Neap

Trial Examination 2023

VCE Biology Unit 3

Written Examination

Suggested Solutions

SECTION A – MULTIPLE-CHOICE QUESTIONS

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

Question 1 A

A is correct. Proteins are made up of chains of monomers called amino acids.

B is incorrect. Nucleotides are the monomers of nucleic acids.

C is incorrect. R groups are the parts of amino acids that change their properties.

D is incorrect. Nitrogenous bases are components of nucleotides.

Question 2 D

D is correct. During translation, mRNA moves through a ribosome, which is comprised of rRNA and protein, and uses codons to provide a blueprint for assembling amino acids into chains. tRNA provides a complementary anticodon so that the amino acids are placed in the specific required order.

A, **B** and **C** are incorrect. All three types of RNA are involved in translation.

Question 3 A

A is correct. As DNA is deoxyribose nucleic acid, the five-carbon sugar in its nucleotides is deoxyribose. As RNA is ribonucleic acid, the five-carbon sugar in its nucleotides is ribose.

B is incorrect. DNA makes up chromosomes, which contain multiple genes; thus, DNA is usually longer than RNA because RNA is generally a copy of a single gene.

C is incorrect. Both DNA and RNA in eukaryotes are located in a variety of cytoplasmic locations (for example, mitochondria and chloroplasts).

D is incorrect. Both DNA and RNA have four different monomers (A, G, C and T in DNA and A, G, C and U in RNA).

Question 4 D

D is correct. In the diagram, the two thick lines represent polypeptide chains and the five thinner, dotted lines represent the bonds that hold the two polypeptide chains together. Thus, the enzyme has a quaternary level of arrangement.

A is incorrect. An enzyme with a primary level of arrangement would consist of an amino acid chain only.

B is incorrect. An enzyme with a secondary level of arrangement would consist of a polypeptide chain with a folding shape.

C is incorrect. An enzyme with a tertiary level of arrangement would consist of a polypeptide chain with a three-dimensional shape.

Question 5 D

D is correct. The regulatory gene (structure M) produces a repressor protein (structure P), which changes shape to conform to the amino acid tryptophan. The repressor protein then has a shape that can bind to the operator (structure N) so that the structural genes (structure O) cannot be transcribed.

A, **B** and **C** are incorrect. These options do not correctly identify structures M–P.

Question 6 A

A is correct. When there is a high concentration of tryptophan, it is a waste of energy for bacteria to form tryptophan via a metabolic pathway. This means that the repressor protein (structure P) will bind to the operator (structure N) and prevent transcription of the *trp* structural genes (structure O).

B and **D** are incorrect. The operator (structure N) does not change shape in the presence of tryptophan.

C is incorrect. The presence of tryptophan does not affect the production of the repressor protein (structure P); it only prevents the transcription of the structural genes (structure O).

Question 7 B

B is correct. Proteomics is the specific study of protein structure and function, and aims to analyse the interactions between proteins in a cell.

A is incorrect. Biotechnology includes the techniques that are used to analyse proteins and DNA.

C is incorrect. Genomics is the study of an organism's genetic material, such as its genes and chromosomes.

D is incorrect. Biochemistry is the study of chemical substances and processes inside living things.

Question 8 A

A is correct. To secrete a protein, the nucleus (structure G) would first transcribe the gene. The ribosomes on the rough endoplasmic reticulum (structure H) would then translate the gene. The protein would move through the lumen of the rough endoplasmic reticulum to the Golgi apparatus (structure I), where it would be modified and packaged into vesicles (structure J) for exocytosis.

B, **C** and **D** are incorrect. These options do not give the correct order of structures G–J.

Question 9 C

C is correct. Phosphodiester bonds hold nucleotides together along a polynucleotide chain. The enzymes that break these bonds in DNA are called restriction enzymes or restriction endonucleases.

A is incorrect. Ligase enzymes form the phosphodiester bonds between nucleotides.

B is incorrect. Polymerase enzymes form phosphodiester bonds during replication or transcription.

D is incorrect. Reverse transcriptase turns RNA into DNA using a similar process to polymerase.

