Victorian Certificate of Education
2023

Name: _____

Teacher's name: _____

STUDENT NUMBER | | | | | | | | | Letter | |

BIOLOGY

Unit 3 Written examination

2023
Reading time: 15 minutes
Writing time: 1 hour 30 minutes

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	25	25	25
B	5	5	50
			Total 75

- 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 book.
- Answer sheet for multiple-choice questions.
- Additional space is available at the end of the book if you need extra space to complete an answer.

Instructions
- Write your student number in the space provided above on this page.
- Check that your name and student number on your answer sheet for multiple-choice questions are correct.
- 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 book.

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 book are **not** drawn to scale.

Question 1

Gel electrophoresis is a process used to isolate particular segments of DNA. Electrophoresis works on the premise that

A. DNA is positively charged.
B. longer fragments of DNA move faster through the electrophoresis gel.
C. DNA is negatively charged.
D. strands of DNA can be separated by heating the DNA.

Question 2

Protein synthesis describes the process by which the information encoded in a gene is used to produce a protein.

The following options describe various steps/processes that occur in eukaryotic cells during protein synthesis followed by protein export from a cell; however, only one option describes the processes correctly and in the correct order. Which option is correct?

A. DNA polymerase moves along the template strand, creating a molecule with a complementary RNA sequence; post-transcriptional modification occurs; the mRNA molecule attaches to a ribosome
B. all exons are removed from the pre-mRNA molecule during post-transcriptional modification; mRNA codons align with their complementary tRNA anticodons at the ribosomes; enzymes fold the protein into its tertiary structure
C. the protein is packaged into a vesicle; a condensation polymerisation reaction joins amino acids together to form a peptide chain; the protein is exported from the cell through exocytosis
D. a pre-mRNA molecule is produced through transcription; introns are spliced out during post-transcriptional modification; the protein-containing vesicle fuses with the cell membrane during export from the cell

Question 3

A particular endonuclease has the following recognition site:

5′. . . G|AATTC . . . 3′
3′. . . CTTAA|G . . . 5′

This endonuclease is mixed with the following section of DNA.

5′ TTGGCCAGTAAATTCCATAGAGAATTCATAGTGTGATCCTATGACGAATTCAGATCGTTAGGGACCCATATCCCG 3′

The resultant DNA is amplified and run through an electrophoresis tank. Assuming that the DNA strand is cut by the endonuclease, which of the following would be observed in the electrophoresis output?

A. two bands of DNA, with one located close to the positive terminal and the other located close to the negative terminal
B. three bands of DNA, located quite close to each other
C. one single band of DNA
D. four bands of DNA spread evenly throughout the gel

Question 4

DNA and RNA both play critical roles in the function of cells and the production of proteins. Which option below correctly describes the structures of DNA and RNA?

A. RNA contains uracil while DNA does not and DNA contains ribose while RNA does not
B. the sugar in RNA contains one fewer oxygen atoms than the sugar in DNA
C. DNA contains thymine while RNA does not and the sugar contained in DNA contains one fewer oxygen atoms than the sugar in RNA
D. in RNA, uracil and thymine form base-pairs, while, in DNA, thymine and adenine form base-pairs

Question 5

The HBB gene contains the instructions to make the protein beta-globin, which is composed of a single polypeptide chain. Beta-globin is a subunit of the protein haemoglobin, which is essential to the transport of oxygen around the body. What can be concluded regarding these proteins?

A. beta-globin has a quaternary structure
B. a mutation in the HBB gene would have little effect on the capacity of cells to aerobically respire
C. the sequence of bases that is translated at the ribosomes is shorter than the sequence of bases in the HBB gene
D. haemoglobin does not have a quaternary structure

Question 6

Photosynthesis involves a number of complex biochemical reactions. These are broadly divided into light-dependent and light-independent reactions. Which of the following is a light-dependent reaction?

