Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

BIOLOGY **9700/42**

Paper 4 A Level Structured Questions **May/June 2024**

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 100.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **24** pages. Any blank pages are indicated.

DC (PB/SG) 330039/2

[Turn over

1 Osmoregulation is the control of the water potential of body fluids such as blood.

(a) Osmoreceptors and antidiuretic hormone (ADH) have an important role in osmoregulation.

(i) Name the location of osmoreceptors.

..... [1]

(ii) State the stimulus that is detected by osmoreceptors.

..... [1]

(iii) Name the structure that secretes ADH into the blood.

..... [1]

(b) ADH acts on the cells of the collecting duct, resulting in changes in the volume and concentration of urine.

Fig. 1.1 shows the relationship between the concentration of ADH in the blood and the rate of production of urine by the kidneys.

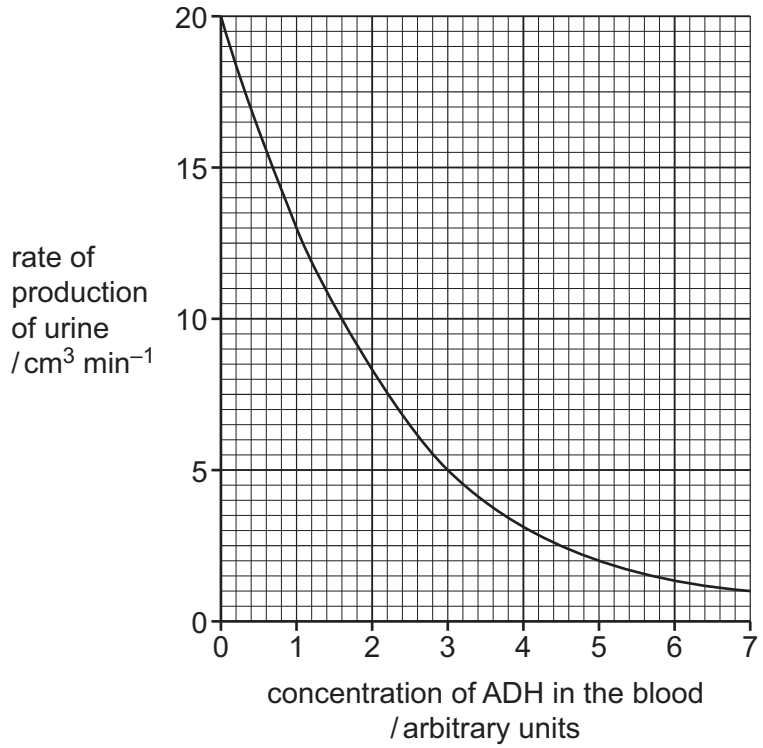


Fig. 1.1

(i) As the concentration of ADH in the blood increases, the rate of production of urine decreases.

Using Fig. 1.1, calculate the percentage decrease in the rate of production of urine between ADH concentrations of 1 and 3 arbitrary units.

Show your working.

Give your answer to **one** decimal place.

answer = ... [2]

(ii) Explain the relationship shown in Fig. 1.1.

.....

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 8]

2 Variation exists in populations of a species and this may provide the opportunity for evolution to occur.

(a) Phenotypic variation exists in many forms and has a number of possible causes.

Describe the main factors that are the cause of phenotypic variation.

.....

.....

.....

.....

..... [3]

(b) **(i)** Outline the theory of evolution.

.....

.....

.....

.....

.....

..... [3]

(ii) The theory of evolution is supported by DNA sequence data.

Explain how DNA sequences are used to show evolutionary relationships between species.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 9]

Question 3 starts on page 6.

3 The tortoise beetle, *Chelymorpha alternans*, is an insect found in Panama that has several different colour patterns. Fig. 3.1 shows a tortoise beetle.

