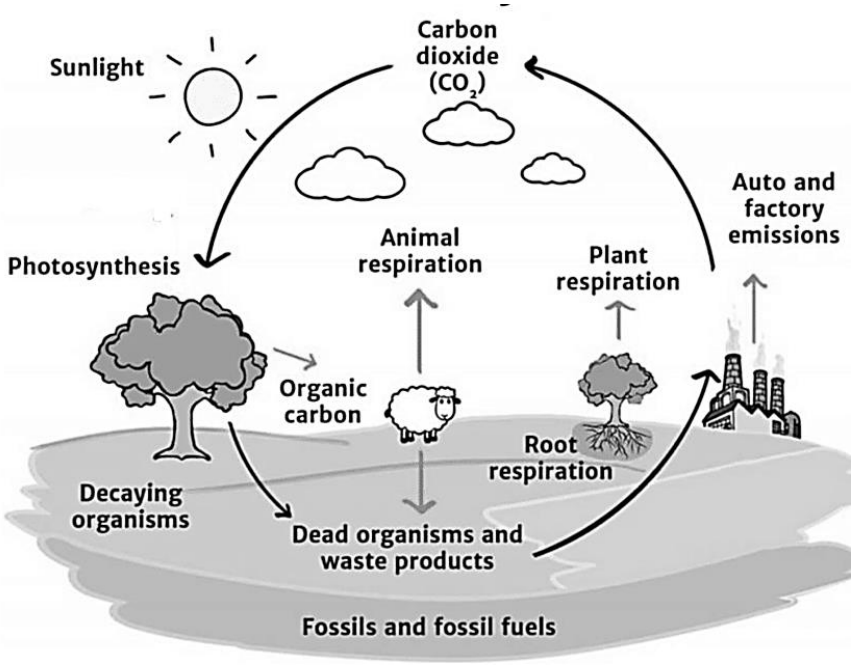


Figure 1.1: The Carbon cycle

(Source: https://farmcarbontoolkit.org.uk/)

i) Name **TWO** processes which add carbon dioxide to the atmosphere. (2)
ii) Describe the significance of the process of photosynthesis in the carbon cycle. (3)
iii) Plant respiration contributes carbon dioxide to the atmosphere mainly during dawn, dusk, and night. Explain. (4)
iv) Describe how organic carbon compounds are passed from plants to animals and the significance of this transfer. (1,1)
v) Describe the importance of decomposers in **all** cycles. (2)

b. Explain how increasing levels of carbon dioxide cause global warming. (4)

This question continues on next page.

c. Figure 1.2 shows the nitrogen cycle.

