Neap

Trial Examination 2021

VCE Biology Units 3&4

Written Examination

Question and Answer Booklet

Reading time: 15 minutes
Writing time: 2 hours 30 minutes

Student's Name: _____

Teacher's Name: _____

Structure of booklet

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	40	40	40
B	10	10	80
			Total 120

Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners and rulers.

Students are NOT permitted to bring into the examination room: blank sheets of paper and/or correction fluid/tape.

No calculator is allowed in this examination.

Materials supplied

Question and answer booklet of 34 pages

Answer sheet for multiple-choice questions

Instructions

Write your **name** and your **teacher's name** in the space provided above on this page, and on the answer sheet for multiple-choice questions.

Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

All written responses must be in English.

At the end of the examination

Place the answer sheet for multiple-choice questions inside the front cover of this booklet.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

SECTION A – MULTIPLE CHOICE QUESTIONS

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.

Choose the response that is **correct** or that **best answers** the question.

A correct answer scores 1; an incorrect answer scores 0.

Marks will **not** be deducted for incorrect answers.

No marks will be given if more than one answer is completed for any question.

Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

Question 1

A light microscope shows a plasma membrane as a continuous line around the circumference of a cell. An electron microscope at high magnification shows the same plasma membrane as two lines with a small space in between.

This provides evidence for

A. the fluid mosaic model of membrane structure.

B. the phospholipid bilayer arrangement of membranes.

C. variation in the structure of plasma membranes compared to organelle membranes.

D. the fact that plasma membranes consist of two membranes rather than one.

Question 2

A secretory cell was exposed to radioactive amino acids and left in a culture plate. A photograph was taken every 20 minutes to determine the level of radioactive material in six specific parts of the cell, which were labelled U–Z. The part of the cell with the highest level of radioactivity for each photograph was then determined. The results of this experiment are shown in the following table.

Time-lapse photograph number	Region with highest radioactivity	Level of radioactivity as a percentage of the total
1	U	80
2	V	75
3	W	70
4	X	68
5	Y	62
6	Z	58

Which row of the table correctly identifies each part of the cell?

	U	V	W	X	Y	Z
A.	mitochondria	nucleus	endoplasmic reticulum	ribosome	vesicle	Golgi apparatus
B.	nucleus	ribosome	endoplasmic reticulum	Golgi apparatus	vesicle	lysosome
C.	ribosome	endoplasmic reticulum	*cis* vesicle	Golgi apparatus	*trans* vesicle	secretory vesicle
D.	nucleus	Golgi apparatus	endoplasmic reticulum	mitochondria	ribosome	vesicle

Question 3

Which one of the following reactions is an example of a condensation reaction?

A. the formation of nucleotides from nucleic acids

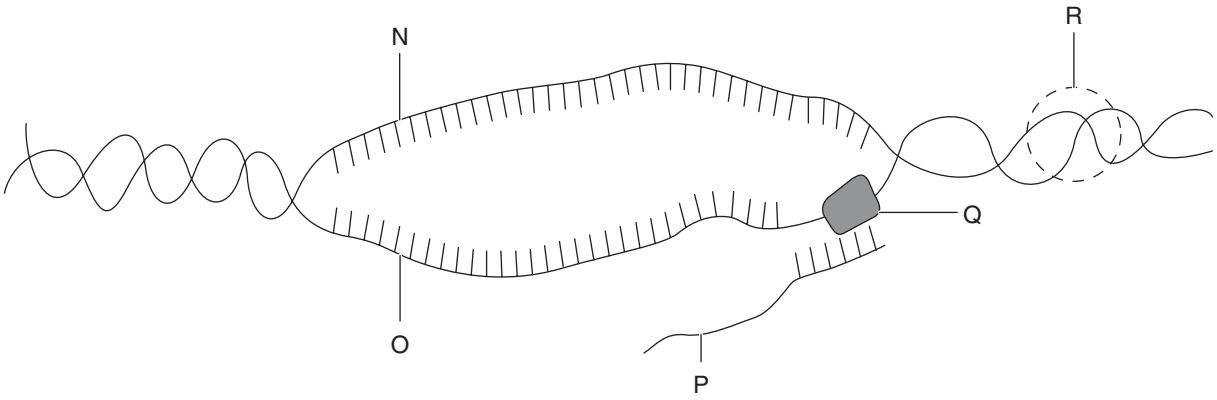
B. the formation of a phospholipid in the smooth endoplasmic reticulum

C. the formation of amino acids from proteins

D. the formation of carbon dioxide from the fermentation of glucose

Use the following information to answer Questions 4 and 5.

The diagram below shows transcription within the nucleus of a eukaryotic cell.



Question 4

Which row of the table correctly identifies each component in the diagram?

	N	O	P	Q	R
A.	template strand	mRNA	DNA	DNA polymerase	termination point
B.	coding strand	template strand	mRNA	DNA polymerase	DNA
C.	DNA	coding strand	template strand	RNA polymerase	mRNA
D.	coding strand	template strand	mRNA	RNA polymerase	termination point

Question 5

The coding strand has the following sequence.

GGA ATT ACC ATG ATG ACG AT

What is the sequence of the complementary mRNA strand?

A. GGA ATT ACC ATG ATG ACG AT

B. GGA AUU ACC AUG AUG ACG AU

C. CCU UAA UGG UAC UAC UGC UA

D. CCT TAA TGG TAC TAC TGC TA

Use the following information to answer Questions 6–8.

Lipase is an enzyme that can break down the fat (triglyceride) in milk, forming fatty acids. The rate of this production can be visualised with a colour-changing indicator. Phenolphthalein is an indicator that can be used; it is colourless in acidic solutions and pink in alkaline solutions.

An experiment was conducted by a class of Biology students to better understand enzyme chemistry. The class followed the method below.

1. 10 mL of full cream milk and 1 mL of phenolphthalein were added to a test tube.
2. 5 mL of 2% lipase was added to a separate test tube.
3. Both test tubes were incubated at 37°C for 10 minutes.
4. The contents of both test tubes were added to a conical flask, mixed and maintained at 37°C.
5. The time it took for a colour change to be observed was recorded.
6. Steps 1–5 were repeated three times and an average time for the colour change was calculated.
7. Steps 1–6 were then repeated using temperatures of 20°C, 30°C, 50°C and 60°C.

The results of the experiment were recorded in the following table.

Temperature (°C)	**Average time taken for a colour change (minutes)**				
	Group 1	**Group 2**	**Group 3**	**Group 4**	**Average of all groups**
20	5.2	5.0	5.3	4.9	5.10
30	1.8	1.2	2.4	1.6	1.75
37	0.5	0.4	0.4	0.5	0.45
50	10.8	9.6	10.1	12.4	10.73
60	(>20)	18.5	12.0	(>20)	15.25

Any experiments where the average time for a colour change to be observed exceeded 20 minutes were not included in the average of all groups.

