

Trial Examination 2022

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 36 pages

Answer sheet for multiple-choice questions

Additional space is available at the end of the booklet if you need extra paper to complete an answer.

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.

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.

Students are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2022 VCE Biology Units 3&4 Written Examination.

Neap® Education (Neap) Trial Exams are licensed to be photocopied or placed on the school intranet and used only within the confines of the school purchasing them, for the purpose of examining that school's students only. They may not be otherwise reproduced or distributed. The copyright of Neap Trial Exams remains with Neap. No Neap Trial Exam or any part thereof is to be issued or passed on by any person to any party inclusive of other schools, non-practising teachers, coaching colleges, tutors, parents, students, publishing agencies or websites without the express written consent of Neap.

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.

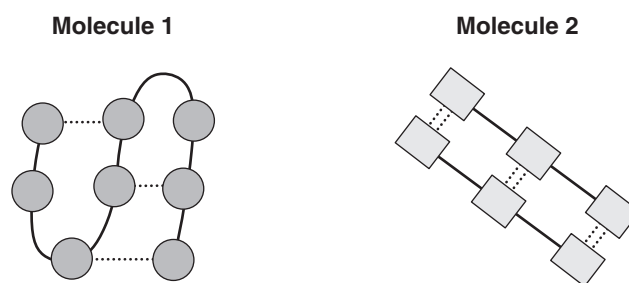
Marks will **not** be deducted for incorrect answers.

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.

Use the following information to answer Questions 1 and 2.

The diagram below shows two biomolecules.



Question 1

Molecule 1 contains

- A. R-groups.
- B. complementary pairing.
- C. phosphate groups.
- D. antiparallel strands.

Question 2

Which one of the following correctly compares the two molecules?

- A. Molecule 1 provides the blueprint for molecule 2.
- B. Molecule 1 is made up of amino acids and molecule 2 is made up of nucleotides.
- C. Molecule 1 is the result of transcription and molecule 2 is the result of translation.
- D. Molecule 1 is the encoded information that is expressed by molecule 2.

Question 3

The *trp* operon gives a model of gene regulation in bacteria. It involves the activation of a metabolic pathway that allows the synthesis of tryptophan in a low-tryptophan environment.

Which one of the following occurs when tryptophan is being produced by the *trp* operon?

- A. A repressor is bound to the operator section of the gene, allowing RNA polymerase to bind to the promoter for the subsequent expression of the gene.
- B. The shape of the repressor prevents it from binding to the promoter, allowing RNA polymerase to bind to the operator for the subsequent expression of the gene.
- C. None of the structural genes from the *trp* operon are expressed.
- D. The structural genes are expressed as RNA polymerase that was once bound to the promoter moves unimpeded along the *trp* operon.

Question 4

Rubisco is an enzyme that functions at a quaternary level of arrangement.

Which one of the following correctly describes this level of arrangement?

- A. Alternative splicing from one gene enables all polypeptides to be manufactured.
- B. Different ribosomes are involved in the manufacture of each polypeptide.
- C. A number of different polypeptides bind together to produce the functional enzyme.
- D. The polypeptides gather at the Golgi apparatus to be modified before they are secreted from the cell.

Question 5

Which one of the following is the branch of science that studies the total set of functional proteins within a cell?

- A. genomics
- B. biochemistry
- C. immunology
- D. proteomics

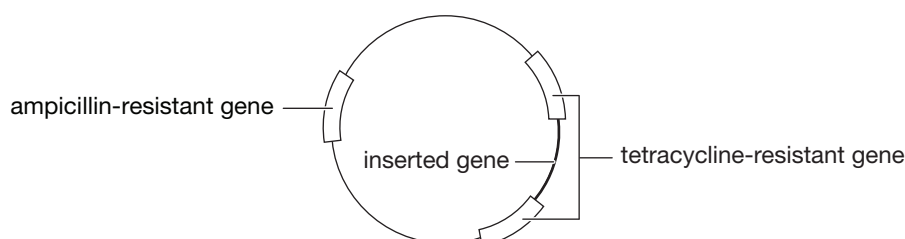
Question 6

An enzyme that cuts DNA is called

- A. ligase.
- B. endonuclease.
- C. RNA polymerase.
- D. DNA polymerase.

Question 7

The recombinant plasmid shown below was successfully integrated into a culture of bacteria. The inserted gene disrupted the tetracycline-resistant gene.



The transformed bacteria were smeared onto the following three luria broth (LB) nutrient agar plates.

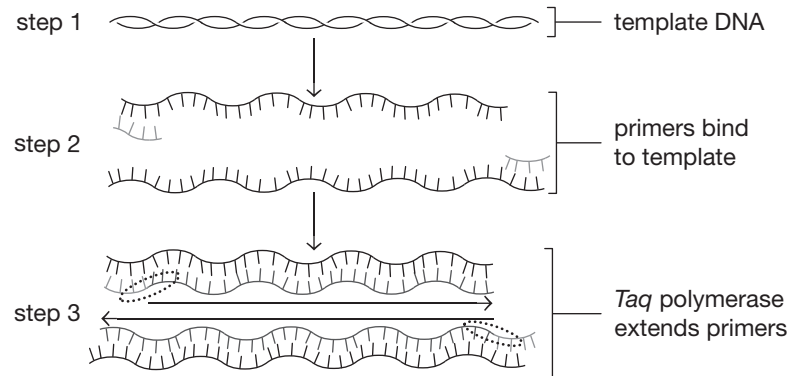
- Plate 1 contains ampicillin.
- Plate 2 contains tetracycline.
- Plate 3 contains ampicillin and tetracycline.

Colonies of transformed bacteria would grow on

- A. plate 1 only.
- B. plate 2 only.
- C. plate 3 only.
- D. plates 1 and 3 only.

Use the following information to answer Questions 8 and 9.

The diagram below shows the steps involved in the polymerase chain reaction (PCR) for a DNA fragment.



Question 8

Which one of the following statements about the PCR is correct?

- A. The primers would only be 2–3 nucleotides long because, if they were longer, the complementary sequence is unlikely to be present in the DNA sample.
- B. Temperatures of 90°C are required in the denaturation stage to break the phosphodiester bonds holding the nucleotides together along the polynucleotide strands.
- C. The *Taq* polymerase binds to a primer before DNA replication can occur.
- D. After each cycle, the small samples of DNA need more nucleotides added because the initial concentration is too low for multiple cycles.

Question 9

The fragment shown in the diagram was the only one used at the start of the process.

How many strands would there be after six cycles?

- A. 16
- B. 32
- C. 64
- D. 128

Question 10

Which one of the following correctly identifies the products of aerobic respiration?

