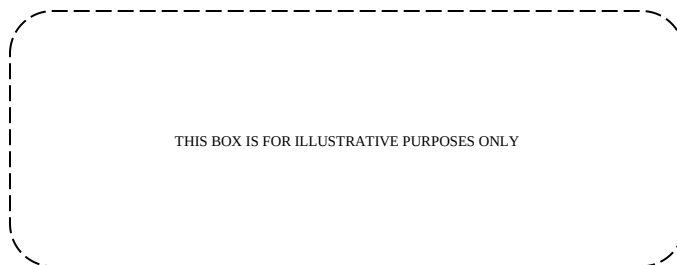




2024 Trial Examination



THIS BOX IS FOR ILLUSTRATIVE PURPOSES ONLY

STUDENT
NUMBER

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Letter

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BIOLOGY

Units 3 & 4 – Written examination

Reading time: 15 minutes

Writing time: 2 hours and 30 minutes

QUESTION & ANSWER BOOK

Structure of book

Section	Number of questions	Number of questions to be answered	Number of marks
A	40	40	40
B	9	9	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 white out liquid/tape.
- No calculator is permitted in this examination.

Materials supplied

- Question and answer book of 24 pages.

Instructions

- Print your name in the space provided on the top of this page.
- All written responses must be in English.

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

SECTION A: Multiple-choice questions

Instructions for Section A

Answer all 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 book are not drawn to scale.

Question 1

The bonds joining adjacent nucleotides in an RNA molecule are:

- A. hydrogen bonds
- B. phosphodiester bonds
- C. peptide bonds
- D. disulfide bridges

Question 2

In the trp operon, the regulatory gene:

- A. is part of the operon and is where the repressor protein binds
- B. is in the leader region and regulates attenuation
- C. produces a repressor protein that can bind to the operator region when active
- D. is the binding site of RNA polymerase, allowing transcription to occur

Question 3

Which of the following statements accurately describes short tandem repeats (STRs)?

- A. They are single nucleotide repeats found in the coding regions of genes.
- B. STRs are non-repetitive sequences of DNA commonly used in protein synthesis.
- C. Short tandem repeats are variations in the number of repeating units of 2 to 6 base pairs in DNA sequences.
- D. They are exclusively located in the mitochondrial DNA and are not present in the nuclear genome.

SECTION A continued

Question 4

Enzymes are:

- A. organic proteins that, when expressed, form part of the proteome
- B. inorganic molecules that donate protons and electrons
- C. molecules that carry the genetic code from the nucleus to the ribosome
- D. specialised vesicles that move proteins from the Golgi to the rough endoplasmic reticulum

Question 5

When creating a recombinant plasmid of insulin:

- A. the insulin A and B chains are purified, then inserted into separate plasmids in separate bacteria
- B. Exons are removed from the insulin A and B chains before being inserted into the CRISPR genome of the bacterium
- C. the insulin A and B genes are inserted next to the gene for β -galactosidase in separate plasmids
- D. the insulin A and B genes are inserted with the β -galactosidase within the same plasmid, changing colour in the presence of a particular chemical

Question 6

The role of DNA ligase is to:

- A. restore hydrogen bonds following cleaving by endonucleases
- B. cleave DNA creating sticky or blunt ends
- C. separate DNA fragments based on size and charge
- D. restore phosphodiester bonds following cleaving by endonucleases

Question 7

When loading wells to run gel electrophoresis, a student accidentally loaded 15 μ L rather than 10 μ L. The DNA mixture contained only one DNA sequence that was amplified. When they compared their results to other groups in the class, they would be expected to observe:

- A. smaller bands at the same position
- B. larger bands at the same position
- C. smaller bands closer to the well
- D. larger bands closer to the well

SECTION A - continued
TURN OVER

Question 8

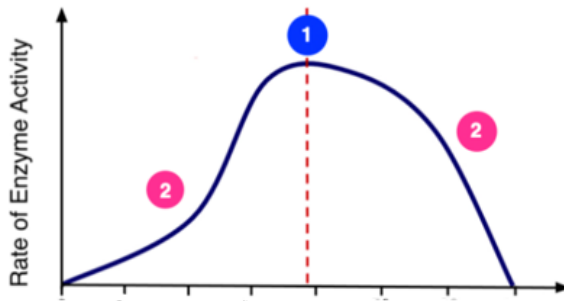
In the presence of a competitive inhibitor:

- A. increasing the amount of substrate will have no effect
- B. increasing the amount of substrate will increase the rate of reaction
- C. the competitive inhibitor can be outcompeted by a non-competitive inhibitor
- D. the active site changes shape

The following graph relates to questions 9 and 10

Question 9

The graph shows the relationship between enzyme activity and:



- A. temperature
- B. pH
- C. substrate concentration
- D. enzyme concentration

Question 10

What does number 1 represent?