Question 6

An appropriate hypothesis supported by the experimental data for this experiment would be that

A. the functioning of lipase with full cream milk will be affected by different temperatures.

B. if the lipase concentration increases, then the average time for a colour change to be observed in the reaction with full cream milk will decrease.

C. if the temperature increases from 20°C, then the rate of the lipase reaction with full cream milk will decrease, which will be observed through an increase in the average time for a colour change.

D. if the temperature deviates away from the optimum temperature of 37°C, then the rate of the lipase reaction with full cream milk will decrease, which will be observed through an increase in the average time for a colour change.

Question 7

An explanation for the results at 30°C would be that the

A. number of collisions between the lipase and triglyceride is reduced because the kinetic energy in the system is higher than that at 37°C.

B. lower temperature has led to the partial denaturation of the lipase enzyme and has caused the reaction to take longer compared to the reaction at 37°C.

C. lower temperature has acted as an irreversible inhibitor to the lipase, stopping it from functioning at the optimum rate.

D. kinetic energy in the system at this temperature is lower than at the optimum temperature, meaning that there are fewer collisions per minute between the lipase and triglyceride, increasing the average reaction time.

Question 8

Two students, Raheel and Thomas, were discussing the quality of the data. Raheel suggested that the average time for the colour change for all groups at 60°C was misleading. Thomas disagreed and said that a clear trend can be observed, meaning the data was reliable.

Which one of the following is a correct statement?

A. Raheel's argument is stronger than Thomas' because the average result of the experiment should have been much higher, which could change the way the trends are interpreted.

B. Thomas' argument is stronger than Raheel's because the experiment was not only repeated but it was also replicated, leading to precise and reliable results.

C. Raheel and Thomas both make a reasonable argument. Even though the results for all of the experiments conducted at 60°C were not included, possibly affecting the data, a trend can still be observed and, combined with repetition and replication, a reliable outcome has been produced.

D. Neither Raheel nor Thomas have a valid argument because each experiment had more than one independent variable being tested.

Question 9

Isolated mitochondria suspended in an isotonic solution need to be provided with two substances for optimal functioning.

Which one of the following pairs of substances are required by these isolated mitochondria?

A. carbon dioxide and oxygen

B. glucose and oxygen

C. pyruvic acid and oxygen

D. pyruvic acid and carbon dioxide

Use the following information to answer Questions 10 and 11.

E10 fuel is petrol combined with 10% ethanol. The ethanol is produced using sugar cane that is digested with an enzyme to liberate the glucose. The biomass mixture is then fermented to form ethanol.

Question 10

The process described above is an example of

A. anaerobic respiration.

B. aerobic respiration.

C. electron transport chain stimulation.

D. exocytosis.

Question 11

Within the cytoplasm of the cells of the biomass mixture, it would be expected that the most active part of the cell would be the

A. mitochondria.

B. nucleus.

C. Golgi apparatus.

D. cytosol.

Question 12

Sex hormones control the development of eggs in female goldfish. Some of the hormones leak out of the female goldfish's gills into the water where they attract male goldfish that can fertilise the female goldfish's eggs.

This situation involves

A. animal hormones.

B. pheromones.

C. neurotransmitters.

D. cytokines.

Question 13

A signalling molecule binds to an extracellular receptor before stimulating a specific response within the cell.

Based on this information, it would be appropriate to conclude that the signalling molecule is

A. water insoluble.

B. lipophilic.

C. hydrophilic.

D. hydrophobic.

Question 14

Intraperitoneal (IP) chemotherapy is a more reliable way of treating ovarian cancer compared to other methods such as intravenous (IV) chemotherapy. In a sample of 800 ovarian cancer patients, the survival rate of those with IP chemotherapy was 50% after 10 years compared to 33% after 10 years for those who had been treated with IV chemotherapy.

Based on this information, it would be reasonable to assume that

A. IP chemotherapy stimulates a greater rate of apoptosis in patients compared with IV chemotherapy.

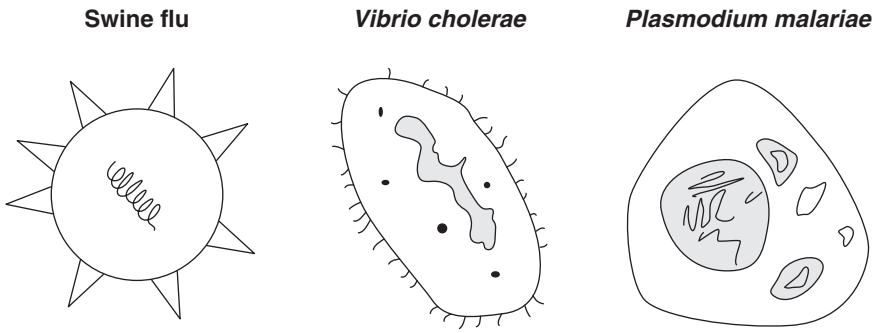
B. IV chemotherapy stimulates a greater rate of apoptosis in patients compared with IP chemotherapy.

C. the rate of cell reproduction in those using IP chemotherapy exceeds that found in patients using IV chemotherapy.

D. the difference in the results involving both therapies is not significant enough to justify a change from IV treatment to IP treatment.

Question 15

The following diagram depicts three different pathogens.



Which one of the following is a correct statement?

A. Swine flu is cellular.

B. *Vibrio cholerae* is eukaryotic.

C. *Plasmodium malariae* is prokaryotic.

D. All three pathogens contain nucleic acid.

Question 16

An appropriate physical barrier in humans that usually prevents the entry of pathogens into the blood stream is

A. lysozyme in tears.

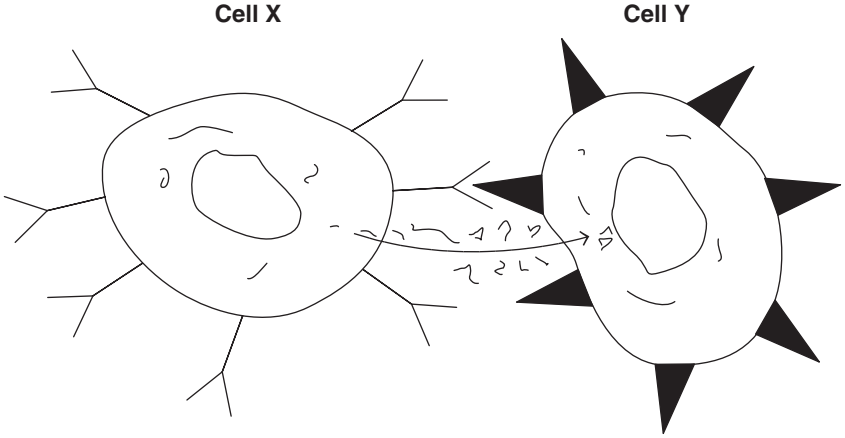
B. tears.