- A. ATP only
- B. ATP and carbon dioxide
- C. ATP, glucose, and oxygen
- D. ATP, carbon dioxide and water

Question 11

Genetically modified organisms (GMOs) that are easier to produce through farming are becoming more available around the world.

Examples of such farmed organisms include:

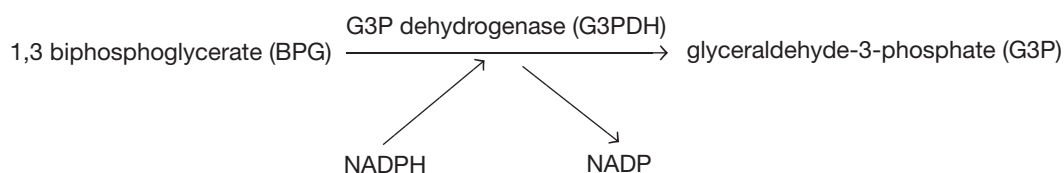
- genetically modified corn that has an added bacterial gene, rendering the corn poisonous to some insects
- genetically modified potatoes that have an added RNA silencing molecule, preventing the potatoes from browning and bruising
- genetically modified salmon with an added growth gene from a salmon and promotor sequence from an ocean trout, increasing the salmon's growth rate.

Which row of the table shows the advantages of each GMO for farmers?

	Genetically modified corn	Genetically modified potatoes	Genetically modified salmon
A.	antibiotic resistance	increased size	greater productivity
B.	insect resistance	less food waste	salmon live longer
C.	lower pesticide use	less food waste	greater productivity
D.	lower pesticide use	reduced antibiotic use	reduced viral infections

Question 12

The biochemical reaction shown below occurs within the cytosol of an autotrophic cell.



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

	Substrate	Product	Catalyst	Coenzyme
A.	BPG	G3P	G3PDH	NADPH
B.	NADPH	G3P	NADP	G3PDH
C.	G3P	G3PDH	NADPH	BPG
D.	BPG	NADP	G3PDH	G3P

Question 13

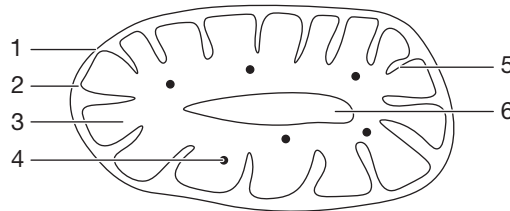
A human enzyme is extracted and purified for the purposes of experimentation. The rate of reaction can be measured by a distinctive colour change from colourless (no reaction) to a bright magenta colour (completed reaction).

Which one of the following factors would most likely decrease the time taken for a magenta colour to appear?

- A. increasing the temperature from 37°C to 45°C
- B. reducing the pH from 9 to 7
- C. reducing the concentration of the substrate from a surplus amount to 25% of that amount
- D. reducing the size of the beaker in which the reaction occurs and reducing the concentration of reactants accordingly

Use the following information to answer Questions 14 and 15.

The diagram below shows a mitochondrion with labels 1–6 representing locations or structures within the organelle.



Question 14

Which one of the following processes occurs at structure 5?

- A. glycolysis
- B. the Krebs cycle
- C. the electron transport chain
- D. ATP phosphorylation

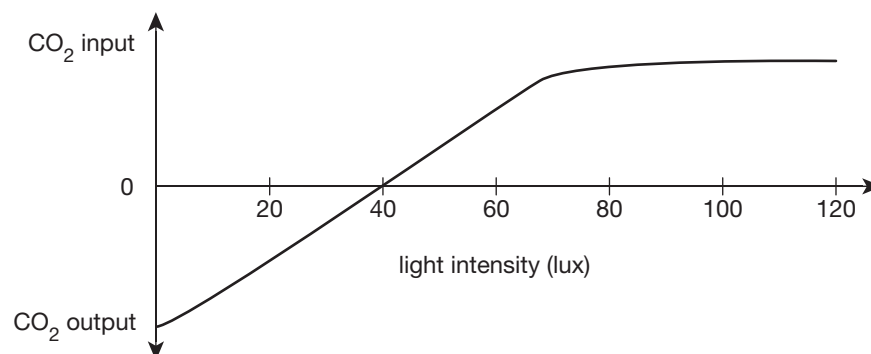
Question 15

The purpose of location 2 is to

- A. remove hydrogen from NADH.
- B. provide a difference in hydrogen concentration compared to location 3.
- C. store enzymes produced by structure 4.
- D. separate structure 1 from structure 6.

Question 16

The graph below shows the changes in carbon dioxide (CO_2) levels in a tomato plant as the light intensity is progressively increased.



Reading from the graph, it could be concluded that

- A. the rate of respiration in the tomato plant is at its lowest level at 0 lux.
- B. the tomato plant is not photosynthesising at 20 lux.
- C. the tomato plant is not metabolising at 40 lux.
- D. the concentration of Rubisco is limiting the tomato plant's CO_2 input at 100 lux.

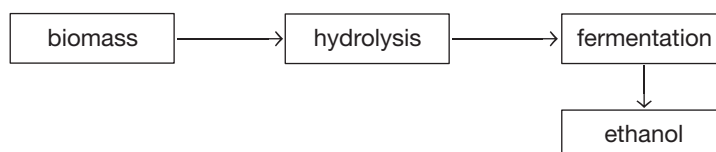
Question 17

What is the difference between C_3 , C_4 and CAM plants?

- A. Unlike C_3 and C_4 plants, CAM plants, such as cactus, absorb carbon dioxide (CO_2) at night.
- B. C_4 plants immediately integrate CO_2 into a 3-carbon compound, whereas C_3 and CAM plants initially integrate CO_2 into a 4-carbon compound.
- C. C_3 plants absorb more CO_2 during the day, whereas C_4 and CAM plants absorb more CO_2 at night.
- D. CAM plants are suited to temperate climates, C_3 plants are suited to dry environments and C_4 plants are suited to marine environments.

Use the following information to answer Questions 18 and 19.

E10 fuel is 90% petrol and 10% ethanol, which is produced on a large scale via the steps shown in the diagram below. E10 fuel does not damage the engine of a petrol-driven vehicle and is regarded as a step towards more ecologically sustainable fuels in the future.

**Question 18**

Which one of the following would be a good source of biomass for the process of ethanol production?

- A. animal manure
- B. bacterial colonies
- C. yeast cultures
- D. wood pulp

Question 19

Which one of the following identifies an advantage of E10 fuel produced from the fermentation of biomass?