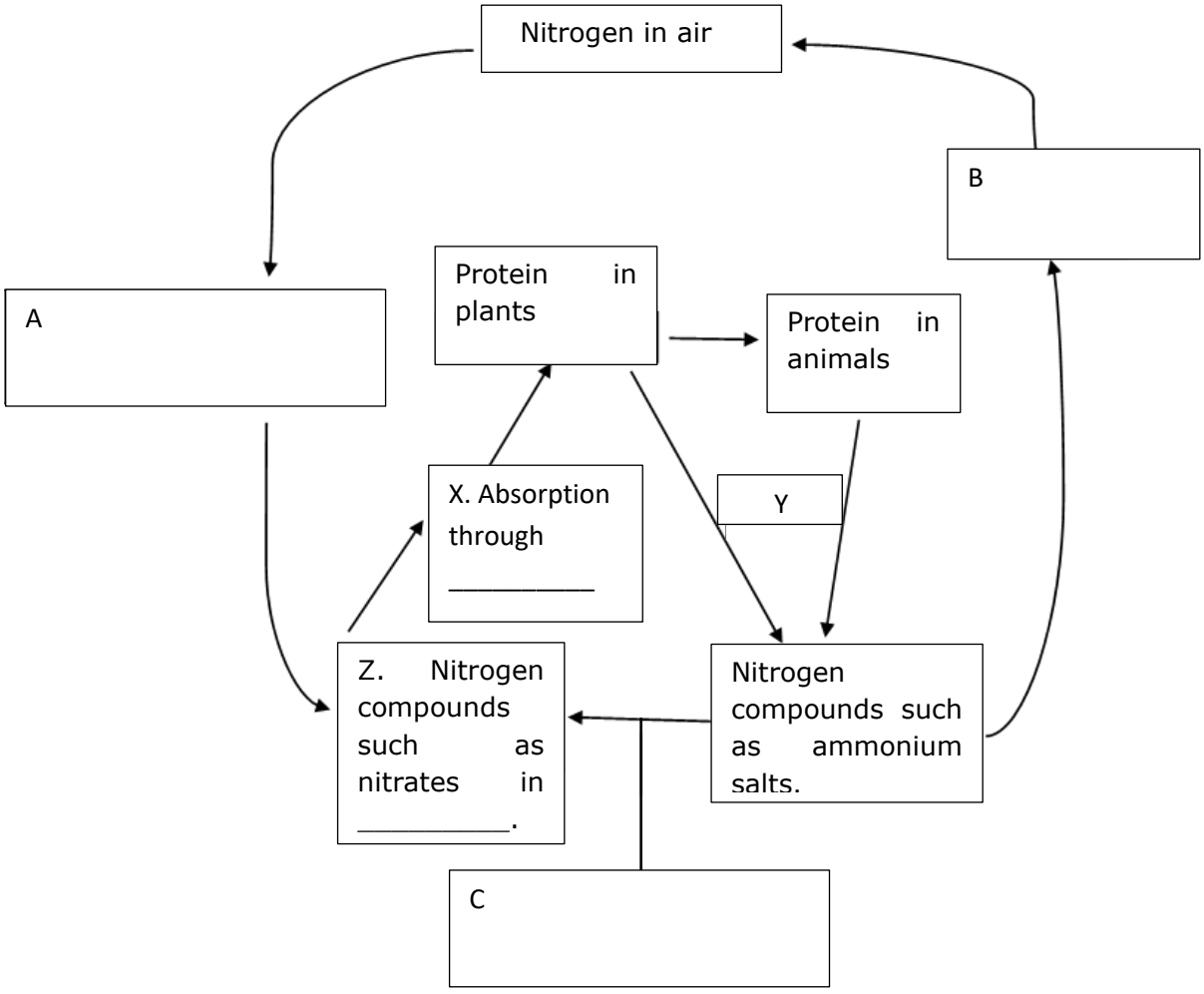


Figure 1.2: The Nitrogen cycle

Copy the diagram and complete it by:

i) filling the empty boxes, A, B and C to show where denitrifying bacteria, nitrifying bacteria and nitrogen fixing bacteria are involved in the cycle; (3)

ii) naming process Y; (2)

iii) filling in the missing terms in boxes X and Z; (2)

iv) writing the letter L to show where lightning is involved in the cycle. (1)

(Total: 25 marks)

2. a. Tardigrades are small animals classified in the phylum Tardigrada. They are a terrestrial species that live in damp environments; other species are found in fresh or salt water. They are commonly known as water bears and most people say tardigrades are the cutest invertebrate.

Tardigrades are about half a millimetre long. Due to their small size, tardigrades survive without a circulatory or a gas exchange system.

Explain why the small size of tardigrades allows them to survive without a gas exchange and a circulatory system. (2)

b. The body of tardigrades is divided into five sections, a head and four body segments. Each segment has a pair of short legs fitted with claws. Tardigrades are covered with a rough but flexible cuticle that must be shed as the organism grows. They are related to Arthropods.

i) Describe **ONE** way how tardigrades are structurally related to Arthropods. (1)
ii) Describe **ONE** way how tardigrades are structurally related to Insects. (1)
iii) Describe **ONE** way how tardigrades are structurally different from Insects. (1)
iv) Explain why the tardigrade must shed the cuticle to grow. (2)

c. Tardigrades have an anatomy and physiology like that of larger animals, including a full alimentary canal and digestive system. It includes a tube with a mouth at one end and an anus at the other end. A stomach and an intestine are present. As in other animals, the oesophagus links the mouth to the stomach. They feed on the fluids of plant cells, animal cells, and bacteria. They are prey to amoebas, nematodes, and other tardigrades. Some species are entirely carnivorous.