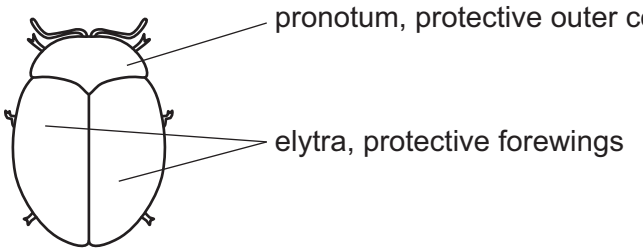
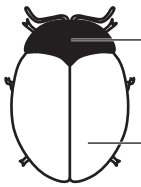
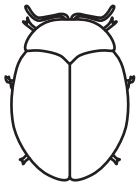


Fig. 3.1

Researchers have identified a gene, ***L***, that controls colour pattern in the pronotum and elytra. Gene ***L*** has four different alleles: $\mathbf{L^V}$, $\mathbf{L^T}$, $\mathbf{L^R}$ and $\mathbf{L^r}$.

Table 3.1 shows five different colour pattern phenotypes of tortoise beetles and their genotypes.

Table 3.1

phenotype		genotypes
rufipennis	 black; red	$\mathbf{L^R\ L^R}$ $\mathbf{L^R\ L^V}$ $\mathbf{L^R\ L^r}$
darien f. militaris-a (**dfm-a**)	 black and red striped	$\mathbf{L^T\ L^T}$ $\mathbf{L^T\ L^V}$ $\mathbf{L^T\ L^r}$
darien f. militaris-b (**dfm-b**)	 black; black and red striped	$\mathbf{L^T\ L^R}$
veraguensis	 red	$\mathbf{L^V\ L^V}$ $\mathbf{L^V\ L^r}$
metallic	 metallic and red striped	$\mathbf{L^r\ L^r}$

(a) Explain why the inheritance of colour pattern in tortoise beetles can be described as involving multiple alleles.

.....

.....

..... [1]

(b) A tortoise beetle with **dfm-b** phenotype was crossed with another tortoise beetle with **dfm-b** phenotype.

Construct a genetic diagram to show the results of this cross, including the ratio of offspring phenotypes.

parental phenotypes: **dfm-b** × **dfm-b**

parental genotypes:

gametes:

offspring genotypes:

offspring phenotypes:

ratio of offspring phenotypes:

[4]

(c) Colour pattern phenotype involves alleles that show codominance. There is also an order of dominance of alleles (dominance hierarchy).

Use the information in Table 3.1 to:

- identify the codominant alleles
- list the dominance hierarchy with alleles from the most dominant to the least dominant.

codominant alleles .....

dominance hierarchy .....

[2]

(d) Researchers carried out two crosses.

Cross 1: female veraguensis tortoise beetles were crossed with male metallic tortoise beetles.

The results are shown in Table 3.2.

Table 3.2

number of observed offspring phenotypes				ratio of observed colour pattern phenotypes
male veraguensis	female veraguensis	male metallic	female metallic	
139	153	136	140	1.06 : 1

Cross 2: female veraguensis tortoise beetles were crossed with male veraguensis tortoise beetles.

The results are shown in Table 3.3.

Table 3.3

number of observed offspring phenotypes				ratio of observed colour pattern phenotypes
male veraguensis	female veraguensis	male metallic	female metallic	
693	592	237	213	2.9 : 1

(i) Using Table 3.1, deduce the genotypes of **each** of the parental beetles used in cross 1 and cross 2.

cross 1 .....

cross 2 .....

[2]

(ii) An assumption was made that female tortoise beetles have XX chromosomes and males have XY chromosomes. Gene ***L*** is **not** located on the X chromosome. It was concluded that colour pattern phenotype followed autosomal inheritance.

Explain how the evidence in Table 3.3 supports this conclusion.

.....

.....

..... [1]

(iii) Name a statistical test that can be used to determine whether the ratio of observed phenotypes is significantly different from the expected ratio.

..... [1]

[Total: 11]

4 Genes have a role in determining the overall phenotype of an organism.

(a) Using haemophilia as an example, explain the relationship between a gene, a protein and a phenotype.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

(b) In the pea plant, *Pisum sativum*, the genotype ***lele*** results in plants with short stems (dwarf plants).