C. a mucus layer along the gut.

D. sebum in the skin.

Question 17

The following diagram represents a T cytotoxic cell at the site of an infection and a target cell.



Which one of the following statements is correct?

A. Cell X is the target cell and cell Y is the cytotoxic cell.

B. Cell X has differentiated in the thymus gland.

C. The response shown in the diagram would be the same regardless of the type of antigen being displayed by cell Y.

D. The release of cytokines from cell X will activate apoptosis in cell Y.

Use the following information to answer Questions 18 and 19.

In Australia, some horses are regularly injected with small amounts of snake venom to promote their immune system to develop an immunological protection against the venom. Once this protection has been developed, blood samples are extracted from the horses and certain factors from the blood are purified. These factors can then serve a therapeutic use for humans.

Question 18

Horses are used for this process, but sheep are not.

Based on the information above it would be reasonable to say that

A. horses require less ethical consideration in experiments than do sheep.

B. the factors extracted using the biochemical technique would be antibodies against the snake venom.

C. after each injection of venom, the horse's immune response would remain the same.

D. the initial immunological response would involve T cells.

Question 19

Which one of the following types of immunity describes the immunity acquired by the horse?

A. active artificial immunity

B. active natural immunity

C. passive artificial immunity

D. passive natural immunity

Question 20

Small sections of chromatids can be exchanged by crossover during meiosis, which can lead to greater variability in inherited DNA. Occasionally, the small sections of chromatids end up on non-homologous chromatids, which can be detrimental to survival.

This could be referred to as

A. a translocation mutation.

B. an inversion mutation.

C. a deletion mutation.

D. an event that leads to aneuploidy.

Question 21

The human genome consists of approximately 1% exons and 25% introns. The rest of the genome is referred to as 'junk' DNA. Mutations are random factors that change the DNA and genome.

Which one of the following statements is correct?

A. Mutations are likely to lead to a changed amino acid sequence in a protein.

B. Mutations are more likely to lead to a change in the 'junk' DNA.

C. Mutations are less likely to affect introns than they are to affect exons.

D. A mutagen, such as UV light, would target the mutations to specific exon sections.

Question 22

Dogs, cats, horses, goats, cows and pigs are all domestic or farm animals. The ancestors of each of these animals had very different appearances to those of the present-day animals.

This is a result of

A. speciation.

B. selective breeding.

C. aneuploidy.

D. gene flow.

Question 23

Based on the fossil record as understood in 2021, which one of the following organisms appeared the most recently?

A. worms

B. mice

C. roses

D. frogs

Question 24

From a rat-like common ancestor, two modern animals have evolved to have the capacity to glide: the Australian marsupial sugar glider and the placental flying squirrel. The Australian marsupial sugar glider can climb up eucalypt trees and glide up to 50 m. The placental flying squirrel, distributed mainly in Southeast Asia, can glide up to 75 m. The common ancestor of both animals did not have a patagium, the furry, parachute-like membrane that stretches from wrist to ankle and enables gliding.

The evolution of the patagium is an example of

A. divergent evolution.

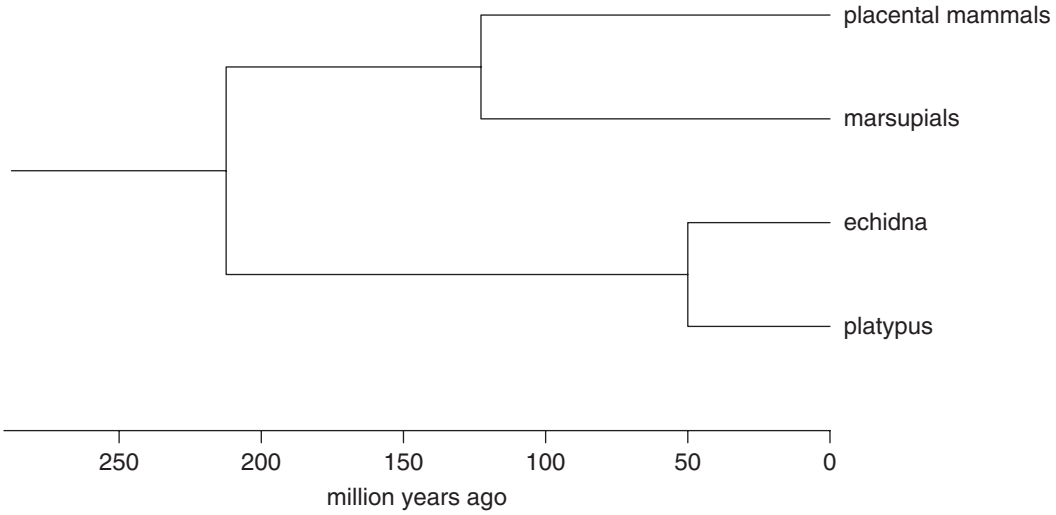
B. convergent evolution.

C. homologous structures.

D. molecular analogy.

Question 25

The following phylogenetic tree shows the relatedness between placental mammals, marsupials and monotremes (the echidna and the platypus). The timeline below the phylogenetic tree can be used to determine relatedness.



Based on the information provided, it would be reasonable to say that

A. placental mammals and marsupials would have more DNA homology than the echidna or the platypus.

B. the common ancestor for all four of the groups of animals existed 200 million years ago.

C. placental mammals and marsupials diverged 150 million years ago.

D. no platypus fossil evidence exists that is older than 50 million years.

Question 26

Molecular homology analyses the ancestral connections between different species by comparing similar protein sequences found within their cells. The EFHC1 gene codes for proteins that have been extensively studied with an alignment search tool. The results between individuals of three different species and a human are outlined below.

	Chimpanzee	**Mouse**	**Mosquito**
Human	99%	84%	42%

Based on the information provided, which one of the following statements is correct?