- A. Ethanol oxygenates petrol, which reduces exhaust emissions.
- B. Fermentation allows us to recycle unleaded petrol and convert this into ethanol, which is more sustainable.
- C. The availability of E10 fuel will encourage people to transition to electric vehicles.
- D. E10 fuel will enable car engines to anaerobically ferment petrol in a more sustainable way.

Question 20

The table below shows the proportion of each type of white blood cell as a percentage of the total number of white blood cells that are typically present in a healthy, adult human body.

White blood cell	Proportion present (%)
neutrophil	50
lymphocyte	30
macrophages	4
eosinophils	2

Reading from the table, the cells involved in the innate immune response are

- A. neutrophils, macrophages and eosinophils only.
- B. lymphocytes and eosinophils only.
- C. lymphocytes, macrophages and eosinophils only.
- D. neutrophils, lymphocytes, macrophages and eosinophils.

Question 21

Which one of the following statements is correct?

- A. An eosinophil binds to a non-self marker on a pathogen and releases cytokines to attract lymphocytes for subsequent phagocytosis.
- B. A neutrophil binds to a non-self marker on a foreign cell and releases cytokines to attract macrophages for subsequent phagocytosis.
- C. A lymphocyte binds to an antigen on the surface of a transplanted cell and secretes complement proteins to destroy the antigens.
- D. A neutrophil migrates to the site of inflammation and secretes antibodies onto the target cells.

Question 22

An individual with a diagnosed allergy to the chemicals in peanuts is simultaneously exposed to the peanut allergen and the influenza type B virus.

Which one of the following would be an appropriate combined immune response?

- A. The mast cells release histamines and the virus-infected cells release interferons.
- B. The dendritic cells absorb the peanut allergen, and the complement proteins coat the virus-infected cells.
- C. The macrophages stimulate mast cells to secrete interferons to stop both exposures.
- D. The immune system would first respond to the peanut allergen and this would stimulate a response to the influenza virus.

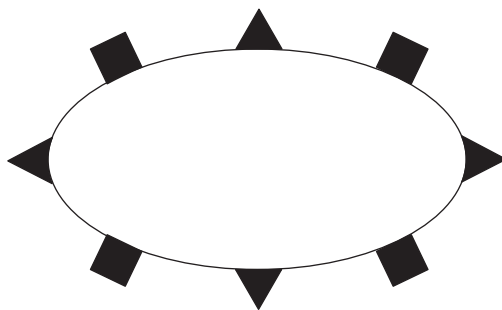
Question 23

The lymphatic system

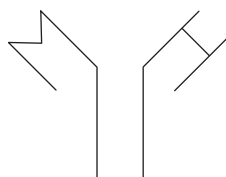
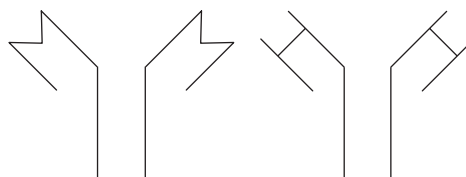
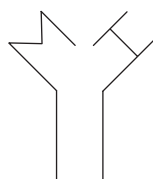
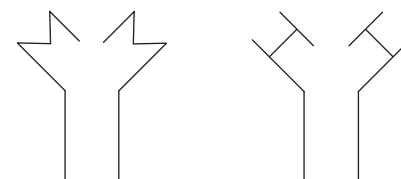
- A. has valves along the lymph nodes to prevent the backflow of lymph fluid moving through the system.
- B. has many nodes that contain mature B and T cells, which initiate an inflammatory response.
- C. is a meeting point between the innate and adaptive immune responses.
- D. releases mature B cells into the circulatory system and contains T cells within the lymph nodes.

Question 24

A body is exposed to a bacterium that has two antigens on its surface, as shown in the diagram below.



Which one of the following diagrams illustrates an appropriate antibody response against this bacterium?

A.**B.****C.****D.****Question 25**

An unborn mammal receives antibodies through the placenta that confer immunity during the first few months after it is born.

Which one of the following types of immunity is described in this example?

- A.** active natural
- B.** active artificial
- C.** passive artificial
- D.** passive natural

Question 26

Between 2016 and 2021, an outbreak of cholera occurred in Yemen. Cholera can have a mortality rate of up to 50% and generally causes problems in overcrowded environments that lack effective sewage treatment and access to clean water.

Which one of the following recommendations is most appropriate in reducing the incidence of cholera?

- A.** Provide food drops that include staple foods such as rice and corn.
- B.** Ensure sewage water enters rivers upstream from the drinking water supply.
- C.** Wash all food with water from the river but only drink bottled water.
- D.** Boil all water that will be used for cooking, drinking and washing.

Question 27

In the eighteenth century, the smallpox virus killed at least 30% of those who contracted it. Some individuals contracted the disease and survived. Other individuals developed immunity to the smallpox virus through early vaccination as well as inadvertent exposure to cowpox or the deliberate exposure of children to smallpox.

When the Europeans first colonised Australia, they passed the smallpox virus onto the First Nations peoples they encountered.

Which one of the following is the most likely effect that this initial exposure to the smallpox virus had on the First Nations population?

- A. The lack of prior exposure meant that the immune systems of First Nations individuals were unable to respond.
- B. The lack of herd immunity in the First Nations population meant that the virus was passed easily from infected individuals to non-infected individuals.
- C. The lack of prior exposure to any pathogens meant that healthy First Nations individuals did not have lymphocytes in their bloodstream.
- D. The lack of cows in Australia meant that there was no short-term immunity available to First Nations individuals.

Use the following information to answer Questions 28 and 29.

Pembrolizumab is a break-through immunotherapy medication and an example of a monoclonal antibody. It is part of the Australian Pharmaceutical Benefits Scheme and is used to treat cancers such as melanomas and some kidney cancers. It has a 30% higher rate of successful cancer treatment compared to traditional methods of treatment, such as chemotherapy.

Question 28

The large-scale production of Pembrolizumab for worldwide use would involve

- A. injecting the antigen into a mammal such as a mouse.
- B. injecting the antigen into an immature B cell.
- C. combining an immature B cell with a cancer cell to produce a hybridoma cell.
- D. isolating cancer cells from humans and fusing them with known cancer cell lines.

Question 29

Cancer cells, such as those in a melanoma, have markers on their surface called PD-L1. PD-L1 markers prevent cancer cells from undergoing cell death by binding to PD-1 markers on the surface of natural killer (NK) cells.

What is the significance of Pembrolizumab being complementary to the PD-L1 marker?

