FOR OFFICIAL USE

National Qualifications 2018

Mark

X707/77/01

Biology
Section 1 — Answer Grid and Section 2

TUESDAY, 15 MAY
9:00 AM – 11:30 AM

X7077701

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Number of seat

Date of birth

Day	Month	Year

Scottish candidate number

Total marks — 90

SECTION 1 — 25 marks

Attempt ALL questions.

Instructions for the completion of Section 1 are given on *page 02*.

SECTION 2 — 65 marks

Attempt ALL questions.

A supplementary sheet for question 1 is enclosed inside the front cover of this question paper.

Write your answers clearly in the spaces provided in this booklet. Additional space for answers and rough work is provided at the end of this booklet. If you use this space you must clearly identify the question number you are attempting. Any rough work must be written in this booklet. Score through your rough work when you have written your final copy.

Use **blue** or **black** ink.

Before leaving the examination room you must give this booklet to the Invigilator; if you do not, you may lose all the marks for this paper.

SQA ©

X707770101

SECTION 1 — 25 marks

The questions for Section 1 are contained in the question paper X707/77/02.

Read these and record your answers on the answer grid on *page 03* opposite.

Use **blue** or **black** ink. Do NOT use gel pens or pencil.

1. The answer to each question is **either** A, B, C or D. Decide what your answer is, then fill in the appropriate bubble (see sample question below).

2. There is **only one correct** answer to each question.

3. Any rough working should be done on the additional space for answers and rough work at the end of this booklet.

Sample question

The thigh bone is called the

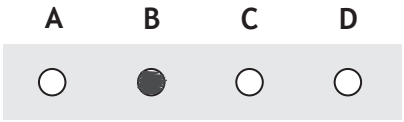
A humerus

B femur

C tibia

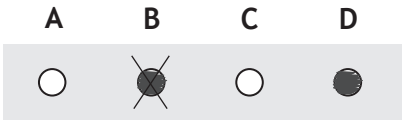
D fibula.

The correct answer is **B** — femur. The answer **B** bubble has been clearly filled in (see below).

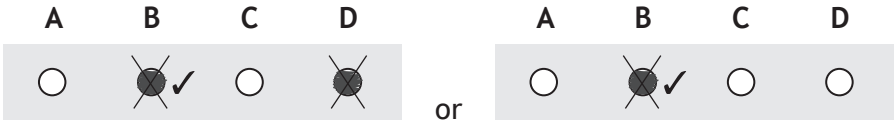


Changing an answer

If you decide to change your answer, cancel your first answer by putting a cross through it (see below) and fill in the answer you want. The answer below has been changed to **D**.



If you then decide to change back to an answer you have already scored out, put a tick (✓) to the **right** of the answer you want, as shown below:



SECTION 1 — Answer Grid

OBJ25AD1

	A	B	C	D
1	○	○	○	○
2	○	○	○	○
3	○	○	○	○
4	○	○	○	○
5	○	○	○	○
6	○	○	○	○
7	○	○	○	○
8	○	○	○	○
9	○	○	○	○
10	○	○	○	○
11	○	○	○	○
12	○	○	○	○
13	○	○	○	○
14	○	○	○	○
15	○	○	○	○
16	○	○	○	○
17	○	○	○	○
18	○	○	○	○
19	○	○	○	○
20	○	○	○	○
21	○	○	○	○
22	○	○	○	○
23	○	○	○	○
24	○	○	○	○
25	○	○	○	○

X707770103

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SECTION 2 — 65 marks

Attempt ALL questions

Question 11 contains a choice

1. Read through the supplementary sheet for question 1 before attempting this question.

(a) Explain why the rate of uptake by GLUT transporters levels off at high glucose concentrations. **1**

(b) **Refer to Figure 2 in the supplementary sheet for question 1.**

Figure 2 shows GLUT3 has the lowest K_M for glucose.