Explain how the ***lele*** genotype and its gene product results in dwarf plants.

.....

.....

.....

.....

.....

.....

..... [3]

(c) Dwarf plants also occur if the genes controlling growth are not activated (switched on).

Explain how DELLA proteins act as repressors preventing gene expression.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 11]

5 The gene *BRCA1* is expressed in breast tissue and in several other tissues of the body. *BRCA1* codes for a tumour suppressor protein. This protein is involved in either repairing damaged DNA, or in triggering the death of a cell if DNA cannot be repaired.

Some mutations in *BRCA1* are associated with an increased risk of developing breast cancer.

(a) State **one** reason why a doctor would recommend that a person has genetic testing for a mutation in the gene *BRCA1* **and** explain why this mutation would put the person at a greater risk of breast cancer.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(b) DNA sequencing is one method used to test for mutations in *BRCA1*. Before DNA sequencing occurs, the DNA sample goes through the polymerase chain reaction (PCR).

Suggest why PCR is used for testing for mutations in *BRCA1*.

.....

.....

.....

.....

..... [2]

(c) Genetic screening shows that in the UK:

- 1 in 400 females have a mutated allele of *BRCA1*
- 70% of females with a mutated allele of *BRCA1* will develop breast cancer by the time they are 80 years old.

In 2022, the population of females in the UK was 3.5×10^7.

Calculate the number of females in the UK population in 2022 who it is estimated will develop breast cancer by the age of 80 years old. Give your answer in standard form.

Show your working.

number of females = ... [2]

(d) One advantage of genetic screening is to determine which drugs should be selected to treat cancer.

A study was carried out on women with breast cancer who had been treated with a DNA-damaging drug that kills tumour cells.

The women had all been tested for *BRCA1* mutations. One group had a *BRCA1* mutation and the other group did **not** have a *BRCA1* mutation.

The researchers used data to assess the probability of survival for the women in each group of the study after treatment with the drug.

Fig. 5.1 shows the probability of survival for a time period of up to 180 months.