- A. The lowest rate of enzyme activity
- B. The point at which an inhibitor is added to the solution
- C. The optimum point of the reaction

The point at which the reaction has the lowest rate of kinetic energy

SECTION A continued

Question 11

Photosynthesis occurs in two stages, the light dependent stage and the light independent stage. During the light dependent stage,

- A. ATP is produced that is used in the stoma to allow glucose to be produced
- B. NAD becomes loaded to become NADH
- C. Water is split into H^+ and carbon
- D. PEP carboxylase catalyses the conversion of $NADP^+$ to NADPH

Question 12

When comparing C4 and CAM plants:

- A. both C4 and CAM plants are adapted to arid conditions
- B. both C4 and CAM plants revert to the C3 pathway when water is abundant
- C. both C3 and CAM plants separate initial carbon fixation by time
- D. both C3 and CAM plants use PEP carboxylase for initial carbon fixation

Question 13

The electron transport chain requires:

- A. a hydrogen gradient to be created to allow ATP synthase to spin
- B. oxygen to act as a hydrogen acceptor
- C. NADH and $FADH_2$ to become unloaded
- D. all the above

Question 14

Muscle cells were deprived of oxygen and the rate of ATP production was recorded. It was found that ATP was produced quickly, albeit in low amounts. In addition to ATP, what other molecule(s) would be produced?

- A. water
- B. ethanol and carbon dioxide
- C. lactic acid
- D. glucose

SECTION A- continued
TURN OVER

Question 15

What is the net output of ATP molecules produced during glycolysis in a plant cell?

- A. 2
- B. 4
- C. 26
- D. 30

Question 16

A company was investigating if using organic biomass to produce bioethanol would be a viable alternative to traditional fossil fuels. It was found that the technology may not be available to all. As such, they may be breaching the ethical concept of:

- A. respect
- B. justice
- C. non-maleficence
- D. beneficence

Question 17

The production of bioethanol requires enzymatic hydrolysis. The purpose of this is to:

- A. mechanically increase the surface area to make the reaction more efficient
- B. break down polymers of sugars into monomers
- C. remove any unwanted molecules
- D. provide an anaerobic environment

Question 18

An innate physical barrier present in some plants is a thick, waxy cuticle. The benefit of this waxy cuticle is to:

- A. prevent water from pooling, minimising fungal growth
- B. aid with the closing of stomata
- C. release chemical mediators that break down bacterial cell walls
- D. provide an additional layer of protection from harmful UV rays that may cause spontaneous mutations in the plant's genome

SECTION A continued

Question 19

A student pierced their skin with an unsterile needle. They didn't see any blood, so they chose not to go to see the school nurse.

After about 30 minutes, they noticed that the area where the needle pierced the skin was red and swollen. This is due to:

- A. mast cells releasing interferon
- B. vasodilation and leaky capillaries
- C. clonal expansion
- D. cytotoxic T cells releasing granzyme and perforin

Question 20

When a macrophage detects a foreign pathogen, they engulf and destroy it. The antigens of the pathogen are then:

- A. presented to B cells on MHC-I markers in the thymus
- B. destroyed by natural killer cells
- C. presented to T helper cells on MHC-II markers in the lymph nodes
- D. activated by interferon to undergo clonal expansion

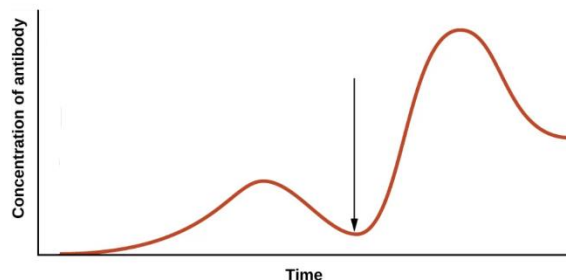
Question 21

MHC-I markers are found on all:

- A. denuded cells and antigen presenting cells
- B. immune cells
- C. nucleated cells
- D. mature red blood cells

Question 22

The graph below shows the concentration of antibodies in the body at varying times. The arrow on the graph is where:



- A. primary exposure to a pathogen has occurred
- B. secondary exposure to a pathogen has occurred
- C. memory cells are depleted
- D. herd immunity has been reached

SECTION A- continued
TURN OVER

Question 23

After being bitten by a funnel web spider during a holiday in Sydney, a student was rushed to emergency and given an anti-venom injection. The immunity that the student received was:



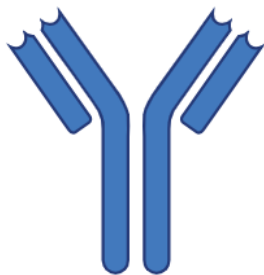
- A. artificial active
- B. artificial passive
- C. natural active
- D. natural passive

Question 24

A social strategy to limit the spread of a novel and highly contagious respiratory disease would be to:

- A. create a vaccine
- B. reach herd immunity in the population
- C. implement a vaccination program in schools
- D. undertake antigenic testing of sewerage

The following diagram relates to Questions 25 and 26



Question 25

Antibodies are released by plasma cells and help to protect the body from extracellular pathogens. The level of protein structure for an antibody is:

- A. primary
- B. secondary
- C. tertiary
- D. quaternary

SECTION A- continued

Question 26

A cell observed in the lymph nodes had numerous antibodies bound to the surface. What type of cell would this most likely be?

- A. plasma B cell
- B. cytotoxic T cell
- C. natural killer cell
- D. memory B cell

Question 27

A potential consequence of using mice to create monoclonal antibodies for use in humans is that:

- A. humans will identify the antibodies as non-self and mount an immune response against them
- B. they could mutate and cause an adverse effect on the body
- C. they target both healthy and deviant cells
- D. they are ineffective at targeting deviant cells

Question 28

A snow leopard from a mountain population migrated to a new population and successfully interbred. An advantage of this action is that:

- A. gene flow occurred, increasing genetic diversity
- B. the migrating snow leopard found a new population
- C. a population bottleneck is now unlikely to occur
- D. selective breeding will no longer be required

Question 29

A small group of snow leopards, genetically unrepresentative of the parental population, left and colonized a new area. After many generations, the two populations were brought back together, and it was found that they were still able to interbreed and produce viable and fertile offspring. It is likely that:

- A. gene flow between the two groups was not occurring
- B. both groups were subject to similar selection pressures
- C. mutations that occurred in each group were selected for
- D. all the above

Question 30

Index fossils are useful for:

- A. absolute dating
- B. relative dating
- C. transitional fossils
- D. showing evidence of relatedness between species

SECTION A- continued
TURN OVER

Question 31

Pugs are an example of a pedigree dog species that show characteristics of breed standard, or what is expected of a pure-bred dog. Many people purchase pugs due to them being aesthetically pleasing.

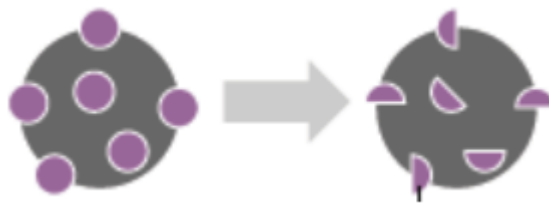


The selection pressure acting on purebred pugs is:

- A. the economy
- B. the environment
- C. humans
- D. food availability

Question 32

Minor changes to the surface antigens on a pathogen pose challenges for treatment, as existing vaccines and memory cells are no longer complementary.



This is an example of:

- A. antigenic selection
- B. allopatric speciation
- C. antigenic shift
- D. antigenic drift

SECTION A- continued

Question 33

A single nucleotide was substituted in a sequence of DNA, and the resultant codon was for a different amino acid.

This type of mutation is:

- A. silent
- B. nonsense
- C. missense
- D. frameshift

Question 34

It is widely accepted that hominins originated in Africa, before migrating to other regions of the world. Two species that migrated and interbred were the *Homo neanderthals* and the *Homo sapiens*.