A. The mouse and mosquito differ in 42% of the amino acids that the EFHC1 gene codes for.

B. Only 1% of the amino acids in the EFHC1 gene of the chimpanzee are different when compared to other chimpanzees.

C. Humans are more closely related to mice than they are to mosquitoes.

D. The EFHC1 genes within the humans that were used in the investigation would have different sequences.

Question 27

If the BMP4 gene is active for longer during the embryological development of a species of Galapagos finch, it is likely that the resultant finch will

A. consume small insects.

B. have a long and slender beak to allow the finch to penetrate tubular flowers.

C. have a thicker beak that will be more able to break open hard seeds.

D. have a smaller beak adaptation that will place the finch at a selective advantage in its niche.

Question 28

Australopithecines are classified as

A. primates only.

B. hominins only.

C. hominids only.

D. primates, hominins and hominids.

Question 29

World human migrations can be mapped out using fossil evidence to trace paths taken and places inhabited, as well as investigating mitochondrial DNA (mtDNA) variations between members of indigenous groups. Based on the evidence available, the length of time that some indigenous groups have inhabited their countries has been estimated, as shown below.

- indigenous peoples in Australia – 60 000 years
- indigenous peoples in Africa – 180 000 years
- indigenous peoples in New Zealand – 1000 years
- indigenous peoples in South America – 15 000 years

Based on this information, it would be reasonable to state that

A. there would be more mtDNA differences between different indigenous peoples in Australia compared to the mtDNA differences between different indigenous peoples in Africa.

B. older human fossils would be likely to be found between Australia and New Zealand.

C. there would be fewer mtDNA differences between different indigenous peoples in South America compared to the differences between different indigenous peoples in Australia.

D. if the mtDNA mutation rate is one nucleotide difference per 1000 years, then there would be exactly 180 differences in the mtDNA between two modern African people.

Question 30

Homo habilis was a species existing 1.5–2.4 million years ago. It was given the name 'Handyman' because there were many stone tools found in the same location as the fossilised remains, which provided irrefutable evidence of ancestral human cultural advancement.

The most significant structural change in *Homo habilis* when compared to older ancestral humans is

A. a more central foramen magnum.

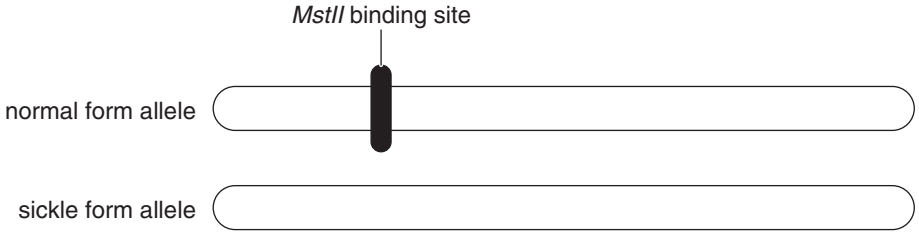
B. a larger cranial capacity.

C. big toes in line with the other toes.

D. a bowl-shaped pelvis.

Use the following information to answer Questions 31 and 32.

Sickle cell disease is an inherited blood disorder affecting the transport of oxygen around the body. It is not usually fatal but can be extremely painful. A genetic test for the disease early in life can provide early treatment and thereby a better quality of life for those who have the disease. The sickle gene codes for β-globin protein and is located on chromosome 11. There are two sickle alleles: a normal form and a sickle form. The difference between the alleles is due to a single nucleotide substitution, which provides the basis for a genetic test. The isolated gene has one restriction enzyme binding site (*MstII*) as shown in the following diagram.



Question 31

There is a *MstII* binding site within the normal form allele because

A. an initial single nucleotide substitution mutation occurred in the sickle form allele, leading to the normal form allele.

B. there is a specific sequence of 4–6 nucleotides that *MstII* binds to, leading to the cutting of the DNA strand in one place.

C. it allows the *MstII* to bind to it, which holds the allele together more strongly.

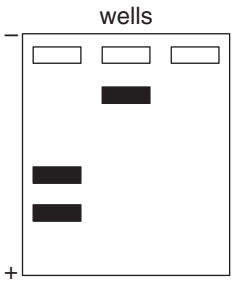
D. it enables the allele to be cut into two equally sized fragments.

Question 32

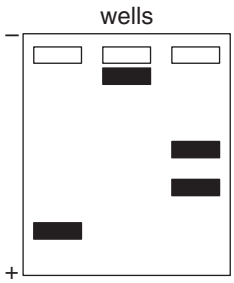
A family was unsure of the genetic status of their three young children, so they undertook a genetic screening of them. They took a blood sample from each child, exposed the isolated DNA to a polymerase chain reaction (PCR) and then to the *MstII* restriction enzyme, and then conducted gel electrophoresis to determine a profile. When they received the results, it was found that only one of the children tested positive for sickle cell disease.

Which one of the following profiles could belong to the three children?

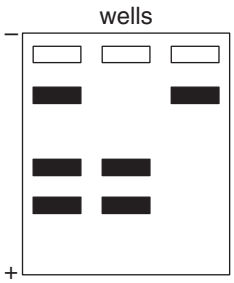
A.



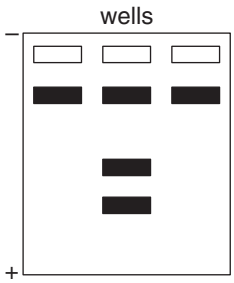
B.



C.



D.



Question 33

The best method to push DNA fragments more quickly through a gel during electrophoresis is to reduce the

A. voltage.

B. size of the fragments.

C. porosity of the gel.

D. duration that the gel is run.

Question 34

Plasmids are

A. circular double-helical strands of DNA.

B. linear single-stranded bacterial DNA.

C. eukaryotic DNA strands that can be transferred to prokaryotes.

D. circular single-stranded DNA.

Question 35

COVID-19 is a viral disease that is transmitted through contact and has a significant mortality risk. During 2020 and 2021, COVID-19 spread rapidly around the world.

A disease that meets these criteria would be categorised as a global

A. pandemic.

B. epidemic.

C. sporadic spreader.

D. endemic problem.

Question 36

Influenza can be a life-threatening viral disease. If a human is exposed to influenza, the antiviral drug Relenza can be taken within 1–2 days following exposure.