Question 10 D

D is correct. Polymerase chain reaction (PCR) is a process that forms multiple copies of small, specific sections of DNA samples. In the first stage of PCR, the DNA is denatured at 95°C to break the hydrogen bonds holding the DNA together, then it is cooled to 55°C so that primers can attach (anneal) to complementary sections of the initial DNA on either side of the target DNA. Finally, the sample's temperature is increased to 72°C, which enables the *taq* polymerase to bind to the primers and form a complementary strand to the template strand along the DNA templates; this is known as the extension stage. This process is repeated many times to create multiple copies of the DNA.

A is incorrect. The denaturation stage is carried out at 95°C.

B is incorrect. The denaturation stage occurs before the extension stage.

C is incorrect. The annealing stage is carried out at 55°C.

Question 11 C

C is correct. Smaller DNA fragments can move through the gel more easily and thus move further in the gel. The fragment that has moved the furthest in the gel, and therefore is the smallest, belongs to individual 3.

A, **B** and **D** are incorrect. These individuals do not have the smallest DNA fragment.

Question 12 B

B is correct. Individuals who are related would share similarities in their profiles. Individual 1 has three bands in common with individual 3; thus, they share 50% of their gene loci. This means individual 1 could be a parent of individual 3 or individual 3 could be a parent of individual 1.

A is incorrect. Individuals 3 and 5 share no common bands whereas individuals 1 and 5 share two common bands; therefore, individual 5 is more closely related to individual 1 than individual 3.

C is incorrect. Individuals 2 and 4 share one common band, so they may be somewhat related; individuals 3 and 5 share no common bands, making them the least related individuals.

D is incorrect. If individual 4 is the child of individuals 1 and 2, individual 4 would have inherited all of their DNA from individuals 1 and 2. However, individual 4 possesses a gel band that is not shared by individual 1 or individual 2, so they are not individual 4's parents.

Question 13 A

A is correct. When using a bacterium to form a human gene, the original nucleic acids must be extracted from the cytosol in the form of mature mRNA, which has been processed and is free of introns. The mRNA is then converted back to DNA using reverse transcriptase before being inserted into a plasmid.

B is incorrect. Nuclear DNA carries introns that must be removed before the DNA can be inserted into a plasmid.

C is incorrect. The plasmid does not have introns as the DNA present is bacterial in origin.

D is incorrect. The DNA needs complementary sticky ends to join with the cut plasmid.

Question 14 C

C is correct. As the recombinant plasmid contains an ampicillin-resistant gene, bacteria exposed to the plasmid will survive in the presence of ampicillin. Therefore, the bacteria should be plated onto an agar medium that has ampicillin mixed with it. The colonies of bacteria that grow in the medium will have the ampicillin-resistant gene and thus the gene of interest.

A is incorrect. Randomly selecting which colonies to grow further would not guarantee that the selected colonies carry the gene of interest.

B is incorrect. Increasing the temperature of the growth medium would kill all the bacteria.

D is incorrect. Heat shock and electroporation encourage the process of bacterial transformation; they are not involved the selection of transformed bacteria from non-transformed bacteria.

Question 15 C

C is correct. The Krebs Cycle occurs in the matrix of the mitochondria, so this is where citrate synthase is located.

A is incorrect. The endoplasmic reticulum is involved in the synthesis and transport of chemicals within cells.

B is incorrect. The nucleus is the site of gene expression.

D is incorrect. The Golgi apparatus is involved in the packaging and secretion of chemicals from a cell.

Question 16 D

D is correct. Acetyl CoA acts as a substrate in this reaction. If a low level of the substrate is present, the rate of reaction would be limited and result in less citrate being produced.

A is incorrect. The reaction is slower due to the limited supply of acetyl CoA, not oxaloacetate.

B is incorrect. The concentration of product is dependent on the reactant in the lowest concentration, which, in this case, is acetyl CoA.

C is incorrect. The active site of citrate synthase is available for the same amount of reactions; however, these reactions will not occur as often as they could due to the lower level of acetyl CoA.