Interbreeding between these two groups primarily occurred in:

- A. Africa
- B. North America
- C. Australia
- D. Europe

Question 35

When using molecular homology to compare relatedness between species, both amino acid and DNA sequences can be compared. A limitation when comparing amino acid sequences is that:

- A. silent mutations are not detected
- B. a longer sequence of DNA is required
- C. unlike DNA, amino acids are not universal
- D. amino acids are only found in eukaryotes

Question 36

When comparing mammals and primates, it can be observed that

- A. mammals are cold blooded, whereas primates are warm blooded
- B. mammals are covered in fur, whereas primates are covered in skin
- C. primates have a precision grip whereas mammals do not
- D. both primates and mammals have fully rotating shoulder joints

SECTION A- continued
TURN OVER

Question 37

While completing an experiment for Outcome 3, a student ran out of time and could only conduct one trial. When they submitted their paper, they described their data as both precise and accurate. This is incorrect as:

- A. multiple trials are needed to determine accuracy
- B. multiple trials are needed to determine precision
- C. school experiments are never precise
- D. school experiments are never accurate

Question 38

Two groups of students used the same method to conduct an experiment at school, and they decided to share their data to allow them to draw more valid conclusions. They found that for the most part, the results were similar. As such their method was:

- A. accurate
- B. repeatable
- C. reproducible
- D. respectful

Question 39

While completing an experiment for Outcome 3, a group decided to use changes in pH as a measure of carbon dioxide production. They set up multiple test tubes and measured the initial and final pH, recording their data in a table for subsequent analysis.

They found that there was significant variation in their data. Upon further investigation, it was discovered that they had used multiple pH meters when taking the data. This is an example of a:

- A. systematic error
- B. random error
- C. personal error
- D. outlier

Question 40

What can reduce the effect of outliers?

- A. Repetition
- B. Using uncalibrated equipment
- C. Comparing to data from previous experiments
- D. Maintaining a proper logbook

END OF SECTION A

SECTION B - Short-answer questions

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 (7 marks)

Ribosomes are found within all living things as proteins are essential to sustain life. Prokaryotes have operons, whereas eukaryotes do not.

a. What is an operon?

1 mark

b. The rate of protein synthesis is faster in prokaryotes than in eukaryotes. Propose 2 reasons for this.

2 marks

c. In the space below, draw a simple diagram that demonstrates repression in the trp operon.

4 marks

SECTION B - Question 1- continued

TURN OVER

Question 2 (11 marks)

Insulin is required by type 1 diabetics to regulate their blood glucose levels. With over 100,000 people diagnosed with type 1 diabetes in Australia, a constant supply of insulin is required.

In the past, pigs were often used as a source of insulin due to our close evolutionary relationship.

a. State and justify an ethical principle that may be breached when using pigs as an insulin source.

2 marks

b. Scientists now use recombinant plasmids to produce insulin. State two benefits that this provides.

2 marks

c. Name 2 enzymes used in the creation of a recombinant plasmid of insulin and state their role.

4 marks

SECTION B – continued

d. β -galactosidase (B-Gal) is referred to as a reporter gene. How does B-Gal help to detect the successful insertion of the insulin gene?

3 marks

Question 3 (13 marks)

Sugar cane is one of Australia's major crops, primarily grown in tropical north Queensland. Sugar cane is a species of grass, with the sucrose stored in the fibrous stalks. Sugar cane has adaptations to minimise photorespiration from occurring.

a. What type of plant (C3, C4 or CAM) would sugar cane most likely be? Justify your response.

3 marks

b. Sucrose in the sugarcane is extracted and refined for consumers, with much of the fibrous stalks used as a source of biomass to produce ethanol.

Outline the 4 steps required to produce bioethanol.

4 marks

SECTION B - Question 3- continued
TURN OVER

c. A sugarcane farmer requested a tax exemption as they were reducing atmospheric carbon dioxide through supplying biomass for bioethanol production. Is there request reasonable? Explain.

3 marks

d. Describe an ethical issue that should be considered when using biomass to produce bioethanol.