Relenza works by binding to the

A. haemagglutinin antigens on the virus, preventing the entry of the virus into the target cell.

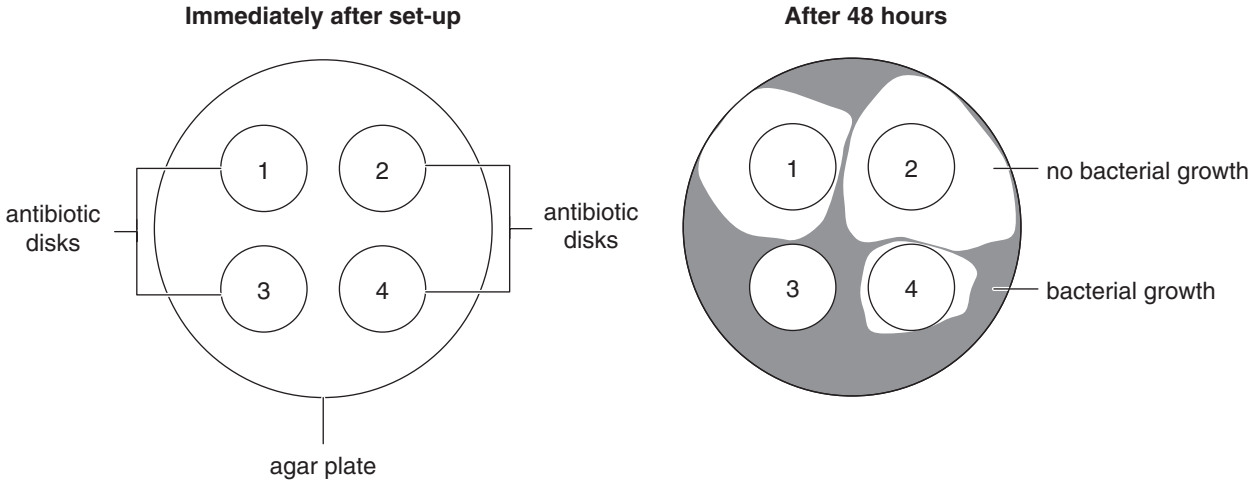
B. neuraminidase antigens on the virus, preventing the exit of replicated influenza virus out of the hijacked cell.

C. haemagglutinin antigens on the virus, preventing the exit of the virus out of the hijacked cell.

D. neuraminidase antigens on the virus, preventing the entry of the influenza virus into the target cell.

Question 37

An unknown bacterial infection was grown in a laboratory on an agar plate and exposed to various antibiotics so that the appropriate antibiotic could be prescribed. The diagram below shows the agar plate immediately after being set up and after 48 hours.



The antibiotics shown in the diagram are listed below.

1. ampicillin
2. tetracycline
3. amoxicillin
4. erythromycin

Which one of the following antibiotics should be prescribed for the bacterial infection?

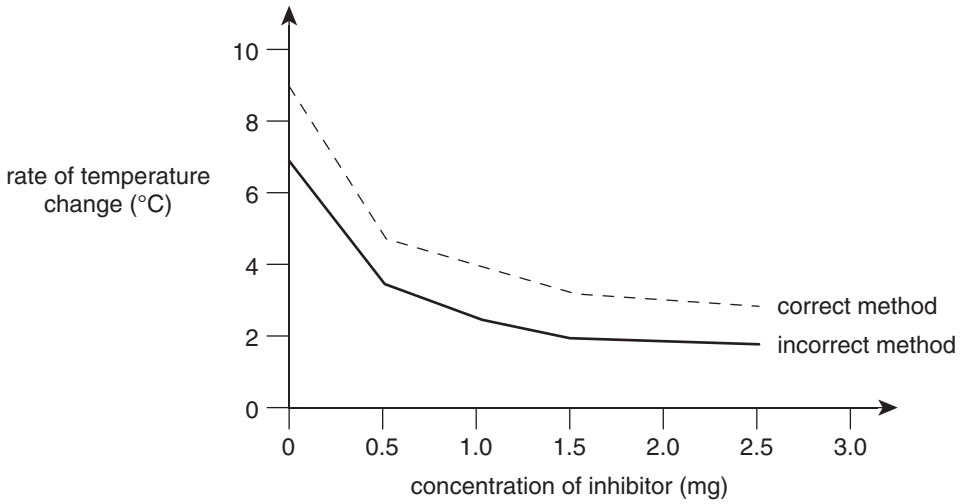
A. ampicillin
B. tetracycline
C. amoxicillin
D. erythromycin

Use the following information to answer Questions 38 and 39.

A Biology class was testing an inhibitor on the effect of cell respiration in yeast. One of the steps in the method was weighing precisely 10 g of yeast using an electronic scale. The teacher demonstrated how to use the scale **incorrectly** by giving the following instructions.

1. Switch the scale on.
2. Tare the scale (set it to zero).
3. Place the plastic weighing dish on the scale.
4. Add dry yeast into the plastic dish until 10 g is measured.

Sugar was added to the yeast samples and then the mixture was added to solutions containing varying amounts of inhibitor. A rate of temperature change was then measured. The collected data was plotted in the following graph. The teacher then revealed that the supplied method was incorrect and plotted a representation of the experimental data that would have been collected if the electronic scale had been used correctly.



Question 38

The data gained by the students was

A. random.

B. affected by experimental bias.

C. affected by poor methodology due to experimenter error.

D. affected by poor methodology due to systematic error.

Question 39

The control in this experiment is the

A. amount of sugar added to each sample.

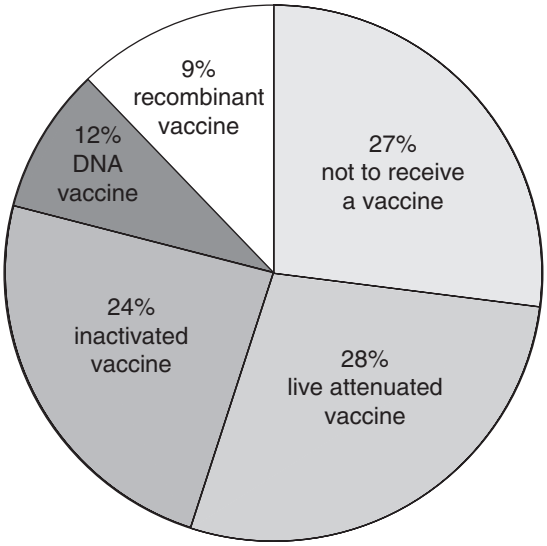
B. inhibitor concentrations of over 1.5 mg.

C. sample that had no inhibitor added.

D. experimental data collected using the correct method.

Question 40

In late 2020, Sandra conducted a survey at a COVID-19 testing site to learn what types of COVID-19 vaccines were preferred by the public. The graph below shows the results of Sandra's survey.



The dependent variable in Sandra's survey is the

A. percentage of the preference for each type of vaccine.

B. type of vaccine.

C. number of people involved in the investigation.

D. proportion of people not getting the vaccine.

END OF SECTION A

SECTION B

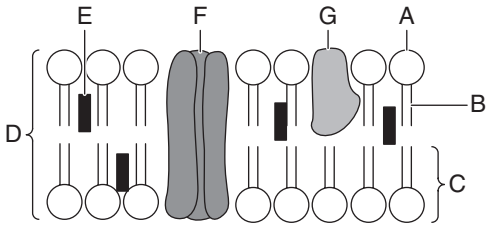
Instructions for Section B

Answer **all** questions in the spaces provided.

Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Question 1 (8 marks)

The following diagram represents the cross-section of a plasma membrane. Labels A–G represent different components of the membrane.



a. **i.** Which components are part of a phospholipid? 1 mark

ii. Which component plays an important role in membrane fluidity? 1 mark

iii. Which components are polar or partly polar? 1 mark

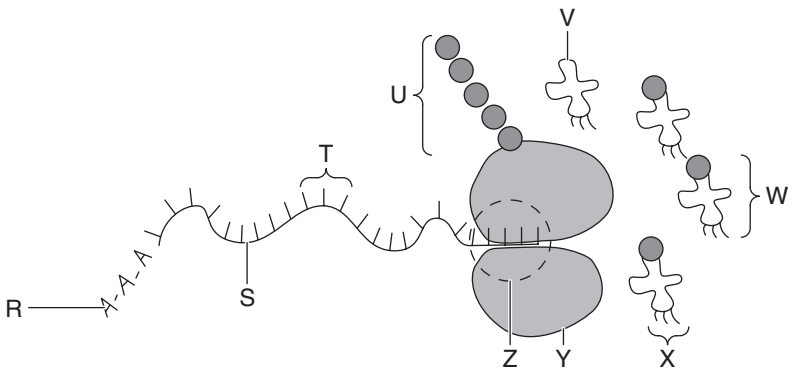
b. Plasma membranes are said to be selectively permeable.

Using an example from the diagram above, describe what is meant by 'selectively permeable'. 2 marks

c. Using the terms 'hydrophobic', 'hydrophilic' and 'ATP', describe how a vesicle can fuse with a membrane prior to the exocytosis of a protein from the cell. 3 marks

Question 2 (6 marks)

The diagram below represents an important biochemical process that occurs within the cytosol of almost every cell. Labels R–Z represent different structures and areas of this process.



a. Name each of the following structures and areas. 2 marks

R _____

S _____

U _____

W _____

b. Outline how structure X interacts with structure T within area Z. 2 marks

_____

_____

_____

_____

c. Explain why structure V is different to structure W and how the cell maintains a steady supply of these structures that are fed into structure Y. 2 marks

_____

_____

_____

_____

Question 3 (8 marks)

Ribulose-1,5-bisphosphate carboxylase/oxygenase, commonly known by the abbreviation 'rubisco', is an enzyme involved in the first major step of carbon fixation and is probably the most abundant enzyme on Earth. The reaction that rubisco catalyses is shown below.

ribulose biphosphate + carbon dioxide $\rightarrow$ phosphoglycerate

a. **i.** What type of biomacromolecule is rubisco? 1 mark

ii. Explain how the structure of rubisco aids its function. 2 marks

iii. Ribulose biphosphate is a 5-carbon molecule and phosphoglygerate is a 3-carbon molecule.

Considering this information, outline how the reaction given above occurs. 1 mark

b. Josephine was interested in the effect that light intensity has on the function of rubisco and set up an experiment to test this. Purified rubisco was placed in a series of small test tubes in a solution containing all the conditions necessary for the reaction to proceed. The results of the experiment are shown in the table below.

	Level of phosphoglycerate produced (arbitrary units)			
Light intensity (lux)	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 4**
0	37	42	39	35
50	42	43	41	42
100	41	38	45	43
150	38	34	44	44

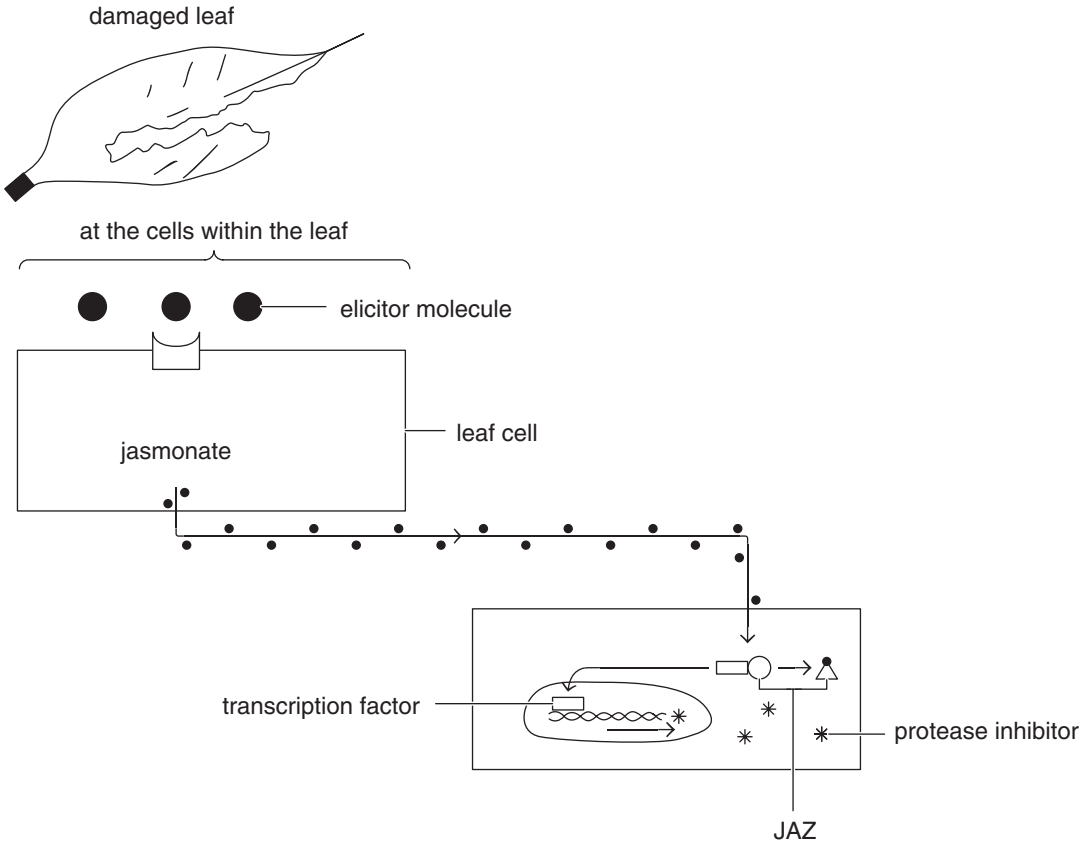
i. Josephine stated that there was a high level of precision for each level of light intensity investigated.