i) Draw a diagram to show the possible arrangement of the 5 different parts of the digestive system mentioned in the paragraph. (5)
ii) Some tardigrades 'are entirely carnivorous.' Explain this statement. (2)
iii) Given that the role of the stomach and the intestine in tardigrades is similar to that in humans, briefly describe the role of the stomach and the intestine in digestion of proteins in a tardigrade. (3)

d. Normally, there are both male and female tardigrades and reproduce sexually. A female tardigrade can lay between 1 and 30 eggs, then a male will come along, and fertilize the eggs by depositing sperm. However, there are some species where it is reported that there are no males at all. In this case the unfertilized eggs give rise to new individuals. There are no larval stages in tardigrades.

i) State if tardigrades show external or internal fertilization. Support your answer with evidence from the text. (2)
ii) Explain why in unfavourable environmental conditions it is better for tardigrades to carry out sexual reproduction. (2)

e. When exposed to dry periods, tardigrades curl up into a little ball called a tun. While in a tun, their metabolism decreases by 99.9% of normal.

i) Explain why tardigrades curl up into a tun to survive dry conditions. (2)
ii) Explain how decreasing the metabolism by 99.9% allows tardigrades to survive for long periods of time. (2)

(Adapted from: Miller W. R, Tardigrades; in American Scientist *https://www.americanscientist.org/article/*)

(Total: 25 marks)

Please turn the page.

3. When members of an endangered species have not been seen for some time, they are declared as extinct. At times, after several years, sometimes centuries, these species are rediscovered.

   a. From the text, identify the term that is defined as follows:
      i) The complete disappearance of a species from Earth. (1)
      ii) A group of organisms that can reproduce with one another in nature and produce fertile offspring. (1)

   b. List **TWO** factors that might make a species endangered or extinct. (2)

   c. The Top-shell *Steromphala nivosa*, found only in Maltese coastal waters, was observed from 1851 to 1978 but no sightings were made until 2006. It was declared as extinct till 2006 and is now registered as endangered.
      i) The Top-shell is a mollusc. Other than having a shell, state **ONE** other characteristic of this group. (1)
      ii) Explain why the binomial name of an organism is used by scientists instead of the common name. (2)
      iii) Give the species name of the Top-shell. (1)
      iv) Previous research had identified the seagrass *Posidonia oceanica* as the main habitat of the Top-shell. This sea grass is a monocot. Describe **THREE** characteristics of monocotyledonous plants. (3)

   d. In 2022, some species were rediscovered. Among these were the rose-veiled fairy wrasse (fish), the tapir frog (amphibian) and the Principe scops owl (bird). The class of these species is in brackets. These organisms are all vertebrates.
      i) State **ONE** characteristic common to vertebrates. (1)
      ii) Distinguish between the body covering of fish and birds. (2)

   e. Fish and amphibians are ectothermic.
      i) Define the term ectothermic. (2)
      ii) How are birds different? Explain. (1, 2)

   f. The identification of a new species of a maned sloth through genetic and physical analysis. Previously it was thought that there existed only one species of maned sloth in Brazil.

      i) The sloth is covered with fur. Name the vertebrate class of this species. (1)
      ii) State **TWO** other structural characteristics of this vertebrate class. (2)
      iii) Scientists use Deoxyribonucleic acid (DNA) sequences for genetic analysis. Using the words: double helix, nucleotide, sugar, phosphate, and nitrogenous base, describe a DNA molecule. (3)

(Total: 25 marks)

4. This question is about gas exchange.

   a. Define the term gas exchange. (2)

   b. Figure 4.1 shows the gas exchange surface in an insect.