A. the energy of sunlight splits water molecules into oxygen and hydrogen in the stroma
B. NADPH coenzymes are unloaded to provide energy for the synthesis of glucose
C. oxygen gas is produced in the grana and released through the stomata of the leaf
D. NAD+ molecules are loaded

Question 7

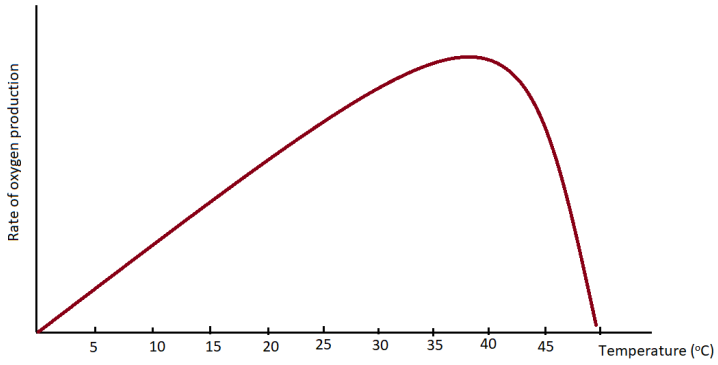
During heavy exercise, human muscle cells may switch to anaerobic respiration due to a lack of oxygen supply. For muscle cells undergoing anaerobic respiration

A. the majority of ATP is produced in the electron transport chain.
B. two net molecules of ATP are produced per molecule of glucose.
C. the process of anaerobic respiration produces more molecules of ATP per molecule of glucose, compared to aerobic respiration.
D. the process of anaerobic respiration is less complex than aerobic respiration.

Question 8

A student sets up an experiment to investigate the effect of temperature on the rate of photosynthesis in a particular plant. The rate of photosynthesis was measured through the rate of oxygen production.

The results obtained by the student showed the following trend:



Which statement best explains the shape of this graph?

A. at approximately 40°C, the active sites of the enzymes controlling the photosynthesis reactions became altered
B. at approximately 40°C, the active sites of the enzymes controlling photosynthesis reactions became saturated
C. enzyme activity slowed down as temperature increased, reaching a minimum at approximately 40°C
D. at approximately 40°C, the enzymes controlling the photosynthesis reactions underwent reversible inhibition

Question 9

The production of biofuels from biomass is a growing area of research and interest given the issues associated with the use of non-renewable fuels. One possible form of biofuel is bioethanol.
Bioethanol is formed through which of the following processes?

A. the anaerobic fermentation of plant sugars
B. the aerobic fermentation of plant sugars
C. the conversion of carbon dioxide into glucose
D. the combustion of crude oils

DO NOT WRITE IN THIS AREA

Question 10

In some prokaryotes, such as *E. coli*, there are two mechanisms that regulate the expression of the structural genes of the *trp* operon: repression and attenuation. In repression

A. the repressor protein binds to the promoter region.
B. the initiation of transcription is blocked.
C. translation begins but stops prematurely.
D. RNA polymerase binds to the operator.

Question 11

Polymerase chain reaction (PCR) is a process that is used to amplify DNA. Which of the following options accurately describes some of the steps of the PCR process in the correct order?

A. DNA is heated to 95°C to separate the two strands; RNA polymerase extends each complementary strand of DNA
B. DNA is heated to 95°C to separate the two strands; the mixture is cooled to 55°C and primers are added
C. DNA is heated to 72°C to separate the two strands; DNA polymerase extends each complementary strand of DNA
D. DNA is heated to 72°C to separate the two strands; the mixture is cooled to 55°C and primers are added

Use the following information to answer Questions 12 – 14.

Two students, Caitlin and Asher, are investigating the effect of light colour on the relative rates of photosynthesis and respiration in *Elodea*, an aquatic plant. Six samples of *Elodea* are divided between six test tubes. The test tubes are filled with water and are stoppered. Three test tubes are wrapped in red cellophane and three are wrapped in green cellophane. The six samples are then left on a windowsill for 24 hours.

A product of aerobic respiration is carbon dioxide; carbon dioxide dissolves in water to form carbonic acid, creating acidic conditions. Conversely, oxygen produced from photosynthesis dissolves in water to form hydroxide (OH^-) ions, creating alkaline conditions.