3 marks

Question 4 (8 marks)

While kicking a football at lunchtime, a group of students accidentally broke a window of a nearby classroom. To avoid getting in trouble, they quickly tried to clean up the broken glass from the area. One student looked down and noticed that they had cut their hand.

a. Which line of defence has been breached?

1 mark

b. The student noticed that their hand had begun to swell, and they went to see the school nurse. What chemical has caused the swelling and what cell is it released from?

2 marks

SECTION B - Question 4 - continued

c. A few days after they had cut their hand, the student noticed that their lymph nodes were swollen. Explain how this has occurred.

5 marks

Question 5 (10 marks)

One of the biggest impacts on the Aboriginal population in the City of Yarra area was the introduction of diseases previously unknown to the Wurundjeri. It has been estimated that disease accounted for up to sixty percent of the Aboriginal deaths across the Port Phillip area.

Even before Europeans began arriving in the Melbourne area, up to a third of the population of the eastern Australian tribes had been killed by an epidemic of smallpox that spread down from Sydney. Tuberculosis was one such disease that infiltrated the Melbourne Aboriginal population, causing many Aboriginal and European people to die.

a. Tuberculosis (TB) is caused by a type of bacterium called *Mycobacterium tuberculosis*. It is spread when a person with an active TB infection in their lung's coughs or sneezes and someone else inhales the expelled droplets, which contain TB bacteria. Describe 3 ways that a person could minimise their chance of contracting TB.

3 marks

SECTION B – Question 5 continued
TURN OVER

b. In 2022, the World Health Organisation recorded 10.6 million cases of TB worldwide. In Australia, there is an average of 1300 cases per year.

Explain how a highly contagious disease such as TB, that is prevalent throughout the world, is quite rare in Australia.

2 marks

c. State three ways that the body's response to TB would differ when compared to the response to a pathogen such as COVID.

3 marks

d. Plants can also be affected by bacterial infections. State 2 ways that plants can defend themselves from an infection.

2 marks

SECTION B – continued

Question 6 (8 marks)

Antibodies, also known as immunoglobulins (Ig), are produced by the immune system in response to the presence of antigens. Antibodies are a crucial component of the adaptive immune system, providing a highly specific and targeted response to a wide variety of antigens.

a. Antibodies are produced by plasma B cells following clonal expansion of naive B-cells. Outline the process by which antibodies are produced in the plasma B cells and how they released to fight pathogens.

5 marks

b. Describe how can each antibody have a different antigen binding site?

2 marks

c. Why are antibodies classified as having a quaternary level of protein structure?

1 mark

SECTION B continued
TURN OVER

Question 7 (6 marks)

The apple maggot fly and hawthorn maggot fly share recent common ancestry and are part of the *Tephritidae* family of flies.

Historically, hawthorn maggot flies laid their eggs on hawthorn fruits. However, some populations of these flies have shifted to a new host—apple trees.

The shift to apple trees likely occurred as a result of European settlers planting apple trees in North America, providing a new and suitable habitat for the flies.

a. What type of speciation has occurred?

1 mark

b. Describe the sequence of events that led to speciation.