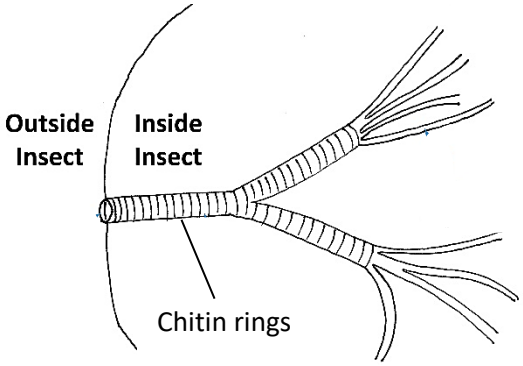


Figure 4.1 The gas exchange surfaces in an insect
(Source: https://dragonflywoman.files.wordpress.com/)

   i) Copy the diagram of the gas exchange surface of an insect and label the following structures: trachea, tracheole, spiracle. (3)
   ii) Explain why some of the tubes in the tracheal system in an insect are supported with chitin rings. (2)
   iii) Describe how the gas exchange surface in insects has a large surface area for efficient gas exchange. (1)
   iv) Insects close their spiracles during parts of the day. Give **ONE** advantage and **ONE** disadvantage that affect the insect when its spiracles are closed. (2)

   c. Gas exchange in plants occurs in the leaves. Although plants do not have a mechanism to move air in or out of the leaves, diffusion still occurs at a fast rate. Describe how a leaf:
   i) ensures a short distance for gases to travel; (1)
   ii) allows gases to enter from air outside; (1)
   iii) creates a large concentration difference between gases inside the leaf and outside. (1)

   d. Figure 4.2 shows the gas exchange surface in a human.

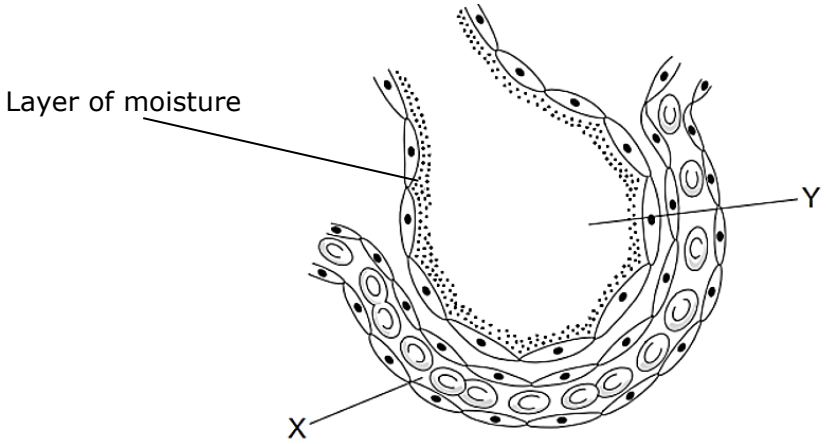


Figure 4.2 The gas surface in a human
(*Source: https://www.goconqr.com/*)

This question continues on next page.

i) Name structures X and Y. (2)
ii) State why the cells lining structure X and structure Y are very flat. (2)
iii) State the role of the layer of moisture lining the inside of structure Y. (1)
iv) Explain how the layer of moisture causes humans to lose water with every breath they exhale. (1)
v) Describe how gaseous exchange occurs between structure X and Y. In your answer clearly identify the gases involved and the direction that they move. (4)

e. In fish, gas exchange occurs in the gills. Water flows through gills in the opposite direction of blood. Table 4.1 gives the percentage concentration of oxygen in water and in blood in part of a gill.

Table 4.1 Percentage concentration of oxygen in water and in blood in part of a gill

Direction of flow of water	→				
% of oxygen in water	100	70	50	30	10
% of oxygen in blood	80	60	40	20	5
Direction of flow of blood	←				

At any point along the gill, the concentration of oxygen in water is higher than the concentration of oxygen in blood. Explain how this pattern of water and blood flow ensures efficient gas exchange in fish. (2)

(Total: 25 marks)

5. An experiment is carried out to investigate the effect of light intensity on the rate of photosynthesis. A plant is kept at constant temperature and the rate of photosynthesis is measured at two different carbon dioxide concentrations: 0.04% and 0.4%.
Table 5.1 shows the results of the experiment.