After 24 hours, Caitlin and Asher measure the pH of the water in each of the test tubes. They produce the following results:

Test Tube #	Cellophane Colour	pH After 24 hours
1	Red	7.4
2	Red	7.1
3	Red	7.3
4	Green	6.2
5	Green	5.8
6	Green	6.9

Question 12

Identify the independent variable in this experiment.

A. the colour of light to which the *Elodea* samples were exposed
B. the temperature at which the test tubes were kept
C. the final pH of the water
D. the rate of photosynthesis of the samples

Question 13

What can be inferred from the results regarding the effect of light colour on rates of photosynthesis in *Elodea*?

A. *Elodea* is more efficient at utilising green light for photosynthesis than red light
B. high rates of respiration relative to photosynthesis result in more acidic water
C. samples of *Elodea* that are exposed to red light will photosynthesise at higher rates than those exposed to white light
D. an *Elodea* plant that is only exposed to green light will experience higher rates of respiration relative to photosynthesis than an *Elodea* plant that is only exposed to red light

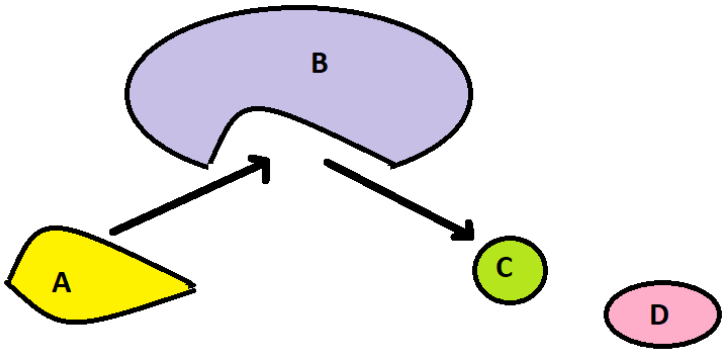
Question 14

Caitlin discovers that the pH meter was incorrectly calibrated, resulting in pH readings that were consistently 0.2 points higher than the actual pH of the water. This type of error is best described as a

A. random error, reducing both accuracy and precision.
B. random error, reducing accuracy only.
C. systematic error, reducing both accuracy and precision.
D. systematic error, reducing accuracy only.

Question 15

Catalase is an enzyme in the liver that converts hydrogen peroxide into oxygen and water. The image below depicts this process:



Which of the following statements is true for this process?

A. molecule B is hydrogen peroxide
B. molecule D is the substrate
C. molecule A binds to the allosteric site of molecule B
D. this enzyme-catalysed reaction would not proceed at a temperature of 95°C

Question 16

CRISPR is a sequence in bacteria that has been used to produce a gene-editing technology that offers a lot of potential for genetic engineering. The CRISPR-Cas9 complex is found naturally in some bacteria and evolved as a defence against bacteriophages (viruses that infect bacteria). What is the purpose of the PAM sequence in CRISPR?

A. to indicate to the Cas9 enzyme where the cutting point is
B. to recognise the DNA sequence of interest and direct the Cas9 enzyme there
C. to cut the DNA at a specific recognition sequence
D. to make a complementary copy of the viral DNA

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Use the following information to answer Questions 17 – 19.

Collagen is a protein that provides strength and support to several of our body tissues, such as cartilage, bones, tendons and skin.

Type I collagen is a protein composed of two pro-α1 chains and one pro-α2 chain which are encoded by the COL1A1 and COL1A2 genes respectively.

Source: https://medlineplus.gov/genetics/gene/col1a1/

Question 17

Type I collagen would best be described as

A. a structural protein with a tertiary structure.
B. a regulatory protein with a tertiary structure.
C. a structural protein with a quaternary structure.
D. a regulatory protein with a quaternary structure.

Question 18

How would the DNA template strand of the COL1A1 gene compare to the corresponding mRNA strand that is used to translate the genetic instructions into a pro-α1 polypeptide at the ribosomes?