- A. When Pembrolizumab binds to the PD-L1 marker, the NK cell is prevented from rejecting the melanoma cancer cell.
- B. The PD-L1 marker will be unable to bind to the PD-1 receptor, which stimulates the death of the melanoma cancer cell.
- C. When the PD-1 marker binds to the PD-L1 marker, both the NK and melanoma cancer cells undergo cell death.
- D. Localised cells will preferentially bind to Pembrolizumab, which allows the NK cells to bind to the melanoma cancer cell and thus leads to its destruction.

Question 30

Influenza outbreaks are reduced through the implementation of annual vaccination programs that counteract the new influenza strains that may have moved into the community. In response to these outbreaks, seasonal flu shots are made available on an annual basis.

The availability of seasonal flu shots is important because

- A. bacteria develop resistance against the initial vaccine.
- B. the virus undergoes antigenic drift.
- C. the population of memory cells from the initial vaccine will drop to very low levels after a period of time.
- D. the development of severe side effects is reduced when the vaccine is regularly administered.

Question 31

Which one of the following would cause the most significant change in a gene pool?

- A. an advantageous mutation in an individual within the population
- B. a cyclone reducing a population of 5000 individuals to 2500 individuals
- C. an influx of 100 members of one population into an area that already carries 50 individuals of a different population
- D. releasing 10 individuals that were bred in captivity into an area with a current population of 1000 individuals

Question 32

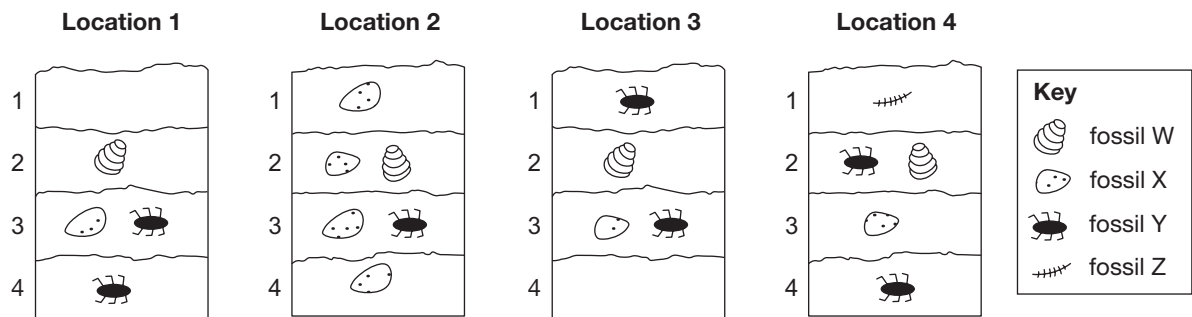
The breeds of dogs that are used as pets are generally friendly and able to be trained by humans. However, the ancestors of these dogs were much more aggressive.

Which one of the following processes is the best explanation for this change?

- A. natural selection
- B. evolution
- C. artificial selection
- D. genetic drift

Question 33

The strata layers of four different geographic locations are shown in the diagram below.



Based on the distribution of the fossils in the four locations, the most appropriate fossil to use as an index fossil would be

- A. W.
- B. X.
- C. Y.
- D. Z.

Question 34

Whales are excellent swimmers; however, they possess very small pelvic bones that play no role in their aquatic way of living. The presence of these bones in whales may provide strong evidence of their ancestral past.

These pelvic bones are regarded as

- A. transition fossils.
- B. vestigial structures.
- C. structural morphologies.
- D. faunal succession.

Question 35

Australopithecus afarensis shares characteristics with

- A. mammals, but not with hominoids.
- B. primates, but not with mammals.
- C. hominins, but not with hominoids.
- D. hominins and hominoids.

Question 37

The average mtDNA differences in a particular gene loci between four samples of 50 Indigenous people from various geographic locations are shown in the table.

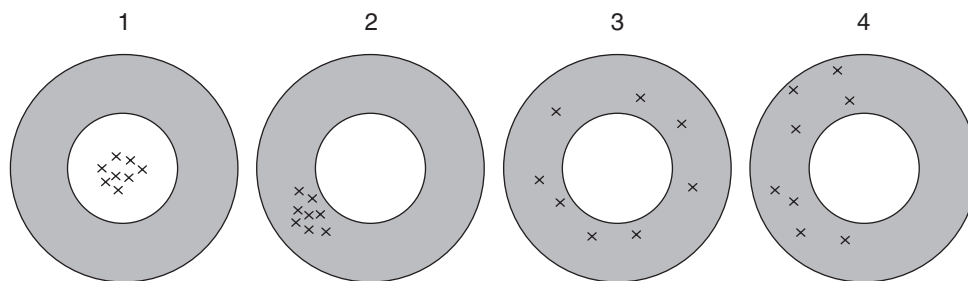
Geographic location	Average mtDNA differences
Africa	300
Australia	100
South America	30
South Asia	80

Based on the evidence from the table, which one of the following lists the four Indigenous groups from most recent to oldest?

- A. Indigenous Africans, Indigenous Australians, Indigenous South Americans, Indigenous South Asians
- B. Indigenous South Americans, Indigenous South Asians, Indigenous Australians, Indigenous Africans
- C. Indigenous Australians, Indigenous Africans, Indigenous South Americans, Indigenous South Asians
- D. Indigenous Africans, Indigenous Australians, Indigenous South Asians, Indigenous South Americans

Use the following information to answer Questions 38 and 39.

As part of a larger scientific investigation, an experiment was conducted in which an independent variable was repeated eight times. The experiment was repeated four times, and the results of each test were analogously represented as a target (1–4), as shown in the diagram below.

**Question 38**

The target that most likely involves a systematic error but has relatively high precision is

- A. 1
- B. 2
- C. 3
- D. 4

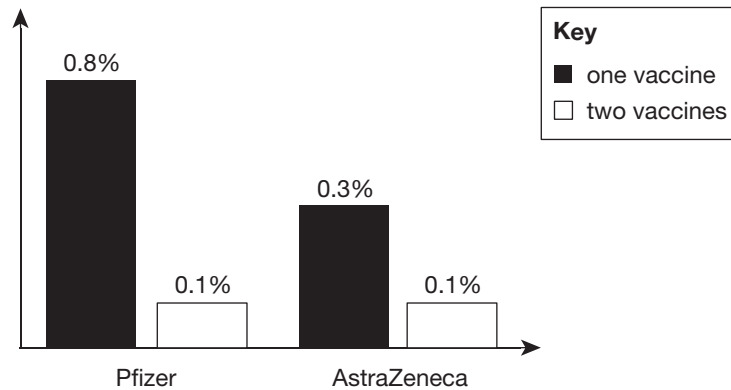
Question 39

Which of the following targets produce an accurate average?