Table 5.1 The rate of photosynthesis at different carbon dioxide concentrations

Light intensity (arbitrary units)	**Rate of photosynthesis at 0.04% CO_2 (arbitrary units)**	**Rate of photosynthesis at 0.4% CO_2 (arbitrary units)**
0	0	0
300	40	95
600	80	190
900	95	230
1200	102	240
1500	103	245
1800	103	245
2100	103	245

a. Figure 5.1 shows the apparatus set-up used to perform this experiment. The pondweed is put in a solution of sodium hydrogen carbonate which provides carbon dioxide.

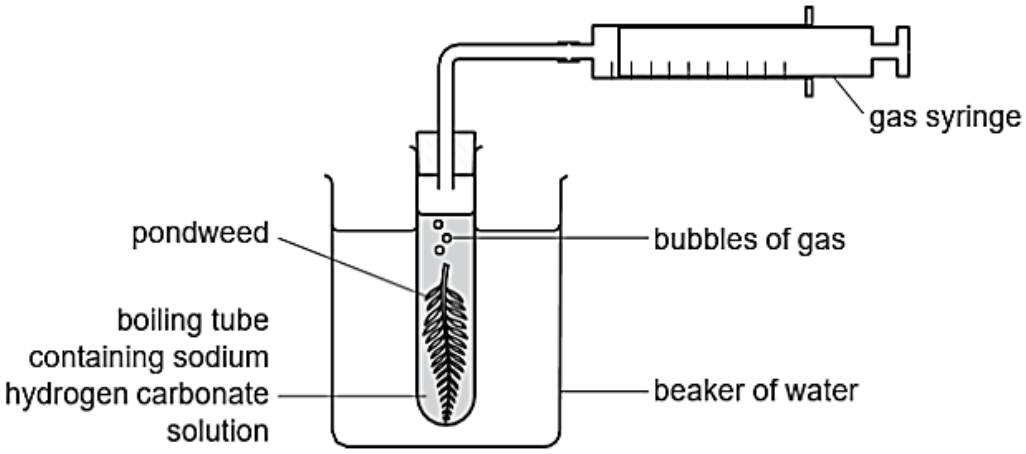


Figure 5.1 Apparatus set-up to investigate the effect of CO_2 concentration on the rate of photosynthesis.
(Source: https://pmt.physicsandmathstutor.com)

i) The volume of gas produced is collected and measured in the gas syringe. Explain how this can be used to determine the rate of photosynthesis. (2)

ii) A student wrote, 'An important precaution in this experiment is to use the same light source that is kept 50 cm away from the pondweed throughout this experiment.' State if this precaution is correct and give a reason for your answer. (2)

iii) A student noted that some bubbles of the gas stick to the pondweed itself. Predict how this will influence the rate of photosynthesis calculated and give a reason for your answer. (2)

b. On the graph paper provided (use the 2 mm grid scale), draw a graph to show the effect of light intensity on the rate of photosynthesis at 0.04% CO_2 concentration. Plot light intensity on the x-axis. (6)

c. i) Describe the relationship between the rate of photosynthesis and light intensity from 0 arbitrary units to 600 arbitrary units. (1)

ii) Explain why the rate of photosynthesis at a light intensity of 1500 arbitrary units is higher than the rate at 600 arbitrary units. (1)

iii) The rate of photosynthesis remains constant and maximum at light intensities above 1500 arbitrary units. Explain why. (2)

d. i) Farmers burn paraffin in greenhouses to collect more crops. Explain how this experiment supports this statement. (3)

ii) The highest rate of photosynthesis observed is 245 arbitrary units at a light intensity of 2100 arbitrary units and a 0.4% CO_2 concentration. Identify **ONE** factor that can increase the rate of photosynthesis without changing the light intensity and the CO_2 concentration. Give a reason for your answer. (1,2)

e. Sometimes farmers use artificial lighting in greenhouses and allow it to shine during the night. Predict how this will affect the amount of crop collected and give a reason for your answer (1,2)

(Total: 25 marks)

Please turn the page.