Explain how this supports the conclusion that GLUT3 has the highest affinity for glucose. **1**

(c) The rate of glucose transport at a given glucose concentration can be calculated using the formula:

$$V = \frac{V_{max} \times [G]}{K_M + [G]}$$

V = rate of glucose transport

[G] = glucose concentration (mmol per litre)

GLUT2 transporters, found mainly in liver and pancreatic cells, have a K_M of 17 mmol per litre. At this concentration of glucose the rate of transport by GLUT2 is 0·02 mmol/min.

The physiological range of blood glucose concentration in a healthy individual after fasting ranges from approximately 3·9 to 5·5 mmol per litre.

(i) Calculate the rate of glucose transport by GLUT2 when the blood glucose concentration is 5·5 mmol per litre. **2**

Space for calculation

_____ mmol/min

1. (c) (continued)

(ii) Increases in blood glucose concentration lead to increased insulin production by the pancreas. Glucose uptake by GLUT2 is important for this response because as glucose entry via GLUT2 increases the pancreas synthesises more insulin.

Suggest why the high K_M of GLUT2 is important in this mechanism for sensing glucose concentration. **1**

(d) Release of insulin into the bloodstream leads to a rapid increase in the transport of glucose into muscle and fat cells via GLUT4.

Explain why this normal response to insulin does not happen in individuals with type 2 diabetes. **2**

(e) **Refer to Figure 3 in the supplementary sheet for question 1.**

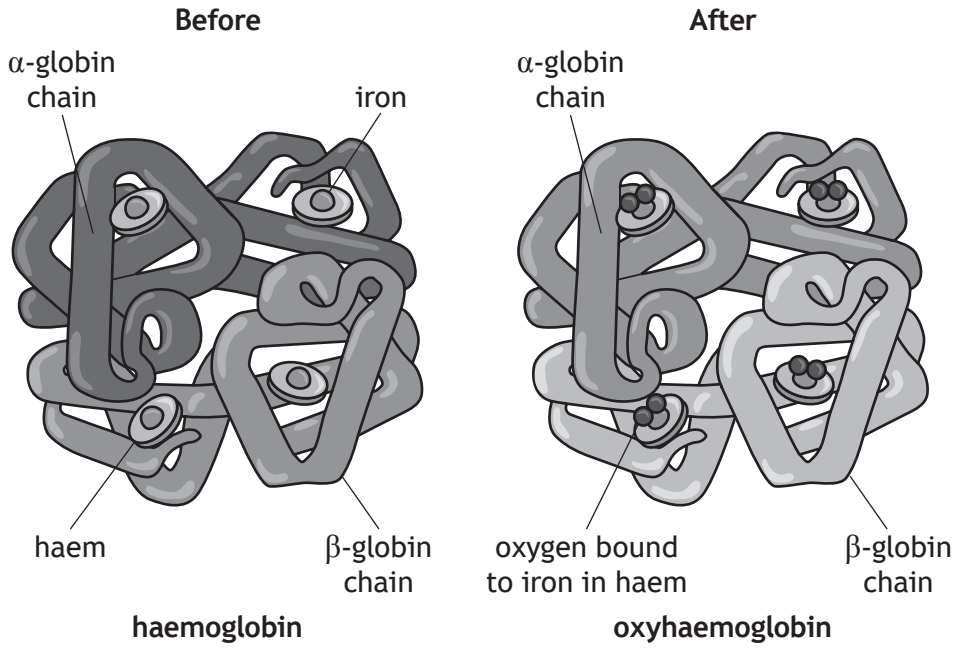
Describe the trend shown in Figure 3. **1**

(f) Blood serum caffeine levels in people who regularly consume caffeine are typically around 6 μmol per litre.

Using Figure 3 predict, with justification, whether this level of caffeine consumption would be likely to have a large effect on the transport of glucose by GLUT1. **1**

[Turn over

2. (a) The figure represents the four subunits (two α, two β) of a haemoglobin molecule before and after binding with oxygen molecules.



(i) Name the process whereby binding of oxygen to one subunit of haemoglobin alters the affinity of the remaining subunits. **1**

_____

(ii) Tissues with higher metabolic rates require more oxygen. These tissues produce more carbon dioxide, which dissolves in tissue fluids to form carbonic acid.