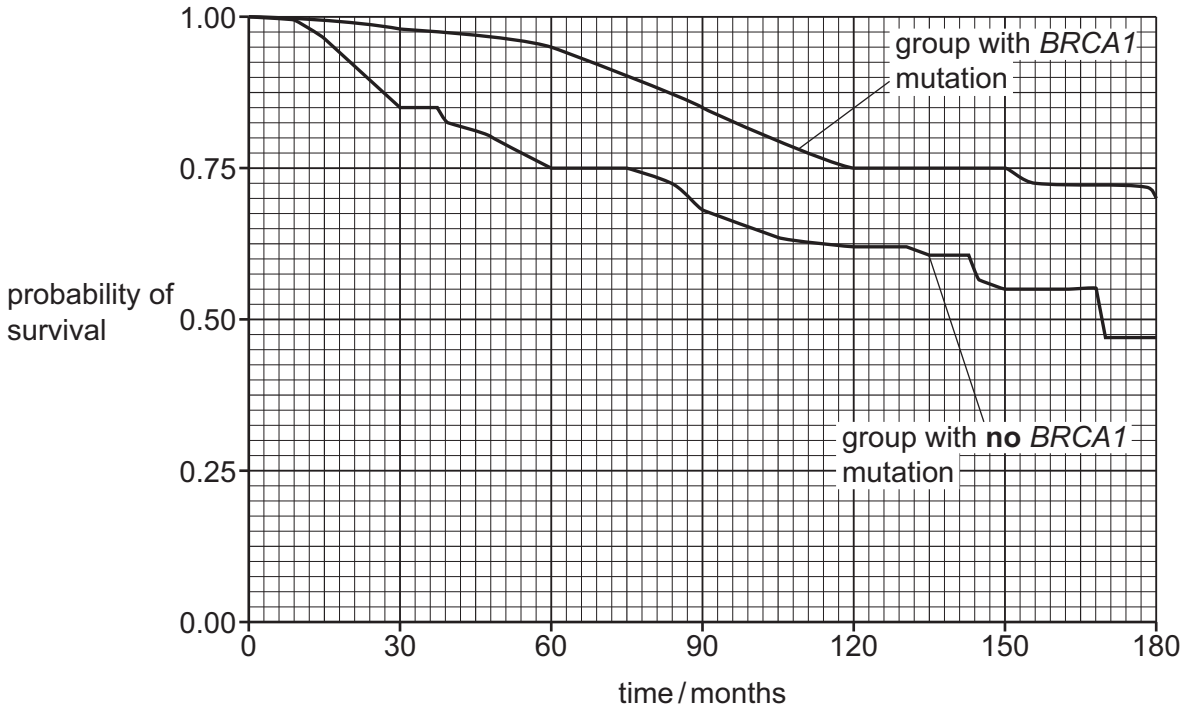


Fig. 5.1

The researchers suggested the hypothesis that the DNA-damaging drug is more effective in women with a *BRCA1* mutation.

Discuss whether the results in Fig. 5.1 support the hypothesis suggested by the researchers.

.....

.....

.....

.....

.....

..... [2]

[Total: 10]

6 **(a)** Fig. 6.1 is a diagram of part of a mitochondrion.

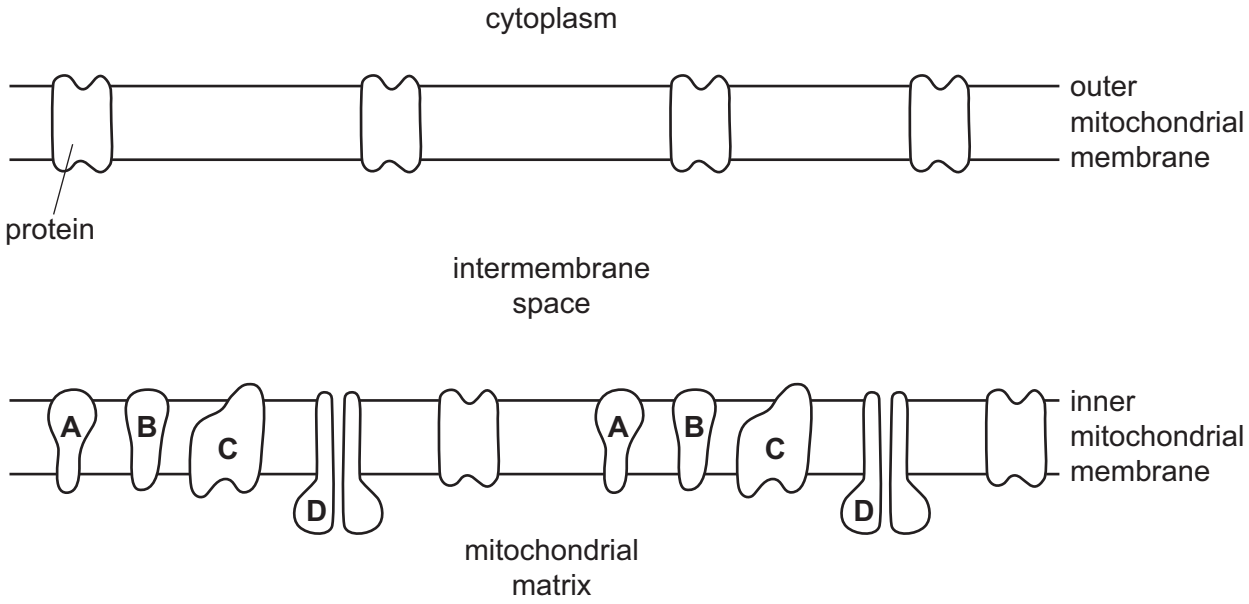


Fig. 6.1

On Fig. 6.1, use arrows to show the route taken by oxygen from the cytoplasm into the mitochondrial matrix. [1]

(b) Identify protein **D** and the group of proteins represented by **A**, **B** and **C and** describe their roles in oxidative phosphorylation.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [7]

(c) The matrix of a mitochondrion contains small circular DNA. In the cells of humans, the mitochondria have circular DNA that contains 37 genes.