6. a. The population of humans in the world reached 8 billion on 15 November 2022. Table 6.1 shows the increase in the world population from 1804 till present.

Table 6.1: Growth of the human population from 1950 to 2050

Year	Number of humans in billions
1804	1
1927	2
1960	3
1974	4
1987	5
1999	6
2012	7
2022	8

(Adapted from: https://www.un.org/development/desa/pd/sites)

Use the data in Table 6.1 to calculate the number of years taken for the human population to increase from:

i) 1 to 2 billion; (1)

ii) 7 to 8 billion. (1)

b. A student suggested that the rate of growth of the human population was higher between 2012 and 2022 than between 1927 and 1960. State if this is true or not and support your answer with evidence from the table. (1,2)

c. Compare the number of births and the number of deaths that contributed to the growth of the population of humans from 1804 to 2022. (2)

d. State how the following factors affect the human population:

i) several people live more than 75 years; (2)

ii) contraception; (2)

iii) improved medical care; (2)

iv) lack of hygiene. (2)

e. Humans increase agricultural activity to support a higher population. Describe and explain how an increased agricultural activity may affect:

i) natural habitats; (3)

ii) the concentration of nitrates in underground freshwater reserves. (3)

f. Increased agricultural activity will lead to a greater use of pesticides. Farmers are urged to use biodegradable rather than persistent pesticides.

i) Distinguish between biodegradable and persistent pesticides. (2)

ii) List **ONE** advantage of using biodegradable pesticides. (1)

iii) List **ONE** disadvantage of using pesticides. (1)

(Total: 25 marks)

7. Figure 7.1 shows a section through the mammalian heart.

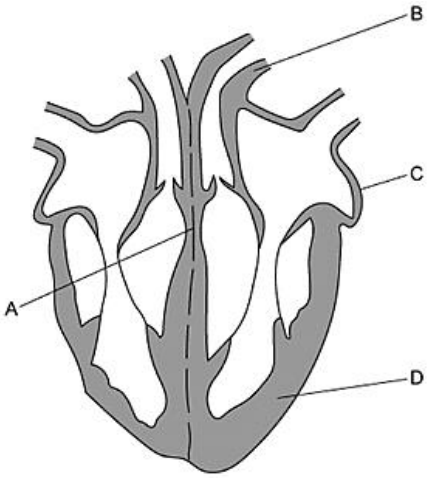


Figure 7.1 Cross section through a human heart.
(Source: https://www.savemyexams.co.uk/)

a. i) Name the parts labelled A, B and C. (3)
   ii) Explain the importance of structure A. (2)
   iii) If structure A does not develop properly in the womb, it can result in an abnormality which can cause serious health problems. The baby may be born with a gap between the lower pumping chambers of the heart. It is sometimes called 'a hole in the heart'. Predict what happens if the 'hole in the heart' does **not** close shortly after birth. (2)

b. Explain why the muscle in the wall of chamber D is much thicker than that in the wall of the chamber C. (2)

c. Copy the following passage about veins and fill in the blanks with the most suitable word.

   Veins usually carry _____ blood towards the heart. The only vein that carries oxygenated blood is the _____ vein. Pressure in the veins is much less than pressure in the arteries. Veins have _____ at intervals to prevent the _____ of blood. (4)

This question continues on next page.

d. A person's heart rate was monitored during periods of exercise and periods of rest. The graph in Figure 7.2 shows the result of one 50-minute test.