Explain how this increases oxygen delivery at these tissues. **1**

_____

_____

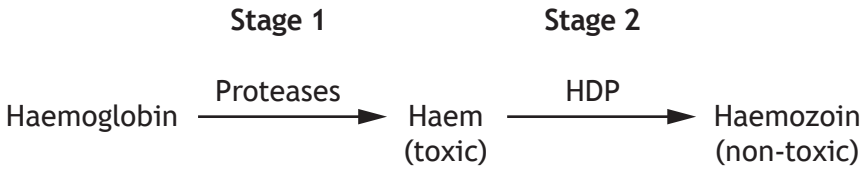
(iii) Haem is a non-protein component important in the function of haemoglobin.

State the term used to describe such a component. **1**

_____

2. (continued)

(b) During one stage in its life cycle, the human parasite *Plasmodium* enters a red blood cell. In order to obtain amino acids that it requires, it digests haemoglobin using a mixture of protease enzymes. This releases the product haem, which is toxic to the parasite. Haem is then converted into non-toxic haemozoin by another enzyme called HDP.



(i) Name the human disease caused by *Plasmodium*. **1**

_____

(ii) Chloroquine is one of a number of drugs used to treat this disease.

Suggest how drugs such as chloroquine, that target Stage 2, may provide an effective treatment. **2**

_____

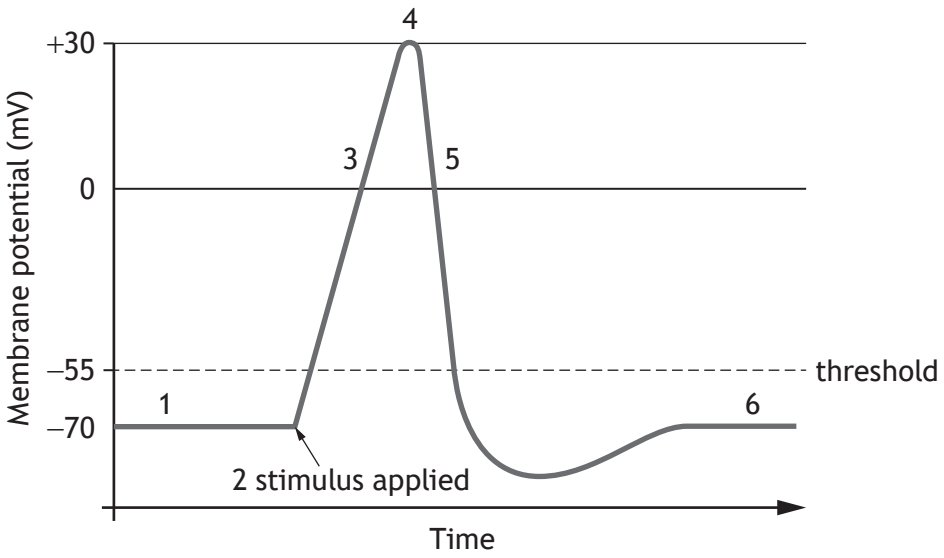
_____

_____

_____

[Turn over

3. The diagram shows stages in the transmission of a nerve impulse.



1 Membrane potential before nerve impulse initiated

2 Binding of a neurotransmitter to a ligand-gated sodium ion (Na^+) channel

3 Voltage gated Na^+ channels open

4 Voltage gated Na^+ channels become inactivated

5 Voltage gated potassium ion (K^+) channels open

6 Membrane potential after nerve impulse has passed

(a) (i) State the term that describes the membrane potential at points 1 and 6. **1**

_____

(ii) Use the diagram to calculate the change in membrane potential between points 1 and 4. **1**

Space for calculation

_____

3. (a) (continued)