Using data from the table above, explain which level of light intensity was the most precise. 2 marks

ii. Using data from the table above, write a possible conclusion for the experiment. 2 marks

Question 4 (7 marks)

Jasmine is an aromatic flowering plant that grows prolifically in Victoria. It is not usually consumed by herbivores because of a chemical response elicited after an insect consumes part of the plant's leaves. The plant's method of defense in response to herbivorous attack is shown in the diagram below.



a. Identify **one** physical barrier that may prevent an insect from eating the jasmine leaf prior to any chemical response from the plant. 1 mark

When a caterpillar eats part of a jasmine plant's leaf, elicitor molecules are released.

b. i. Using evidence from the diagram above, identify the chemical nature of the elicitor molecules. 1 mark

ii. State the steps involved in the elicitor molecule leading to the production of jasmonate. 1 mark

c. Compare the action of jasmonate in gene control to the action of lactose in the *lac* operon. 2 marks

d. After the process depicted in the diagram on the previous page is complete, explain what will happen if another caterpillar starts to consume the leaf. 2 marks

Question 5 (8 marks)

In early December 2020, the results from a COVID-19 trial vaccination program from the pharmaceutical company Moderna were published and confirmed a 94% success rate. As a result of these successes, the vaccine was able to be provided to members of the general population.

a. In terms of immunity, what is the purpose of a vaccine? 1 mark

b. Describe the steps involved in an immune response upon first exposure to a vaccine. 3 marks

c. Trial vaccination programs should be conducted so that members of the general population can be confident in the results.

Outline the steps involved in conducting a trial vaccination program. 4 marks

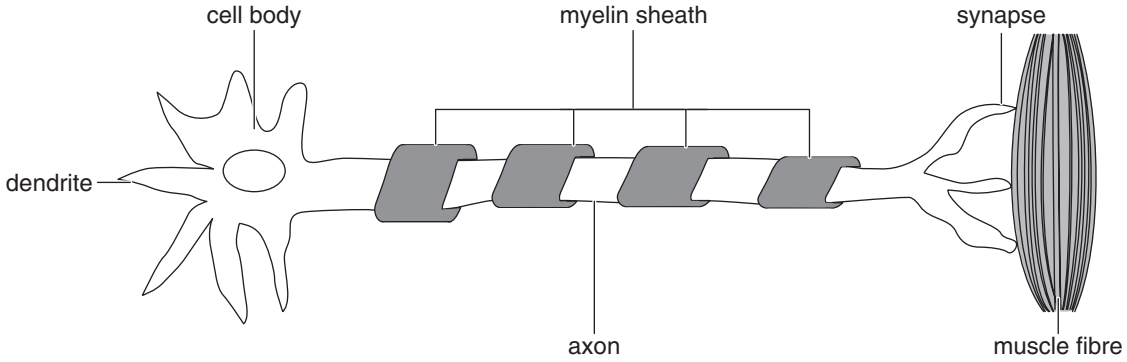
Question 6 (7 marks)

Deficient and malfunctioning immune systems can lead to diseases such as multiple sclerosis. There are about 25 000 Australians who have multiple sclerosis. The onset of symptoms for multiple sclerosis usually begins when a person is 20–40 years old and the symptoms usually become progressively worse with time. Symptoms can include:

- difficulty walking
- blurred vision
- speech difficulty
- body tremors.

a. What type of disease is multiple sclerosis? 1 mark

b. The diagram below shows the parts of the motor neuron.



Which part of the motor neuron is affected by multiple sclerosis when symptoms develop? 1 mark

c. Explain how multiple sclerosis develops in an individual and relate this development to **one** of the symptoms listed above. 3 marks

d. There is no cure for multiple sclerosis; however, there are medications available that may reduce the onset of symptoms. There may also be behavioral changes that could also reduce the onset of symptoms. Some of the factors that could be considered when developing treatment plans are listed below.

- In Australia, individuals from northern states are 10 times less likely to develop multiple sclerosis than individuals from southern states.
- multiple sclerosis sufferers can reduce the onset of symptoms by spending more time in the sun.
- Vitamin D supplements can reduce the symptoms of multiple sclerosis.

A 30-year-old female has recently been diagnosed with multiple sclerosis; however, the symptoms have not yet become debilitating.

Develop an action plan that could reduce the patient's onset of symptoms based on the factors listed above. 2 marks

Question 7 (7 marks)

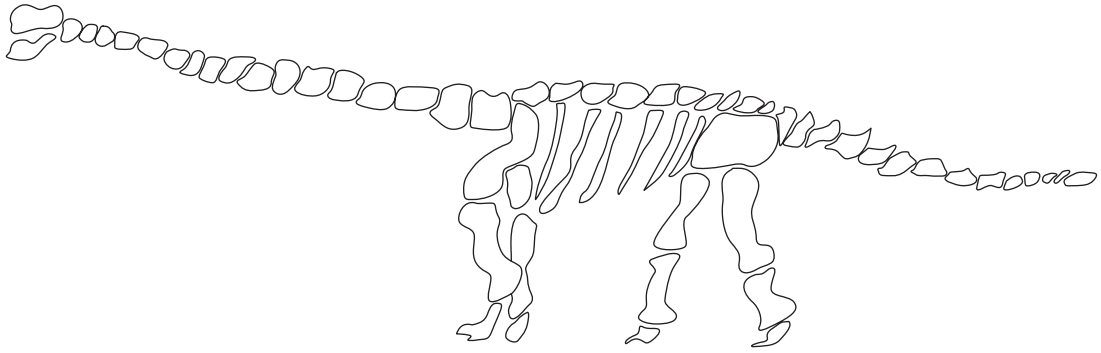
When the Grand Canyon in the USA formed approximately 10 000 years ago, squirrels (and other small mammals) that had once been part of a single population were unable to interbreed. The Kaibab squirrel (*Sciurus kaibabensis*) lives on the southern rim of the canyon and the Abert's squirrel (*Sciurus aberti*) lives on the northern rim of the canyon.

a. Name and describe the process that would have led to the emergence of the Kaibab and Abert's squirrels. 5 marks

b. Explain whether the process described in **part a.** is an example of evolution. 2 marks

Question 8 (8 marks)

Mamenchisaurus is a genus of dinosaur known for their very long necks. The neck of this dinosaur made up at least half the total body length. A possible example of this genus was estimated to have been 35 m in length when alive and to have weighed approximately 80 tonnes. A diagram of a *Mamenchisaurus* skeleton is shown below.



a. Outline **one** method that could be used to estimate how much a live *Mamenchisaurus* would have weighed. 1 mark

The *Mamenchisaurus* genus was estimated to be alive between 160 and 145 million years ago.

b. i. What evidence would have enabled this time period to be determined? 1 mark

ii. Uranium-238 has a half-life of 4.5 billion years.