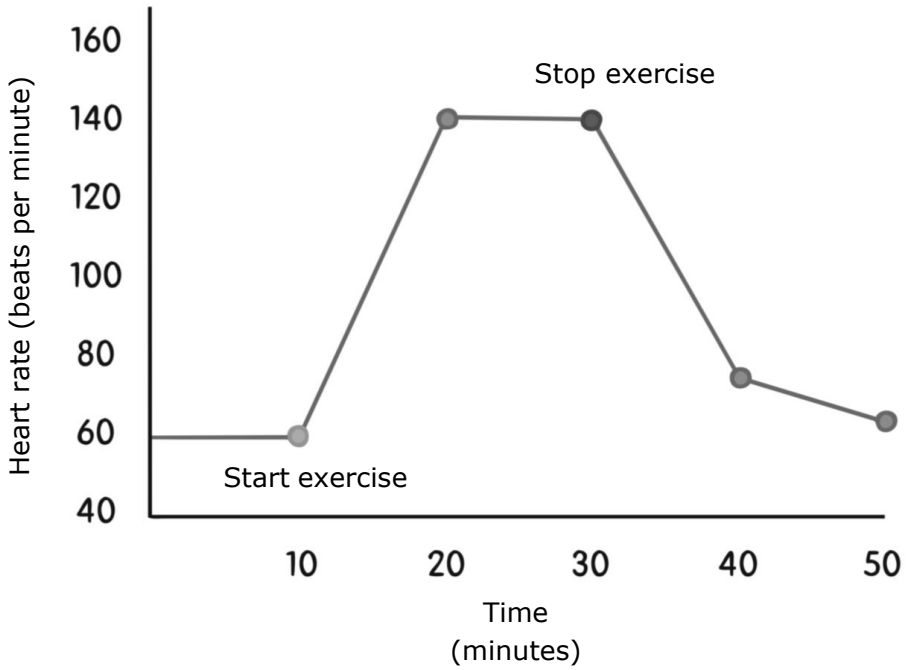


Figure 7.2: Changes in heart rate in 50 minutes
(Source: https://www.twinkl.com.mt/)

Use the graph to:

i) Determine the heart rate at the start of the test. (1)
ii) Determine the maximum heart rate reached during the test. (1)
iii) Describe the changes in the heart rate as the person continued exercising. (2)
iv) Describe the changes in the heart rate between 30 and 50 minutes. (2)
v) Write a general conclusion about the effect of exercise on the heart rate and the pulse rate. (3)

e. Having an increased heart rate is not a health condition in and of itself; rather, it is a symptom caused by any number of lifestyle factors. It may be a reaction to something that is happening in one's life.
List **TWO** commons reason for an increased heart rate which are **not** related to health conditions. (2)

f. There is overwhelming evidence that some lifestyle factors, such as obesity, are leading risk factors for heart disease. Identify **ONE** example of lifestyle practices which help reduce risk factors for heart disease. (1)

(Total: 25 marks)

8. Central precocious adolescence is an inherited condition that causes early puberty in boys and girls. Boys and girls start developing secondary sexual characteristics before the age of 9 and 8 respectively.

a. Secondary sexual characteristics may be specific to males or females or common to both. Copy the table and mark with a (✓) the correct cell. (4)

Statement	Males	Females	Both
Deepening of voice			
Hair growth on genital area and armpits			
Body growth/spurt			
Widening of hips			

b. The cause of this condition is a mutation of a gene found on chromosome 15. The normal allele produces a protein that directs puberty to start at the right time. The mutated allele does not produce a functional (that works) protein and so puberty is initiated early.

i) Define the term mutation. (2)
ii) A student thinks that the inheritance of this condition is an autosomal one. Is the student correct? Give **ONE** explanation for your answer. (1, 2)
iii) The table below shows the probability results of when a father with central precocious adolescence (affected) is crossed with a mother who does not suffer from this condition (unaffected). The mutated allele is dominant.

Parental cross	% of affected children	% of unaffected children
Affected x Unaffected	50%	50%

Is the father homozygous dominant or heterozygous? Explain your answer using genetic diagrams. (1, 4)

c. The onset of menstruation is one of the secondary sexual characteristics in girls. This indicates that the girl is fertile. Within the ovary, an ovum matures until it is released midway through the menstrual cycle.

i) Name the hormone produced by the ovary that stimulates puberty. (1)
ii) State the process when a mature ovum is released from the ovary. (1)
iii) Describe the route taken by ejaculated sperm from where they are released in the female reproductive system to the site where fertilisation occurs. (4)
iv) Describe how fertilisation occurs. (3)
v) The uterus has a thick layer of muscle. Explain why this organ has a powerful muscle. (2)

(Total: 25 marks)