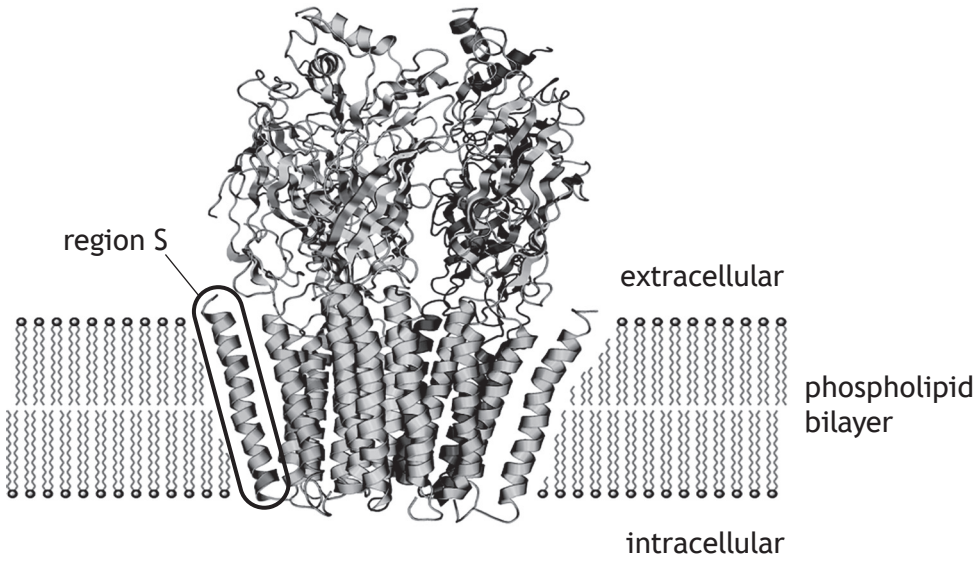
(iii) Use the information in the diagram to explain the importance of K^+ channels in nerve transmission. **2**

(b) Tetrodotoxin is a poison found in some fish, such as the pufferfish, which has its effect at stage three of the process shown in the diagram.

Suggest a possible mechanism for the toxicity of this substance. **1**

[Turn over

4. The neurotransmitter gamma-aminobutyric acid (GABA) binds to $GABA_A$ receptors in nerve cells. $GABA_A$ receptors are a family of structurally related transmembrane ion channels. One proposed structure of a $GABA_A$ receptor is shown in the diagram.



(a) (i) All $GABA_A$ receptors consist of five subunits.

Name the level of protein structure describing several connected polypeptide subunits. **1**

_____

(ii) Region S has some of the R groups in contact with the bilayer.

Predict the class of R groups to which these amino acids belong. **1**

_____

4. (continued)

(b) It has been suggested that different forms of the $GABA_A$ receptor subunit can arise as a result of alternative RNA splicing.

Explain how alternative RNA splicing could result in the production of variant forms of $GABA_A$ receptor subunits. **2**

(c) Suggest what happens to the receptor protein when GABA binds to it. **1**

(d) The drug diazepam increases the effect of GABA molecules by binding to a secondary (allosteric) binding site on $GABA_A$ receptors.

State the term used to describe the effect of diazepam on $GABA_A$ receptors. **1**

[Turn over

5. Microtubules are found in all eukaryotic cells.

(a) Name the globular protein of which microtubules are composed. **1**

_____

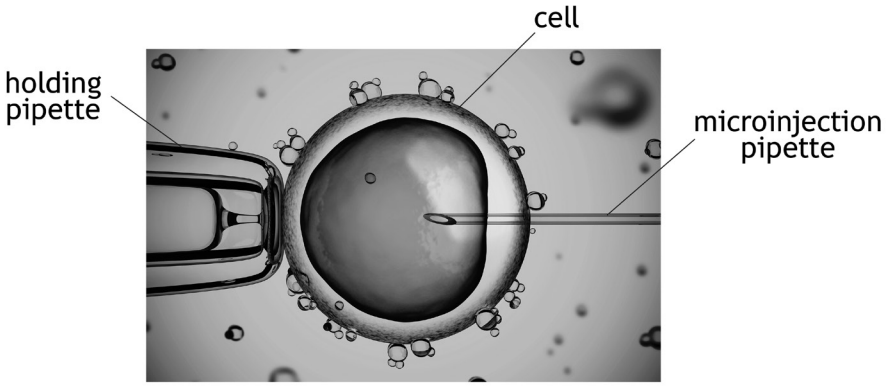
(b) Name the structure from which microtubules radiate. **1**

_____

(c) The formation and functioning of mitotic spindle fibres depends on the action of specific enzymes such as *cytoplasmic dynein*.