Suggest functions for these mitochondrial genes.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 11]

7 **(a)** A student investigated the effect of temperature on the rate of photosynthesis at two different light intensities. The rate of photosynthesis was determined by measuring the rate of oxygen production of the plant.

Fig. 7.1 shows the result of the investigation.

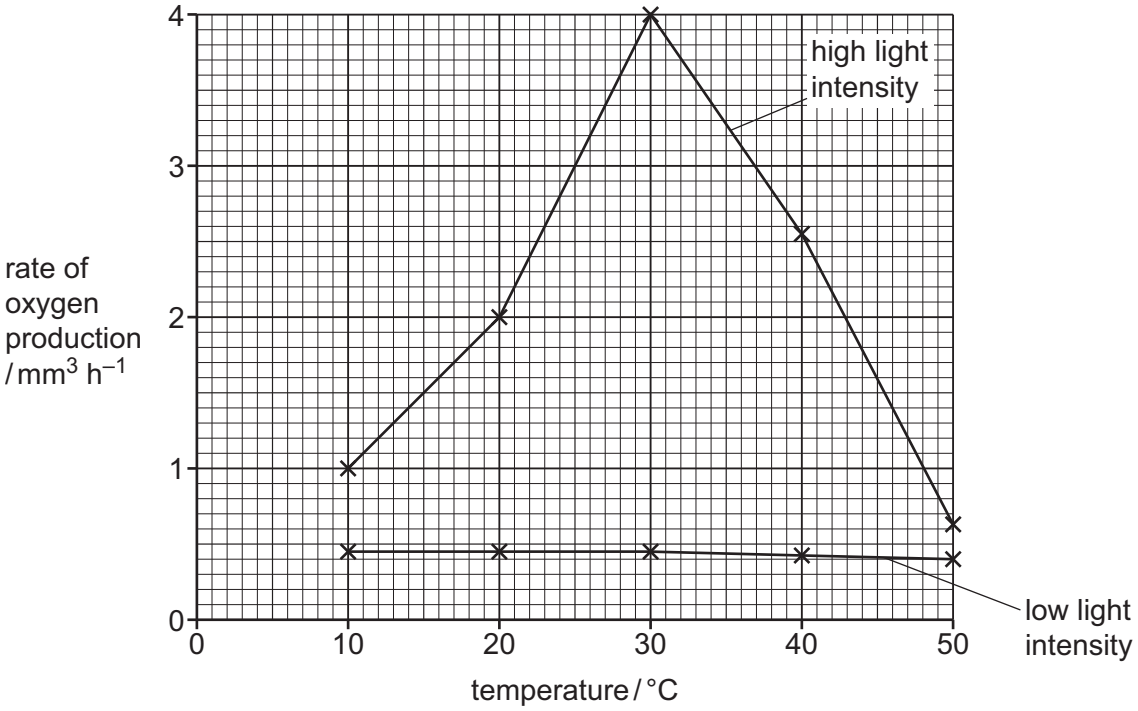


Fig. 7.1

(i) With reference to Fig. 7.1, describe **and** explain the results of the investigation for the plant in **low** light intensity.

.....

.....

.....

.....

.....

.....

.....

..... [3]

(ii) With reference to Fig. 7.1, describe **and** explain the results of the investigation for the plant in **high** light intensity **above** 30 °C.

.....

.....

.....

.....

.....

.....

.....

..... [3]

(b) Describe the process that produces oxygen during non-cyclic photophosphorylation.

.....

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 9]

8 **(a)** Fig. 8.1 is a diagram of a sensory neurone.