A. the mRNA strand would contain the same number of nucleotides as the template strand but would be complementary and would contain uracil rather than thymine
B. the mRNA strand would be shorter than the template strand and would contain thymine rather than uracil
C. the mRNA strand would be shorter than the template strand and would have a guanine cap at the 5' end
D. the mRNA strand would be shorter than the template strand and would have a guanine cap at the 3' end

Question 19

Following the synthesis of the pro-α1 and one pro-α2 chains, what else occurs before the type I collagen protein is secreted from the cell?

A. the protein chains are folded into their required 3D shape and are exported to the ribosomes before being packaged into a vesicle and exported from the cell via exocytosis
B. the protein chains are folded into their 3D shape and are transported to the Golgi apparatus before being packaged into a vesicle and exported from the cell via exocytosis
C. the protein chains are folded into their 3D shape and are transported to the Golgi apparatus before being packaged into a vesicle and exported from the cell via endocytosis
D. the protein chains are folded into their 3D shape and are transported to the smooth endoplasmic reticulum before being packaged into a vesicle and exported from the cell via exocytosis

Question 20

Mayah is attempting to grow broad beans. She wishes to optimise the rate of photosynthesis in her seedlings. Mayah understands that carbon dioxide is a key input to photosynthesis, so she sets up the seedlings in a tank with a carbon dioxide concentration that is higher than atmospheric levels. However, while increasing carbon dioxide concentration increases the rate of photosynthesis initially, as she further increases carbon dioxide concentrations, the rate of photosynthesis plateaus. Which of the following is *not* a possible explanation for the plateau?

A. the active sites of the enzymes that catalyse the reactions that synthesise glucose in the light-dependent reactions are all occupied

B. although there is excess carbon dioxide available for glucose synthesis, the rate of NADPH supply from the light-dependent reactions limits the rate of photosynthesis

C. the rates at which the light-independent reactions can proceed are limited by the concentration of enzymes in the stroma

D. the light intensity, and thus the amount of light energy available, cannot produce enough H+ ions in the light-dependent reactions to continue to increase the rate of photosynthesis

Use the following information to answer Questions 21 and 22.

Recombinant plasmids are used to transform bacteria with the purpose of producing large quantities of certain genes, such as the human insulin gene.

Insulin consists of two polypeptide chains that are referred to as the alpha and beta subunits. Therefore, to produce insulin, two different recombinant plasmids are required: one producing the alpha subunit and one producing the beta subunit.

A suitable plasmid is mixed with two restriction enzymes, EcoR1 and BAMHI, and the subunit A gene. The subunit A gene is flanked by recognition sites for one of these restriction enzymes. This plasmid contains two antibiotic resistant genes: the amp^R gene, which encodes for antibiotic resistance to ampicillin, and the tet^R gene, which encodes for antibiotic resistance to tetracycline. The tet^R gene has a recognition site for one of the restriction enzymes inside it, while the amp^R gene does not.

Question 21

When the plasmids are mixed with the restriction enzymes and subunit A gene, some plasmids will incorporate the subunit A gene. What else must be added to the mixture to join the fragments of DNA together?

A. free nucleotides

B. DNA ligase

C. DNA polymerase

D. RNA polymerase

Question 22

The plasmids are then mixed with bacteria, which are stimulated to take up the plasmids; however, not all of the bacterial cells will take up plasmids and, of those that do, not all of the plasmids will be recombinant plasmids. The bacteria that successfully take up the recombinant plasmids only will be resistant to