The role of cytoplasmic dynein in mitosis was investigated. Preparations of purified antibodies that inhibit cytoplasmic dynein's action were injected into cultured mammalian cells at different stages in mitosis. Comparable cells were injected with a buffer solution containing no antibodies.

The figure shows a cell undergoing microinjection.



The following results were obtained.

- Mitosis was blocked in 73% of the cells injected with the antibody at 12 mg/cm^3 during prophase.
- Injection of buffer alone had no effect on mitosis.
- Lower concentrations of antibodies (6 mg/cm^3) had no obvious effect on mitosis.
- Cells injected with antibody during metaphase or anaphase completed mitosis with no detectable differences compared to cells injected with buffer alone.

5. (c) (continued)

(i) State the purpose of injecting cells with buffer solution only. **1**

_____

(ii) Give a valid conclusion for this experiment. **1**

_____

_____

(d) Once mitosis is complete, the cytoplasm separates to give two daughter cells.

State the term used to describe this process. **1**

_____

[Turn over

6. The following customer comment was used to promote a product intended to treat cats that suffered from cancer.

> 'My cat was diagnosed with bone cancer three years ago. Her leg was amputated, and I was told that she would only live for another six months. I saw advertising for *Vivafel* and immediately started her on this product. She has been in remission and healthy ever since. I thoroughly recommend this product and the effect it has on cancer in cats.'

(a) (i) What is the conclusion that appears to have been drawn by the cat's owner? **1**

_____

_____

(ii) Apart from being based on one cat, give **one** reason why this conclusion is invalid. **1**

_____

_____

(b) Suggest why the results of the treatment are unlikely to be caused by a placebo effect, in which even a dummy treatment can bring about some improvement. **1**

_____

_____

6. (continued)

(c) Trials to test the effectiveness of the drug Vivafel were set up using living cats.

(i) Describe **one** way to ensure that these trials were ethical. **1**

_____

_____

(ii) State an appropriate null hypothesis for these trials. **1**

_____

_____

[Turn over

7. Where it is impractical to measure every individual in a population, a representative sample of the population must be obtained.

Discuss the principles and strategies that should be employed in the collection of representative samples. **4**

[Turn over for next question

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8. Giraffes are the tallest terrestrial animals, growing up to 5 m tall. Approximately half of a giraffe's height is due to its long neck. Modern giraffes have evolved from ancestors with much shorter necks.

The figures represent two different hypotheses regarding the evolution of the giraffe's long neck.

Competing browsers hypothesis

Necks for sex hypothesis

Charles Darwin suggested that the long necks evolved by natural selection: longer necks allowed animals to feed higher up trees with less competition — the 'competing browsers' hypothesis.

This hypothesis was not thought to be consistent with all the evidence available and a rival hypothesis, 'necks for sex', has been put forward. This suggests long necks have evolved as a result of sexual selection through male–male rivalry, where male giraffes fight for access to females by standing side by side and hitting each other with their heads.

(a) Use the competing browsers hypothesis to explain how long necks evolved by natural selection. **2**

8. (continued)

(b) Long necks evolved around 13 million years ago when much of the African forest was replaced by grassland with a greatly reduced number of trees.

Explain how this supports the competing browsers hypothesis. **1**

(c) (i) Explain how long necks could have evolved through sexual selection. **1**

(ii) A study published in 2013 concluded that there was no sexual dimorphism in neck length in giraffes.