- A. 1 and 2
- B. 1 and 3
- C. 1 and 4
- D. 2 and 3

Question 40

COVID-19 vaccines were administered to most of the world's population in 2021. A study about the effectiveness of the Pfizer and AstraZeneca vaccines in preventing hospitalisation against new strains of COVID-19 infections was conducted. The study involved 500 000 vaccinated individuals; half were vaccinated with Pfizer and half were vaccinated with AstraZeneca. The graph below illustrates the percentage of individuals in the sample who contracted a new strain of COVID-19 and were consequently admitted to hospital.



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

- A. There is a very low chance that vaccinated individuals will be hospitalised after contracting a new strain of COVID-19.
- B. To prevent hospitalisation after contracting a new strain of COVID-19, it is more efficient to have had one vaccine than two vaccines.
- C. To prevent hospitalisation after contracting a new strain of COVID-19, it is more efficient to have the Pfizer vaccine than the AstraZeneca vaccine.
- D. The data cannot be analysed because there is no control group in the study.

END OF SECTION A

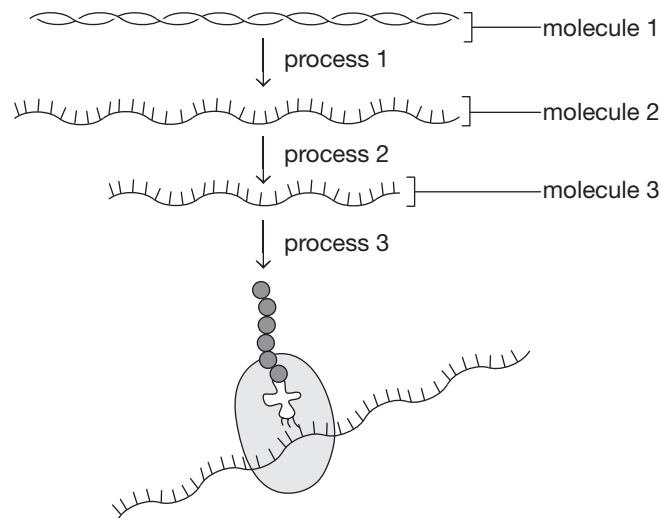
SECTION B**Instructions for Section B**

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

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

Question 1 (8 marks)

The diagram below shows the steps of the gene expression sequence that occurs in all living cells. The processes and molecules (1–3) involved in the sequence are indicated.



- a. Complete the table below by naming the processes and molecules indicated in the diagram. 3 marks

Process	Process name	Molecule	Molecule name
1		1	
2		2	
3		3	

- b. Describe how process 2 produces a smaller molecule (molecule 3) and how this molecule is made stable enough for process 3. 2 marks

The sequence shown is from the template of molecule 1 and was involved in process 3.

GAC CAG GAT TAC GAC CTT

The table below lists codons and corresponding amino acids.

		Second base				
		U	C	A	G	
First base	U	Phe	Ser	Tyr	Cys	U
		Phe	Ser	Tyr	Cys	C
		Leu	Ser	Stop	Stop	A
		Leu	Ser	Stop	Trp	G
	C	Leu	Pro	His	Arg	U
		Leu	Pro	His	Arg	C
		Leu	Pro	Gln	Arg	A
		Leu	Pro	Gln	Arg	G
	A	Ile	Thr	Asn	Ser	U
		Ile	Thr	Asn	Ser	C
		Ile	Thr	Lys	Arg	A
		Met	Thr	Lys	Arg	G
	G	Val	Ala	Asp	Gly	U
		Val	Ala	Asp	Gly	C
		Val	Ala	Glu	Gly	A
		Val	Ala	Glu	Gly	G

- c. Using the information in the table above, determine the outcome of process 3.

2 marks

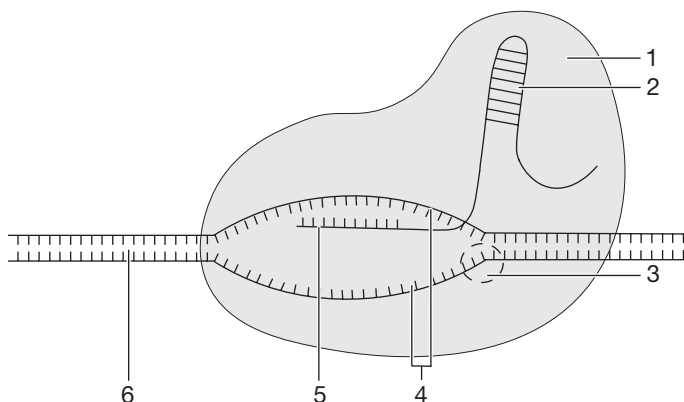
- d. The product of process 3 is a molecule that is secreted from the cell.

Name the organelles of the cell involved in the production, transport, modification and eventual secretion of the molecule from the cell.

1 mark

Question 2 (7 marks)

CRISPR-Cas9 technology has revolutionised modifying genes through the methods of disruption, correction or replacement. The diagram below shows a CRISPR-Cas9 complex and labels 1–6 represent different parts of the complex.



- a. Complete the table below by stating the name and describing the function of the listed parts of the CRISPR-Cas9 complex. 3 marks

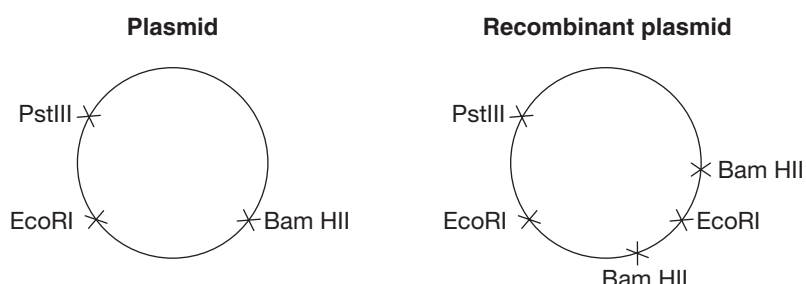
Part	Name	Function
3		
4		
5		

- b. Explain how CRISPR-Cas9 would be used to disrupt a gene that makes a plant more susceptible to salinity. 3 marks

- c. Explain how the process described in your answer to **part b.** could be advantageous. 1 mark

Question 3 (9 marks)

The diagram below shows a plasmid when it is first extracted from a bacterium, which is then modified to become a recombinant plasmid by inserting a gene of interest. The crosses included along each plasmid show the location of the restriction enzyme binding sites for Bam HII, EcoRI and PstIII.



- a. Describe how a gene of interest could be inserted into a plasmid to form a recombinant plasmid.

3 marks

- b. Explain why the recombinant plasmid has two Bam HII restriction enzyme binding sites and an extra EcoRI restriction enzyme binding site.