A. both ampicillin and tetracycline.

B. neither ampicillin nor tetracycline.

C. ampicillin but not to tetracycline.

D. tetracycline but not to ampicillin.

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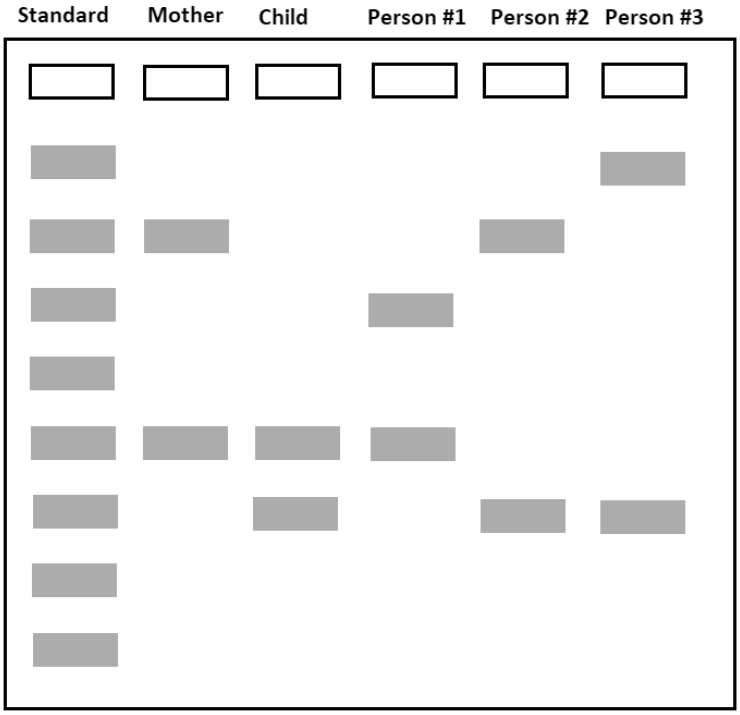
Question 23

In a paternity case, short tandem repeats (STRs) were used to identify the father of a child. A particular STR site was compared between the child, the mother, and three potential fathers. The following electrophoresis output was produced.



Which of the following conclusions can be made from this information?

A. none of the three people tested could possibly be the father
B. only person #2 could be the father
C. all three people tested could potentially be the father
D. persons #2 or #3 could be the father

Question 24

Polymerase chain reaction (PCR) is a method used to amplify DNA. If a gene of interest undergoes four cycles of PCR, how many pieces of DNA will exist after these cycles?

A. 4
B. 8
C. 16
D. 32

Question 25

Plants can be categorised as C3, C4 or CAM plants based on differences in how they capture and store carbon for photosynthesis. Which statement correctly compares C3, C4 and CAM plants?

A. the stages of photosynthesis are identical between all three types of plants, but the role of rubisco varies
B. all three types of plants use the same amount of energy in photosynthesis
C. the light-dependent stage is the same for all three types of plants, but the light-independent stage differs
D. CAM plants use the least amount of energy in photosynthesis

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 (13 marks)

A pair of biology students set up an experiment to investigate the effect of temperature on the rates of photosynthesis in spinach leaves. Twelve beakers of four different temperatures (three beakers per temperature) were prepared, each containing 30 spinach leaf discs in bicarbonate solution, with the air removed. The solution in each beaker was kept at a constant temperature. After 10 minutes, the number of floating leaf discs was recorded. Three beakers were prepared for each of the following temperatures:

Temperature 1: 10°C
Temperature 2: 20°C
Temperature 3: 30°C
Temperature 4: 40°C

White light was shone on each beaker, using 12 identical lamps of the same light intensity. The relative rates of photosynthesis in the spinach leaves were determined by counting the number of floating leaf discs after 10 minutes. Assume that the floating discs are *not* floating due to the production of carbon dioxide gas. The following results were obtained:

Temperature	**Number of Floating Discs After 10 Minutes**			
	Beaker 1	**Beaker 2**	**Beaker 3**	**Average**
10°C	14	14	15	14.3
20°C	25	29	24	26.0
30°C	18	15	20	17.7
40°C	4	1	2	2.3

a. Identify the independent and dependent variables in this experiment. 2 marks

Independent variable: _____

Dependent variable: _____

b. In relation to photosynthesis, what was causing the discs to float? 2 marks

_____

_____

_____

_____

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c. Identify the stage of photosynthesis that results in the formation of the product identified in Question 1b and name the structure in the chloroplasts at which this occurs. 2 marks

d. For which temperature was the most precise set of results obtained? Justify your answer. 2 marks

e. Using data, what conclusion can be drawn from the results regarding the optimal temperature for photosynthesis in spinach leaves? 1 mark

f. Suggest reasons for the low numbers of floating discs at 10^{o}C and at 40^{o}C. 2 marks

g. Identify two controlled variables that were not identified in the experiment description. 2 marks

Question 2 (14 marks)

Golden Rice is a variety of genetically engineered rice designed to combat vitamin A deficiencies in certain parts of the world. Golden Rice is engineered to biosynthesise beta-carotene, which is then converted into vitamin A in the gut.