Question 17 B

B is correct. The lock-and-key model of enzyme structure and function describes the shape of the substrate(s) as complementary to the shape of the enzyme's active site. Thus, when the substrate and enzyme collide with sufficient energy in the correct orientation, a reaction occurs.

A is incorrect. The active site moulds around the substrate in the induced fit model.

C is incorrect. Enzymes do not look for a substrate; the enzyme and substrate collide with each other randomly.

D is incorrect. If the temperature is too high, the enzyme will denature.

Question 18 A

A is correct. Competitive inhibitors have a similar shape to the substrate in a reaction; in this case, Relenza will be similar in shape to sialic acid. When present, Relenza will bind to the enzyme (neuraminidase) to slow down the reaction that releases the influenza virus into the bloodstream. An increased dose of Relenza would occupy more neuraminidase active sites, limiting the number of neuraminidase–sialic acid reactions and thus the amount of virus particles.

B is incorrect. The neuraminidase active sites need to be saturated with the competitive inhibitor for the antiviral to be effective; therefore, a high dose of Relenza is required.

C is incorrect. Both non-competitive and competitive inhibition would slow down reactions, but the effectiveness is dependent on substrate concentration.

D is incorrect. Relenza has a shape similar to the substrate (sialic acid), which is complementary to the neuraminidase.

Question 19 B

The wavelengths of green light are reflected away from plant leaves and thus cannot be used in photosynthesis at all. The wavelengths of violet and red light are absorbed by the chlorophyll in the leaves and start the light independent reaction of photosynthesis. Thus, Chanul is correct and Arun is incorrect.

Question 20 B

B is correct. The light dependent reaction of photosynthesis occurs within the chloroplasts in the thylakoid membrane, which is part of the membranous sacs making up the grana.

A is incorrect. The matrix is in the mitochondria.

C is incorrect. The cytoplasm is outside the chloroplast.

D is incorrect. The stroma is the site of the light independent reaction.

Question 21 B

B is correct. Photorespiration is the term given to the reaction between oxygen and Rubisco during photosynthesis. Carbon dioxide competes with oxygen for the active site of Rubisco; thus, photorespiration is more likely to occur when the level of oxygen is higher than the level of carbon dioxide.

A is incorrect. A higher level of carbon dioxide promotes carbon fixation, not photorespiration.

C is incorrect. Water availability will not directly affect the action of oxygen or carbon dioxide.

D is incorrect. When the stomata close at night, less oxygen will be present as the light dependent reaction does not occur and more carbon dioxide will be present as cellular respiration increases.

Question 22 D

D is correct. As part of the electron transport chain, NADH (chemical A) has its hydrogen (chemical B) offloaded and pushed to the intermembrane space (area 1). This creates a concentration gradient that enables the hydrogen to move through the ATPase and form ATP. The level of hydrogen in the matrix (area 2) then builds up, providing a continuous concentration gradient by combining with oxygen (chemical D) to form water (chemical C).

A, **B** and **C** are incorrect. These options do not correctly identify chemicals A–D.

Question 23 B

B is correct and **D** is incorrect. The space between the cristae and the outer membrane (area 1) is called the intermembrane space. The electron transport chain takes place inside the mitochondria, which is known as the matrix (area 2).

A is incorrect. Cytosol is the liquid component of the cytoplasm, which is outside the mitochondria.

C is incorrect. Nucleoplasm is the substance inside the nucleus and cytoplasm is the liquid component of the cytoplasm.

Question 24 A

A is correct. The electron transport chain occurs in both eukaryotes and some prokaryotes (aerobic bacteria) but the ATP yield is slightly different in each type of cell (26 or 28 ATP in eukaryotes and 28 ATP in aerobic bacteria).

B is incorrect. Depending on the cell, the three stages of aerobic cellular respiration will produce a total of 30 or 32 ATP.

C and **D** are incorrect. These options are outdated ATP yields for the electron transport chain and aerobic cellular respiration respectively.