2 marks

To measure the size of the inserted gene, EcoRI and PstIII were added to both plasmids and the resultant fragments were run through an electrophoretic gel. Four additional fragments (markers) were also added to the gel to determine the size of the plasmid fragments.

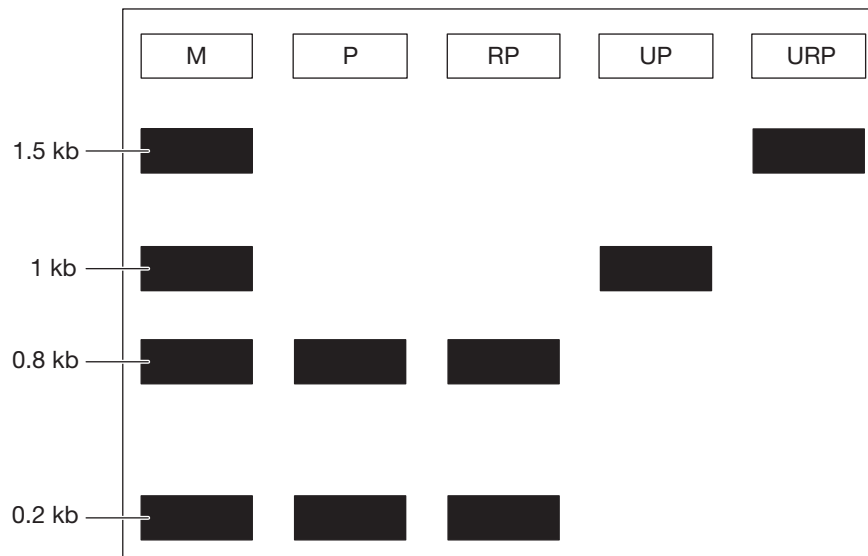
- c. State **two** conditions that need to be applied to the electrophoretic gel so that the DNA fragments in each sample separate successfully.

2 marks

d. The resultant genetic profile is shown below. The following five samples were added to the wells.

- the markers (M)
- the restricted original plasmid (P)
- the restricted recombinant plasmid (RP)
- the unrestricted original plasmid (UP)
- the unrestricted recombinant plasmid (URP)

The band containing the inserted gene has not been included. The size of each marker (in kilobases) is indicated on the diagram.



i. Determine the size of the inserted gene. 1 mark

ii. On the genetic profile above, draw the inserted gene fragment in the correct band position on the gel. 1 mark

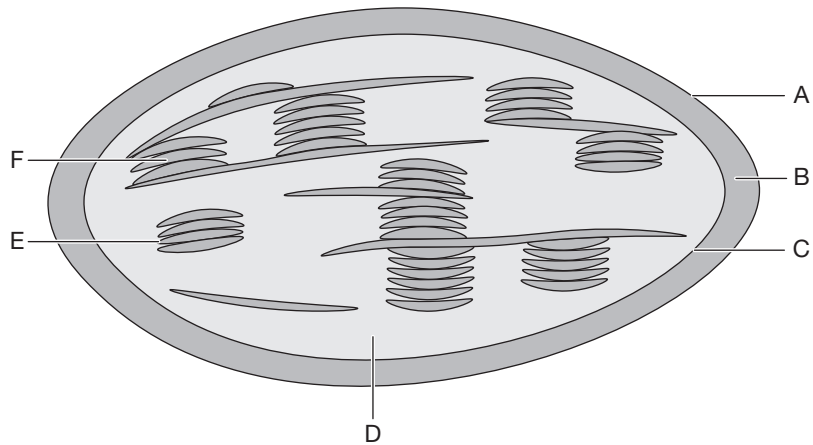
Question 4 (8 marks)

Chloroplasts can be isolated from photosynthetic cells and then further investigated to better understand the processes occurring within the organelle.

- a.** State **two** conditions that isolated chloroplasts would need to be exposed to for effective photosynthesis to occur.

2 marks

A diagram of a typical chloroplast is shown below. Labels A–F are structures or regions involved in the process of photosynthesis.



- b.** Give the correct label(s) (A–F) for the location where each of the following occurs.

- i.** the light-dependent reaction

1 mark

- ii.** Rubisco

1 mark

- iii.** formation of oxygen

1 mark

- iv.** electron transport proteins

1 mark

- c. Five samples of the isolated chloroplasts were prepared and exposed to conditions that were thought to increase the rate of photosynthesis. The results are shown in the table below.

Trial	Conditions	Photosynthetic rate (mL gas/min)
1	30°C, 250 ppm CO ₂ , 1000 lux of light, 3000 chloroplasts	140
2	40°C, 150 ppm CO ₂ , 1000 lux of light, 300 chloroplasts	30
3	30°C, 50 ppm CO ₂ , 2000 lux of light, 1500 chloroplasts	100
4	50°C, 350 ppm CO ₂ , 500 lux of light, 3000 chloroplasts	25
5	30°C, 250 ppm CO ₂ , 2000 lux of light, 3000 chloroplasts	260

Which of the five trials are comparable to each other? Justify your response.

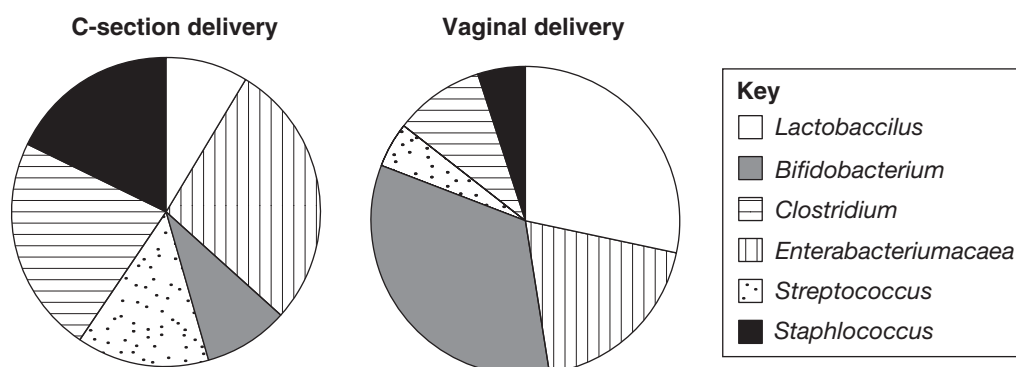
2 marks

Question 5 (6 marks)

Caesarean section (C-section) delivery is a surgical procedure that is performed when vaginal delivery is unsafe for either the mother or baby.

The World Health Organization's (WHO) recommended rate of C-section delivery is between 10% and 15% of births; however, the rate of C-section deliveries is increasing, especially in developed countries. This may lead to long-term consequences in the baby's gut microbiome.