Golden Rice is created by transforming rice with two beta-carotene genes: *Psy* (phytoene synthase) from daffodils (*Narcissus pseudonarcissus*) and *Crt1* (carotene desaturase) from the bacterium *Erwinia uredovora.*

The restriction enzyme EcoR1 is used to cut out the desired genes from both the daffodil DNA and the bacterial DNA. EcoR1 has the following restriction site:

5′. . . G|AATTC . . . 3′
3′. . . CTTAA|G . . . 5′

The *Psy* and *Crt1* genes are isolated, amplified and transferred into the *Ti* plasmid of the bacterium *Agrobacterium tumefaciens*, which then goes on to infect the rice embryos. The embryos then grow into mature rice plants with the desired traits.

Source: med.nyu.edu

a. Would Golden Rice be described as a transgenic organism? Explain your answer. 2 marks

b. Consider a different section of double-stranded DNA: 1 mark

5′ GTAAATTCCATAGAGAATTCATAGTGTGTATCCTATGACGAATTCAGATCGTTAGGGACCCATA 3′

5′ CATTTAAGGTATCTCTTAAGTATCACACATAGGATACTGCTTAAGTCTAGCAATCCCTGGGTAT 3′

How many fragments of DNA would there be after this section of DNA is mixed with the EcoR1 enzyme?

c. When an endonuclease cuts a section of DNA, it can leave sticky or blunt ends. Explain the difference between the two. 1 mark

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d. The *Psy* and *Crt1* genes, once isolated, are amplified using PCR. 4 marks

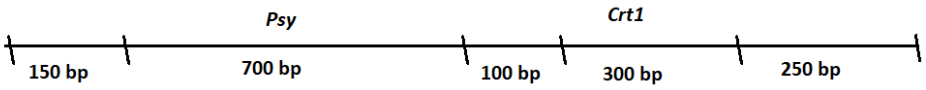
Describe the steps involved in one cycle of the PCR process.

e. Explain why *Taq* polymerase, rather than mammalian DNA polymerase, is used for the process of PCR. 1 mark

f. The desired genes are mixed with the *Ti* plasmids, which are then incorporated into the *Agrobacterium tumefaciens* bacteria. It is important that these plasmids contain two antibacterial resistant genes; one located away from an EcoR1 restriction site and the other containing an EcoR1 restriction site within its sequence. 2 marks

Describe the purpose of these two antibacterial-resistant genes in identifying the successfully transformed bacteria.

g. The figure below shows the EcoR1 restriction sites of the section of rice DNA in which the two desired genes are incorporated. 2 marks



Consider a plant that has incorporated the *Psy* gene but not the *Crt1* gene. Describe the electrophoresis output when this section of DNA is mixed with EcoR1 then run through an electrophoresis gel. Explain your answer.

h. Explain how the universality of the genetic code allows for the genetic modification of the rice embryos to produce Golden Rice. 1 mark

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Question 3 (9 marks)

Calandrinia balonensis is an Australian flowering plant found in arid regions west of the Great Diving Range, and throughout central Australia. It is well-adapted to its warm climate and is usually found growing in red sandy soils and spinifex zones. Like many plants that are adapted to a hot, dry climate, *C. balonensis* utilises the CAM pathways of photosynthesis.

Source: https://www.anbg.gov.au/gnp/interns-2013/calandrinia-balonensis.html

a. Describe how the adaptations of *C. balonensis* maximise the efficiency of photosynthesis in a warm, arid environment. 2 marks