Question 25 A

A is correct. CRISPR-Cas9 technology can be used to cut and disable a gene (method 1). Introducing a new gene into a plant adds an additional step to this process. After the DNA is cut using the CRISPR-Cas9 complex, the new gene must be inserted into the open position before the DNA strand repairs itself (method 2). Adding this step increases the difficulty of the process.

B is incorrect. The time taken for each method is not indicated, so it cannot be determined whether method 2 is faster than method 1.

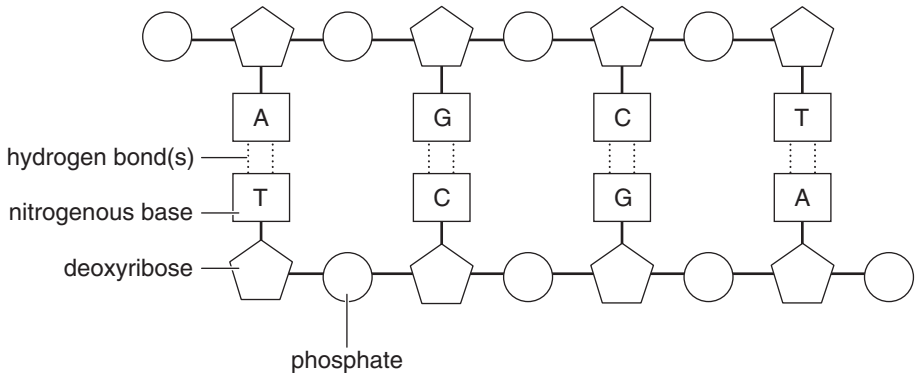
C is incorrect. Both methods involve the cutting of DNA, not RNA.

D is incorrect. Non-maleficence is the ethical concept stating that scientists should cause no harm. New technologies should not be rejected unless trials of the technology indicate that it will cause harm.

SECTION B

Question 1 (12 marks)

a.



4 marks

1 mark for drawing a diagram showing an antiparallel double helix.
1 mark for showing the correct sequence of nucleotides with complementary pairing.
1 mark for labelling a phosphate, nitrogenous base, and deoxyribose.
1 mark for labelling hydrogen bonds across the double helix.

b. *Any two of:*

- The introns are removed from the pre-mRNA.
- The remaining exons are joined together.
- A methylated cap is added to stabilise the mRNA.
- A poly A tail is added to stabilise the mRNA.

2 marks

1 mark for each event identified.

c. **i.** UCA GGC AUG GCC AAC 1 mark

ii. Ser-Gly-Met-Ala-Asn 1 mark

Note: Consequential on answer to ***Question 1c.i.***

d. alternative splicing 1 mark

This process may include or exclude particular exons from the mRNA produced by the gene. As a result, the gene's exons can be combined into different arrangements, which leads to a variety of mRNA strands and thus a variety of polypeptides. 1 mark

e. **i.** The rough endoplasmic reticulum provides an internal lumen for the polypeptide to move through. 1 mark

ii. The Golgi apparatus modifies and packages the polypeptide into vesicles for eventual secretion. 1 mark

Question 2 (8 marks)

a. The CRISPR-Cas9 complex allows the bacterium to cut sections of foreign viral DNA and incorporate them into its CRISPR gene. 1 mark

Thus, the bacterium can 'remember' the bacteriophage so that if the bacterium is infected again, it will be able to identify and destroy the foreign DNA. 1 mark

b. The spacer is complementary to a section of the viral DNA. 1 mark

c. A strand of guide RNA is constructed with a spacer section that is complementary to the adult haemoglobin gene. 1 mark

The single guide RNA is added to a CRISPR-Cas9 complex, which is then added to the extracted stem cells. The guide RNA binds to the haemoglobin gene in a complementary fashion. 1 mark

The DNA in the haemoglobin gene is then cut at the location the guide RNA is bound to. When the DNA is repaired with other nucleotides, the DNA sequence is altered and the gene is thus disrupted. 1 mark

d. The ethical concept of beneficence relates to the maximisation of benefits when undertaking a particular course of action. 1 mark

Question 4 **OR** 5 relates to the additional benefits associated with this research; thus, it relates to beneficence. 1 mark