The development of the gut microbiome in babies born vaginally is significantly different from babies born via C-section. During vaginal delivery, infants are exposed to a number of bacterial microbes through contact to vaginal, faecal and skin microbes that are not encountered by babies born via C-section. The most significant differences between the two delivery methods are found up to one year after the birth of the child. The following pie charts compare the gut microbiome of a baby delivered via C-section and a baby delivered vaginally after one year.



The functions of each microorganism in their optimal environment are listed in the table.

Microorganism	Function
<i>Bifidobacterium</i>	allows the digestion of fibre in the gut
<i>Lactobacillus</i>	produces lactic acid in the gut
<i>Staphylococcus</i>	provides good skin health
<i>Streptococcus</i>	a potential pathogen located on the skin and throat
<i>Clostridium</i>	helps with gut microbiome balance in the right amount, but can be pathogenic
<i>Enterabacteriumacaea</i>	helps with gut microbiome balance in the right amount

- a. Discuss the most significant difference between the gut microbiome of a baby delivered via C-section and a baby delivered vaginally after one year.

2 marks

- b.** State **two** ways in which a healthy gut microbiome can increase the general health of an individual.

2 marks

- c.** Identify the **two** most common microorganisms in the gut microbiome of a baby delivered vaginally and outline how these microorganisms could function in the environment to promote good gut health.

2 marks

1.

2.

Question 6 (9 marks)

Pfizer and AstraZeneca are two vaccines against the SARS-Cov-2 virus, which causes the COVID-19 disease. The Pfizer vaccine is an RNA vaccine that uses an alternative technique to activate an immune response; the AstraZeneca vaccine uses a more traditional technique. The techniques that each vaccine uses are outlined below.

- Pfizer works by introducing mRNA to a cell in the body, which expresses the spike protein from the virus on the cell surface.
- AstraZeneca works by binding a harmless virus in a viral vector to a target cell, which causes the host cell to synthesise a spike protein on its surface.

a. Describe the general structure of a virus. 1 mark

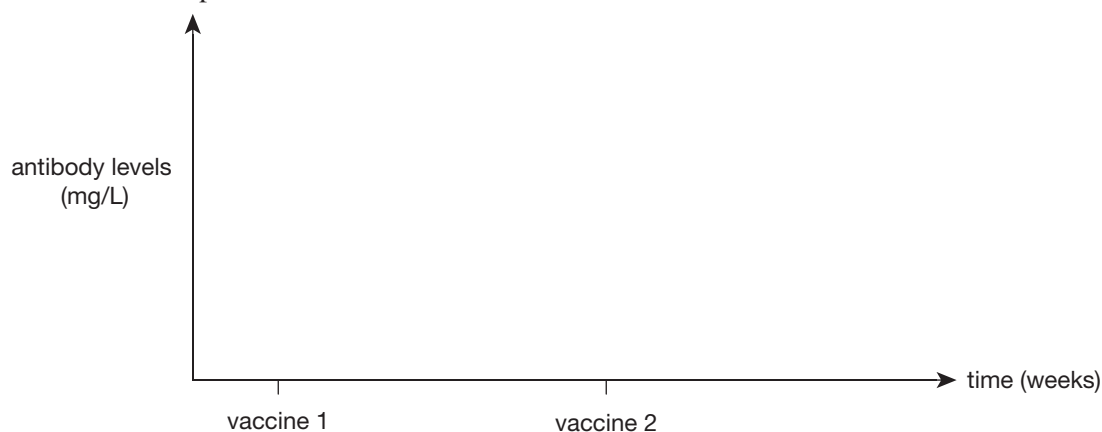
b. Identify and explain **one** factor that would need to be considered by a country that is choosing the most appropriate vaccine for its population. 2 marks

c. Outline the body's response to a vaccine once the spike protein has been recognised as non-self. 3 marks

d. For an optimal immune response, it is recommended to administer a secondary dose of the vaccine approximately six weeks after the first dose.

On the graph below, draw a single line to illustrate the change in antibody levels of an individual who has received a first and second dose of a vaccine against SARS-CoV-2 over a 10-week period.

3 marks



Question 7 (7 marks)

Prior to the emergence of the large range of finch phenotypes found in the Galápagos Islands, a small group of ancestral finches was most likely randomly blown to the area.

- a.** An island in the Galápagos contains a high proportion of seeds with hard shells.

Describe the events that would lead to a large, strong beak being the predominant phenotype in a population of finches on this particular island.

3 marks

- b.** The Galápagos finches and *Howea* palms are regarded as clear examples of speciation.

Identify and explain the speciation methods for both groups of organisms.

4 marks

Galápagos finches _____

Howea palms _____

Question 8 (9 marks)

In 2006, the sauropod dinosaur fossil *Australotitan cooperensis* was discovered protruding from the ground in Queensland and is the largest dinosaur species known to have existed in Australia. *Australotitan cooperensis* was an enormous dinosaur that was 25–30 meters in length, 5–6.5 meters in height and weighed the equivalent of nine African elephants. Absolute dating places *Australotitan cooperensis* at around 100 million years old, at which time Australia was still attached to Antarctica.

- a. Outline **two** conditions in which a fossil protruding from the ground could have originally been fossilised. 2 marks

- b. Given that uranium has a half-life of 700 million years, explain how the age of *Australotitan cooperensis* could be calculated using uranium–lead dating. 2 marks

The excavated hip and leg bones from *Australotitan cooperensis* were used to determine the type and size of the dinosaur. Three-dimensional digital scanning technology was used to make comparisons between the fossil and other sauropod dinosaurs found both in Australia and overseas, which led to the conclusion that the fossil discovered was a new species.

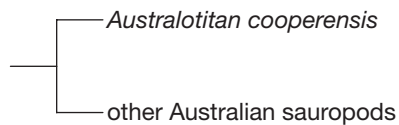
- c. Describe how each of the following pieces of evidence could be used to determine the size or species of the sauropod.

- i. hip and leg bones 1 mark

- ii. 3D-scanning technology 1 mark

Including *Australotitan cooperensis*, four known sauropod dinosaurs lived in Australia around 100 million years ago. These sauropod dinosaurs were more closely related to each other than to dinosaurs found elsewhere in the world. Additionally, the species of dinosaur found in Australia share more similarities with titanosaurians found in South America than with sauropods found in Asia.

- d. Complete the following phylogenetic tree by adding the titanosaurians found in South America and the sauropods found in Asia. 1 mark



- e. Sauropods would have been slow-moving dinosaurs without adaptations for swimming or flight.

How could 100-million-year-old sauropods be dispersed in areas of the world such as Australia, South America and Asia?