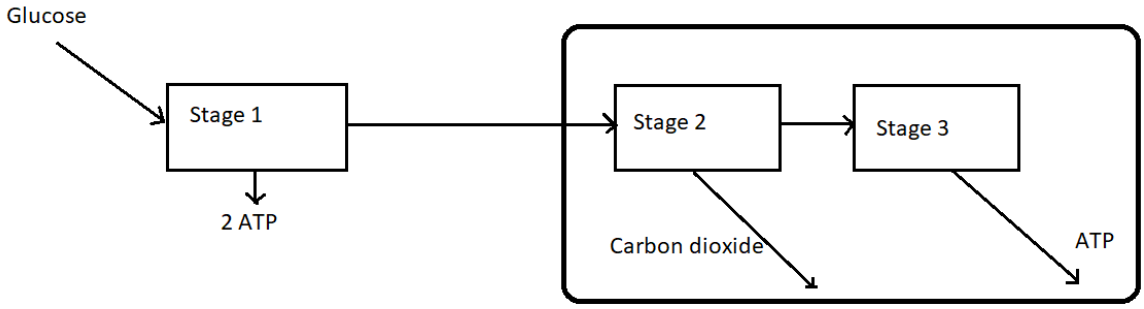
b. Briefly describe the role of Rubisco in synthesising glucose in photosynthesis and outline how coenzymes are involved in this process. 2 marks

c. Referring to the role of Rubisco, explain why photorespiration is more likely to occur at higher temperatures. 2 marks

d. Like CAM plants, C4 plants are adapted to hot climates. Compare the process of photosynthesis in C4 and CAM plants. 3 marks

Question 4 (8 marks)

The figure below depicts an essential process that occurs in most eukaryotic cells. Note that not all of the inputs and outputs of each stage are shown.



a. Name Stages 1, 2 and 3. 1 mark

1.

2.

3.

b. Identify two outputs from Stage 1. 1 mark

1.

2.

c. In which organelle and in which parts of the organelle do Stages 2 and 3 occur? 2 marks

d. When human muscle cells are subjected to heavy exercise and, thus, limited oxygen, they may switch from the process depicted above to a different biochemical process. 4 marks

Name this process and describe how this alternate biochemical process differs from the one shown above, in terms of location and outputs.

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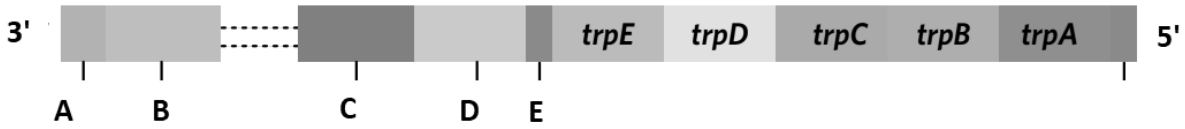
Question 5 (6 marks)

An example of gene regulation in prokaryotes like *E. coli* is the *trp* operon. The transcription and translation of the five structural genes in this operon forms part of the process of the production of the amino acid tryptophan. The figure below shows the general structure of the *trp* operon.



a. Identify part D and describe its function in regulating the transcription of structural genes. 2 marks

b. There are two ways in which the *trp* operon regulates the transcription of structural genes: repression and attenuation. 3 marks

Describe what occurs during attenuation when levels of tryptophan are high.

c. In prokaryotic cells, the DNA is not located in a nucleus. Explain why this allows for attenuation to occur in prokaryotic cells. 1 mark

END OF QUESTION AND ANSWER BOOK

Extra space for responses

Clearly number all responses in this space.

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VCE Unit 3 BIOLOGY
Written Examination
ANSWER SHEET – 2023

Student name:	

Use a **PENCIL** for **ALL** entries. For each question, shade the box which indicates your answer.

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

NO MARK will be given if more than **ONE** answer is completed for any question.

If you make a mistake, **ERASE** the incorrect answer – **DO NOT** cross it out.

1	A	B	C	D
2	A	B	C	D
3	A	B	C	D
4	A	B	C	D
5	A	B	C	D
6	A	B	C	D
7	A	B	C	D
8	A	B	C	D
9	A	B	C	D
10	A	B	C	D
11	A	B	C	D
12	A	B	C	D
13	A	B	C	D
14	A	B	C	D

15	A	B	C	D
16	A	B	C	D
17	A	B	C	D
18	A	B	C	D
19	A	B	C	D
20	A	B	C	D
21	A	B	C	D
22	A	B	C	D
23	A	B	C	D
24	A	B	C	D
25	A	B	C	D