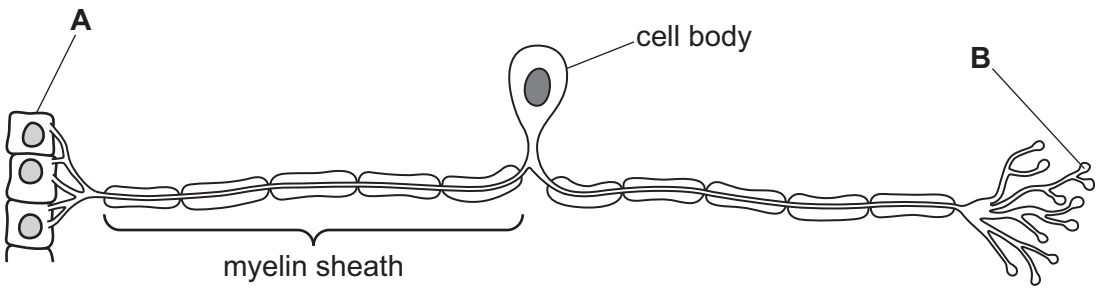


Fig. 8.1

(i) Name the type of cell represented by cell **A**.

..... [1]

(ii) Name a type of cell that forms a synapse with structure **B**.

..... [1]

(iii) Name the cells that form the myelin sheath.

..... [1]

(b) State **and** explain the differences in the transmission of impulses between myelinated and unmyelinated neurones.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(c) Opioids are therapeutic drugs that are used to relieve pain. Morphine is an example of an opioid. It affects the functioning of synapses.

Fig. 8.2 is a diagram of a cholinergic synapse.

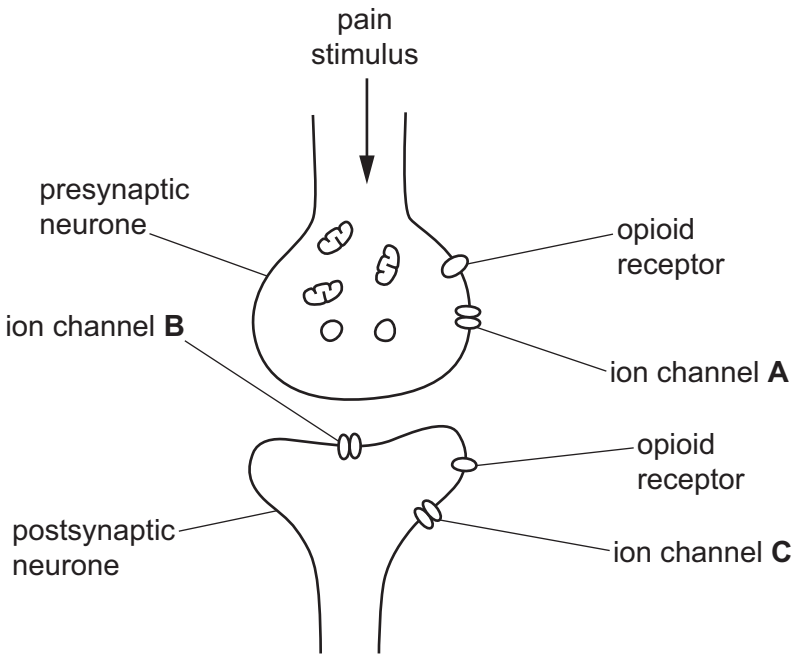


Fig. 8.2

(i) With reference to Fig. 8.2, describe the differences between ion channel **A** and ion channel **B**.

.....

.....

.....

.....

..... [2]

(ii) Morphine binds to the opioid receptor in the presynaptic membrane. This stops the ion channel **A** from opening.

Suggest **and** describe the effects of the binding of morphine to this opioid receptor on the functioning of the cholinergic synapse.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(iii) Morphine also binds to the opioid receptor in the postsynaptic membrane. This results in the opening of ion channel **C**, allowing potassium ions to diffuse out of the cell.

Suggest how this would affect the synapse.

.....

.....

.....

.....