Question 3 (8 marks)

a. Initially, the plasmid is mixed with a restriction enzyme that cuts it once. The DNA that contains the gene of interest is also mixed with the same restriction enzyme to isolate the gene of interest. 1 mark

The restriction enzyme leaves the plasmid and gene of interest with sticky ends, rather than blunt ends. 1 mark

Both the restricted plasmid and restricted gene of interest are mixed together with DNA ligase, which causes the complementary sticky ends to anneal and thus forms a recombinant plasmid. 1 mark

b. To assist with the selection of transformed *Agrobacterium tumefaciens*, the recombinant plasmid will usually have an antibiotic-resistant gene alongside the gene of interest in the genome. 1 mark

The sample of bacteria that have been exposed to the recombinant plasmid are then grown on an agar plate that contains the antibiotic. 1 mark

As the recombinant plasmid carries the antibiotic-resistant gene and the gene of interest, any bacteria that grow in the presence of the antibiotic will also carry the gene of interest. 1 mark

c. A consequences-based ethical approach focuses on the result of an investigation. If there is a positive and successful outcome, then the due diligence followed is justified. 1 mark

For example, any one of:

- The gene is heritable so that farmers can use seeds from the genetically modified plants continually.
- The plants are initially grown in greenhouses to ensure any problems are contained.
- The field evaluations are isolated so that genes do not flow into other crops that are not genetically modified.
- The fields used in the evaluation are observed for two years to ensure the plants are safe.

1 mark

Question 4 (11 marks)

a.

Component	Name
A	**grana/thylakoid membrane**
B	**oxygen**
C	**ADP and Pi**
D	**NADPH**
E	**carbon dioxide**
F	**glucose**

4 marks

Award 4 marks for 6 correct table entries. Award 3 marks for 4–5 correct table entries. Award 2 marks for 2–3 correct table entries. Award 1 mark for 1 correct table entry.

b. Rubisco is an enzyme that catalyses the inclusion of carbon dioxide into the Calvin cycle, as it combines carbon dioxide and RUBP to form a C3 compound. 1 mark

c. Photorespiration occurs when Rubisco binds with oxygen instead of carbon dioxide. 1 mark

Thus, it is most likely that photorespiration will occur when there is a higher concentration of oxygen than carbon dioxide. 1 mark

d. **i.** CAM plants 1 mark

hot, dry environment 1 mark

ii. Closing the stomata during the day prevents carbon dioxide from entering the plant. However, photosynthesis continues to occur, which increases the level of oxygen and hence increases the rate of photorespiration. 1 mark

iii. CAM plants take in carbon dioxide at night and store it as malate in the central vacuole. During the day, the malate is converted into carbon dioxide, which maintains the required level of carbon dioxide and thus reduces the incidence of photorespiration. 1 mark

Question 5 (7 marks)

a. Pyruvate (2), 2 ATP, 2 NADH

2 marks
1 mark for stating the correct molecules.
1 mark for stating the correct number of each molecule.

b. Each enzyme has a differently shaped active site. 1 mark

The substrates (glucose and glucose 6-phosphate) and other factors (coenzymes and/or cofactors) have complementary shapes that fit into specific active sites and ultimately form different products. 1 mark

c. Quantitative tests involve numerical or measurable data. Qualitative tests involve descriptive data. 1 mark

d. As the fluorescent spot test checks for the presence of NADPH, an individual who has favism would produce a spot that is not bright or fluorescent as the individual lacks NADPH. 1 mark

This is because NADPH is produced by G6PD as part of the PPP; thus, an individual who has favism would also lack NADPH because they lack G6PD. 1 mark

Question 6 (4 marks)

a. biodiesel **OR** biogas 1 mark

b. When the cellulose in the plant stubble is exposed to certain conditions, such as a specific temperature and pH, enzymes convert the cellulose into glucose. 1 mark

The glucose is then exposed to anaerobic conditions in a cellular environment, such as yeast or algae cells, to form bioethanol. 1 mark

c. Biofuels are renewable energy resources because they are produced using natural resources that constantly replace themselves and thus never run out. 1 mark