Explain how uranium dating could be used to determine the age range of the *Mamenchisaurus*. 2 marks

c. There have been many *Mamenchisaurus* fossils discovered, each one providing evidence relating to the genus. Some of the fossils are listed below.

- 14 incomplete neck vertebrae
- 19 complete neck vertebrae
- one incomplete skull with four vertebrae
- one incomplete skull, forelimb, shoulder bones and some fused tail vertebrae

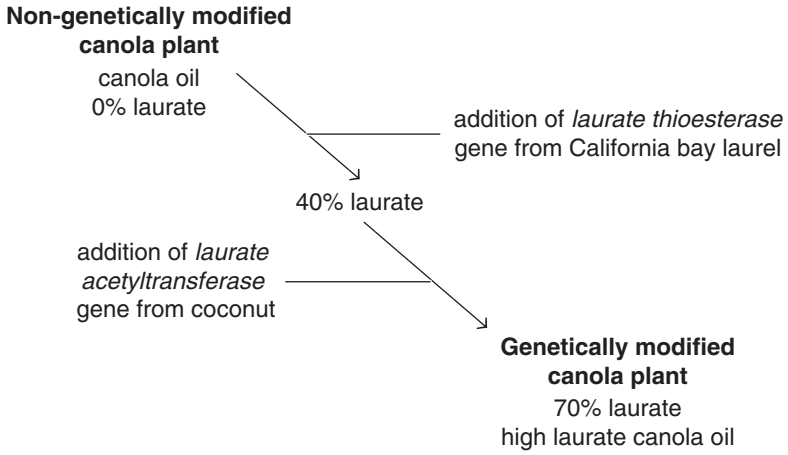
Some paleontologists believe the fossils listed above belong to different species of the genus, whereas some think they are from the same species.

Based on the fossil evidence listed above, describe the factors that would support the argument that these fossils are from members of the same genus but different species. 4 marks

Question 9 (8 marks)

Canola oil is a vegetable oil derived from rapeseed, the bright yellow member of the family *Brassicaceae*, and is extensively used in the cooking industry. The plant grows easily in semi-arid conditions and produces a seed from which a large volume of canola oil can be extracted.

Coconut oil has better cooking properties than canola oil but is more expensive to produce. If the properties of canola oil are modified to mirror the properties of coconut oil, then a lucrative market niche could be developed. This can be achieved with high laurate canola. The diagram below demonstrates how biotechnologists have increased the laurate levels in canola oil from 0% to 70%, making the product equal in quality to coconut oil for cooking. This modified canola oil has not yet been permitted to be sold for human consumption.



a. State **one** social and **one** ethical implication of the availability of genetically modified canola plants. 2 marks

b. Outline the steps involved in splicing the gene from the California bay laurel into the genome of the canola plant. 4 marks

c. Is the high laurate canola plant an example of a transgenic organism, a genetically modified organism or both? Justify your answer. 2 marks

Question 10 (13 marks)

Taq polymerase is a heat-resistant enzyme routinely used in processes like PCR. To determine that the optimal temperature for the functioning of this enzyme was 75°C, an experiment was conducted. The method for the experiment is listed below.

1. Isolated DNA fragments of the same sequence and length were obtained.
2. Equal volumes of the DNA fragments were added to five Eppendorf tubes.
3. The Eppendorf tubes were all heated to 90°C for 60 seconds.
4. The Eppendorf tubes were then cooled to 60°C for 30 seconds.
5. Equal volumes of primer and *Taq* polymerase were added to each Eppendorf tube.
6. The temperatures of the Eppendorf tubes were each increased to a different temperature for 90 seconds each. The five temperatures were:
   - I. 60°C
   - II. 70°C
   - III. 75°C
   - IV. 78°C
   - V. 85°C
7. Finally, the Tm was calculated.

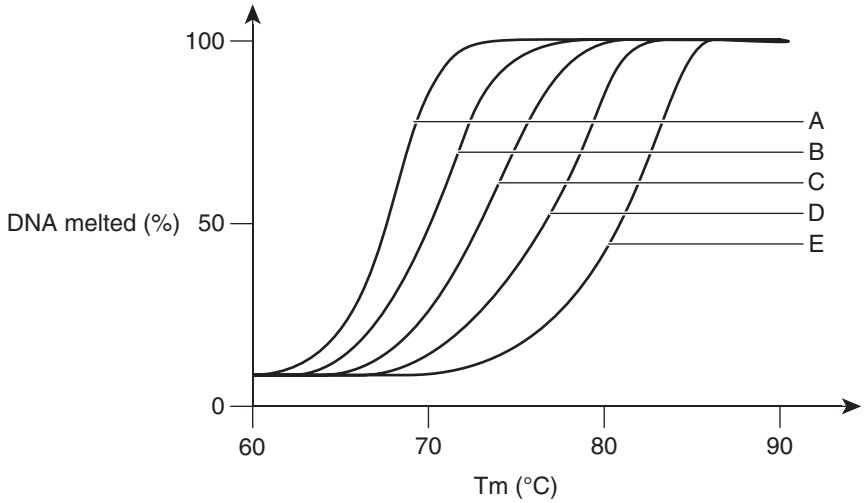
The Tm is a measure of the amount of heat required to 'melt' the existing DNA fragments in a solution. A higher Tm means there is a greater number of fully formed DNA fragments within the mixture. A lower temperature means insufficient time has elapsed for the *Taq* polymerase to be fully functional.

a. State a possible hypothesis for this experiment. 1 mark

b. State **two** controlled variables in this experiment. 2 marks

c. Using your knowledge of DNA structure, explain why the experiment would be invalidated if the original DNA fragments did not have the same sequence and length. 2 marks

Tm data is gathered by slowly heating the DNA present to 90°C for 60 seconds. During this time, the viscosity of the solution is measured by running the DNA through a narrow tube. The Tm is reached when 50% of the DNA present has melted, shown in the graph below by the central steep section of each curve.



d. **i.** Complete the data table below with the original temperature that the mixture was heated to and Tm for each Eppendorf tube sample, as shown in the graph above. 4 marks

Tube Number	Temperature that the mixture was heated to (°C)	DNA melted (%)
A		
B		
C		
D		
E		

ii. The aim of the experiment was to determine the optimal temperature for the functioning of the enzyme.

With reference to *Taq* polymerase function and the data shown above, explain what is meant by 'optimal temperature'. 2 marks

e. PCR is a process where small samples of DNA can be converted into large samples in a short space of time. PCR is used commercially, which means the process needs to be very reliable and to have the qualities of repeatability and reproducibility.

i. Define the quality of 'repeatability'. 1 mark

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ii. Define the quality of 'reproducibility'. 1 mark

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END OF QUESTION AND ANSWER BOOKLET