2 marks

Question 9 (7 marks)

Genetic analysis has uncovered a direct descendant of two separate hominin groups: ‘Denny’, a female hominin who died around 90 000 years ago and was half-Neanderthal and half-Denisovan. In 2014, Denny’s finger bone was discovered in Denisova Cave in Russia. This was the first time scientists were able to analyse a fossil whose parents belonged to two distinct human groups.

In 2008, other human bones were found in Denisova Cave, leading to the classification of the hominin species *Homo denisovan*. Denisova Cave was also an occasional home for Neanderthals and, although sexual encounters between Neanderthals and Denisovans may have been common in that region, both groups inhabited very different geographic areas. This may explain why the two hominin populations remained genetically distinct for hundreds of thousands of years before their encounters in Denisova Cave.

Analysis revealed the following information about Denny’s finger bone.

- Radiocarbon dating determined that the bone belonged to a hominin who lived more than 50 000 years ago.
- Mitochondrial DNA sequencing showed the mitochondrial DNA came from a Neanderthal.
- A study that compared Denny’s DNA with the DNA of three other hominins – a Neanderthal and a Denisovan found in Denisova Cave, and a modern-day human from Africa – showed that Denny’s DNA was 40% Denisovan and 40% Neanderthal.
- By sequencing the sex chromosomes, Denny was found to be female and around 13 years old.

The terms ‘Neanderthal’ and ‘Denisovan’ imply that the two groups are discrete species of human. However, the boundaries between them are less certain and may change the way species are defined in the natural world.

- a.** Using the information provided, explain how it is possible that Denny had parents from two different hominin species.

2 marks

- b.** Denny is dated to be 90 000 years old.

Explain why radiocarbon dating would only show she was 50 000 years old and suggest how she could be dated correctly.

2 marks

- c.** Using the information provided, suggest how it could be concluded that Denny's father was a Denisovan and her mother was a Neanderthal. 1 mark

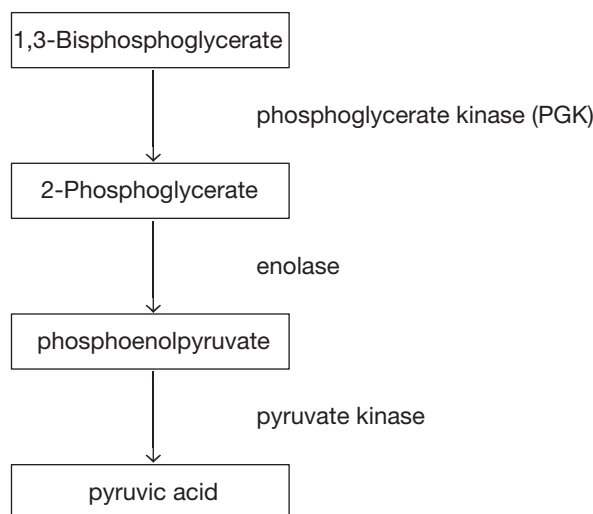
- d.** Using the information provided, justify each of the following statements.

- i.** Neanderthals and Denisovans should be regarded as discrete species. 1 mark

- ii.** Neanderthals and Denisovans should **not** be regarded as discrete species. 1 mark

Question 10 (10 marks)

Enzymes involved in glycolysis were isolated from the cytosol of a eukaryotic cell so that further analysis of the pathway could be conducted. The diagram below shows the enzymes, substrate, intermediate and final products of glycolysis.



A properly controlled experiment was set up to investigate the effect that changing the concentration of phosphoglycerate kinase (PGK) would have on the production rate of pyruvic acid. The change in pH over a five-minute period was used as a measure of the rate of reaction. The data gathered for the experiment is shown in the table.

Concentration of PGK (mmol)	Change in pH/min			
	Trial 1	Trial 2	Trial 3	Trial 4
0	0	0	0	0
2	0.5	0.8	0.7	0.2
4	1.4	1.3	1.4	1.2
6	2	2.1	4.4	1.9
8	2.1	2	1.9	2.3

- a. i.** List **four** factors that would need to be controlled for this experiment to be valid. 2 marks

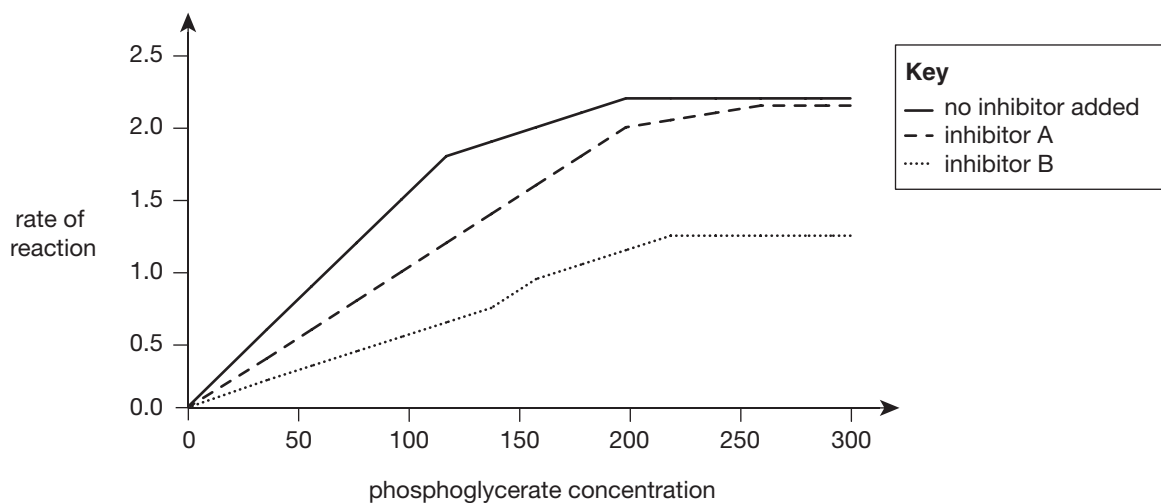
- ii.** Identify the independent variable for this experiment. 1 mark

- iii.** Identify the dependent variable for this experiment. 1 mark

- b. i.** Describe the purpose of the control in the experiment. 1 mark

- ii.** Excluding 0 mmol, which concentration of PGK produces the most precise set of results? Justify your answer. 2 marks

- c.** Another experiment was conducted involving the addition of chemicals (inhibitors A and B) that were thought to have an inhibitory effect on enolase. The results gained from the experiment are shown in the graph below.



- Compare the effects of inhibitors A and B on the biochemical pathway. 3 marks

END OF QUESTION AND ANSWER BOOKLET

Extra space for responses

Clearly number all responses in this space.

[illegible]