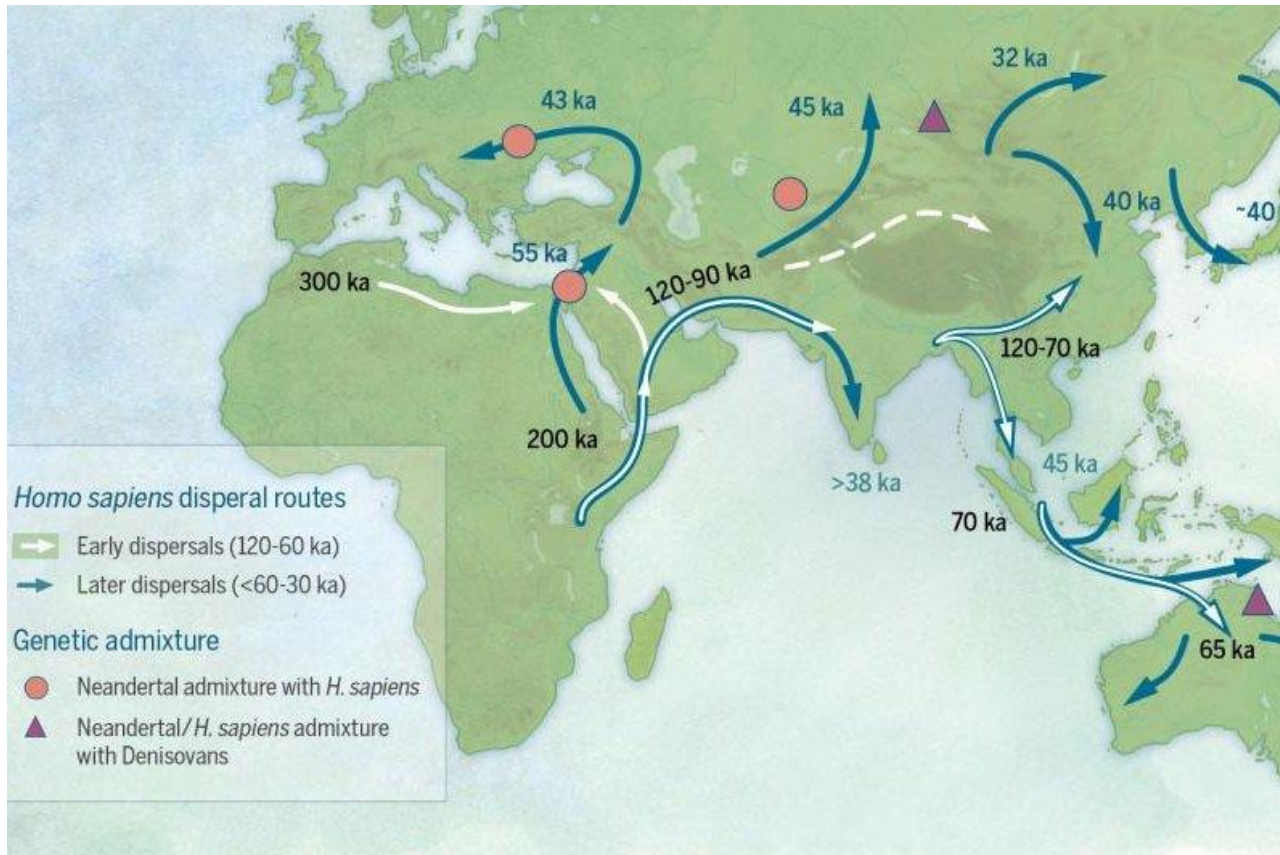
5 marks

SECTION B continued

Question 8 (9 marks)

Early *Homo* species arose in Africa, with *Homo sapiens* migrating to eventually inhabit most regions of the Earth.

It is now thought that rather than one large scale migration Out of Africa, an early and a later migration occurred, as shown below.



https://www.upi.com/Science_News/2017/12/08/Scientists-revamp-Out-of-Africa-model-of-early-human-migration/7031512739851/

a. Explain how molecular evidence could support the multiple migration hypothesis shown above?

3 marks

SECTION B continued

TURN OVER

b. Would you expect Indigenous Australian's to have Neanderthal DNA in their genomes? Justify your response.

3 marks

c. What characteristic of the modern *Homo sapiens* leg structure facilitated the migration from Africa to Australia?

2 marks

d. Phylogenetic trees that show the evolutionary relationships between different *Homo* groups are constantly changing and evolving. Why is there not more fossil evidence available?

1 mark

SECTION B continued

Question 9 (8 marks)

An experiment was conducted to investigate the rate of an enzyme driven reaction. Three conical flasks had 25mL of hydrogen peroxide solution added. A small piece of liver was added to the first flask, a small piece of potato to the second flask, and a small piece of celery to the third flask.

In the presence of catalase, hydrogen peroxide is converted to water and oxygen.

A glowing splint was placed in the neck of each flask and the time taken before each glowing splint is relit by the produced oxygen was measured.

a. What is the independent variable in this investigation?

1 mark

b. State 2 factors that should be controlled in this experiment

2 marks

c. The experiment does not have a control group. What is the purpose of a control group, and what should the control consist of for this experiment?

2 marks

SECTION B – Question 9 continued
TURN OVER

d. A student wanted to extend their investigation. Outline how the student could conduct the future experiment and the detail the results that they would expect. one extension, how this would be done and what results you would expect to obtain.

3 marks

END OF QUESTION AND ANSWER BOOK