..... [2]

[Total: 15]

9 **(a)** The Asian common toad, *Duttaphrynus melanostictus*, arrived accidentally in eastern Madagascar in 2010 on a ship.

Fig. 9.1 shows an Asian common toad.

Fig. 9.1

The Asian common toad is now regarded as an invasive alien species because:

- it breeds fast in the warm, wet conditions of eastern Madagascar
- it can travel up to 2.5 km per year
- its skin contains poison, which is highly toxic to humans and predators.

Suggest ways in which the Asian common toad may affect the ecosystem of eastern Madagascar.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(b) Zoos work with local groups around the world to help conserve endangered species.
One example of this is the use of assisted reproduction, such as IVF, with endangered mammals such as the eastern black rhino.

Outline the process of IVF.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 8]

10 (a) In mammals, blood glucose concentration is maintained around a set point so that the mammal can function efficiently. This is an example of homeostasis.

Name the mechanism that maintains blood glucose concentration around a set point.

..... [1]

(b) Fig. 10.1 shows how the blood glucose concentration varies before, during and after a period of exercise.

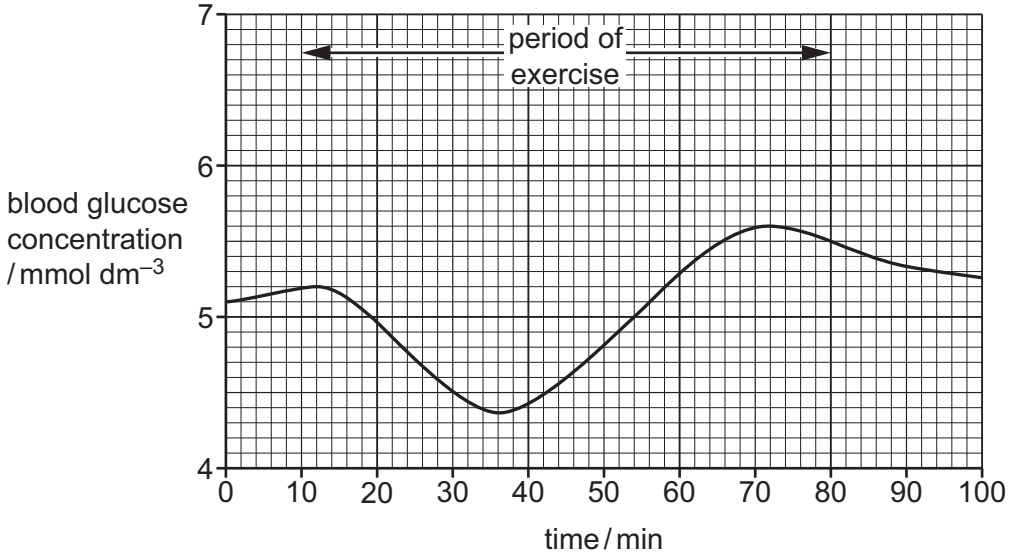


Fig. 10.1

Explain the results shown in Fig. 10.1 between 15 minutes and 70 minutes.

.....

.....

.....

.....

.....

.....

.....

.....

..... [3]

(c) Type 1 diabetes in humans is a condition where the pancreas does not produce enough insulin to control blood glucose concentration.

Test strips are used to measure the concentration of glucose in a sample of urine. Two reactions take place on the test strip and a colour change occurs if glucose is present in the urine.

The equations for these reactions are:

$$\text{glucose} + \text{oxygen} \xrightarrow{\text{glucose oxidase}} \mathbf{A} + \text{hydrogen peroxide}$$

$$\text{hydrogen peroxide} + \mathbf{B} \xrightarrow{\text{peroxidase}} \text{oxidised } \mathbf{B} + \text{water}$$

(i) Identify compound **A** and the type of substrate represented by **B**.

A .....

B .....

[2]

(ii) Most people with diabetes mellitus use a biosensor to obtain their blood glucose concentration.

Suggest the advantages of using a biosensor rather than test strips.

.....

.....

.....

.....

.....

..... [2]

[Total: 8]