Suggest how this finding would cast doubt on the necks for sex hypothesis. **1**

[Turn over

9. New Zealand mud snails, *Potamopyrgus antipodarum,* are widely distributed in freshwater streams and lakes in New Zealand. Snail populations consist of females that reproduce asexually by parthenogenesis together with females that reproduce sexually by cross fertilisation with males.

(a) State **two** disadvantages of sexual reproduction. **2**

1 _____

_____

2 _____

_____

(b) New Zealand mud snails are commonly infected with parasitic worms of the genus *Microphallus*. Sexual reproduction is more common in the snails when the prevalence of parasites is high.

Explain how this observation supports the Red Queen hypothesis. **2**

_____

_____

_____

_____

(c) The New Zealand mud snail has become invasive by spreading beyond its native habitat to colonise areas of Europe and North America.

Suggest why invasive populations are found to be composed entirely of parthenogenic females. **1**

_____

_____

[Turn over for next question

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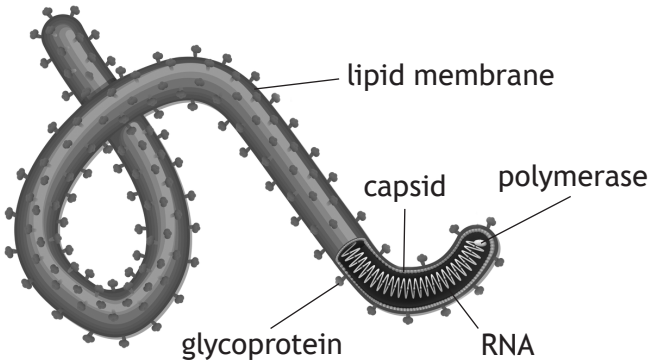
10. The figure shows an Ebola virus, cause of Ebola virus disease (EVD), prevalent in a number of West and Central African countries. The virus is transmitted to people from wild animals and outbreaks may then occur through human to human transmission.



(a) Ebola viruses have a diameter of $8 \times 10^{-2}\,\mu m$.

Give this measurement in nanometres (nm). ($1\ nm = 10^{-3}\,\mu m$) **1**

Space for calculation

(b) The flow diagram shows some stages in the replication of this virus.

Virus attaches to host cell receptors

⬇

Virus enters host cell

⬇

Viral RNA is used as a template to synthesise complementary mRNA

⬇

mRNA is translated into viral proteins

⬇

Viral RNA replicated

⬇

New virus particles assembled

⬇

Viruses released and cell destroyed

Explain why the Ebola virus **cannot** be regarded as a retrovirus. **1**

10. (continued)

(c) EVD symptoms result from viral disruption of immune cell function such as the loss of lymphocytes by apoptosis.

State the cause of cell death during apoptosis. **1**

(d) The genes coding for some Ebola virus proteins have a high rate of mutation.

Why would this make development of a vaccine more difficult? **1**

(e) EVD has a very high mortality rate. Some researchers have suggested that new treatments should not be assessed by clinical trials that use negative control groups.

State whether you agree or disagree with this suggestion.

Justify your answer. **1**

(f) Apart from medical treatments, suggest **one** measure that could be effective in controlling or preventing outbreaks of EVD in the tropical regions of Africa. **1**

[Turn over for next question

11. Answer **either A or B** in the space below and on *page 27*.

A Discuss the concept of niche under the following headings:

(i) realised and fundamental niche; **3**

(ii) features of parasite niches. **6**

OR

B Discuss the formation of variable gametes during meiosis under the following headings:

(i) the activity of homologous chromosomes; **7**

(ii) meiosis II. **2**

MARKS | DO NOT WRITE IN THIS MARGIN

SPACE FOR ANSWER FOR QUESTION 11

[END OF QUESTION PAPER]

MARKS | DO NOT WRITE IN THIS MARGIN

ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

MARKS | DO NOT WRITE IN THIS MARGIN

ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

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ACKNOWLEDGEMENTS

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Question 4 – Image of GABAA receptor by BogHog2 is taken from https://commons.wikimedia.org/wiki/File:NAchR_2BG9.png. Public Domain.

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