

X274/13/02

NATIONAL
QUALIFICATIONS 2014

FRIDAY, 16 MAY
1.00 PM – 3.30 PM

BIOLOGY
ADVANCED HIGHER
(REVISED)

SECTION A—Questions 1–25 (25 marks)

Instructions for completion of Section A are given on *Page two*.

SECTION B (65 marks)

The answer to each question should be written in ink in the answer book provided. Any additional paper (if used) should be placed inside the front cover of the answer book.

Rough work should be scored through.

All questions should be attempted. Candidates should note that Question 10 contains a choice.

Question 1 is on Pages 10, 11 and 12. Question 2 is on Page 13. Pages 12 and 13 are fold-out pages.



Read carefully

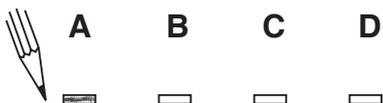
- 1 Check that the answer sheet provided is for **Biology Advanced Higher Revised (Section A)**.
- 2 For this section of the examination you must use an **HB pencil** and, where necessary, an eraser.
- 3 Check that the answer sheet you have been given has **your name, date of birth, SCN** (Scottish Candidate Number) and **Centre Name** printed on it.
Do not change any of these details.
- 4 If any of this information is wrong, tell the Invigilator immediately.
- 5 If this information is correct, **print** your name and seat number in the boxes provided.
- 6 The answer to each question is **either** A, B, C or D. Decide what your answer is, then, using your pencil, put a horizontal line in the space provided (see sample question below).
- 7 There is **only one correct** answer to each question.
- 8 Any rough working should be done on the question paper or the rough working sheet, **not** on your answer sheet.
- 9 At the end of the examination, put the **answer sheet for Section A inside the front cover of the answer book**.

Sample Question

Which of the following molecules contains six carbon atoms?

- A Glucose
- B Pyruvic acid
- C Ribulose biphosphate
- D Acetyl coenzyme A

The correct answer is **A**—Glucose. The answer **A** has been clearly marked in **pencil** with a horizontal line (see below).



Changing an answer

If you decide to change your answer, carefully erase your first answer and using your pencil, fill in the answer you want. The answer below has been changed to **D**.



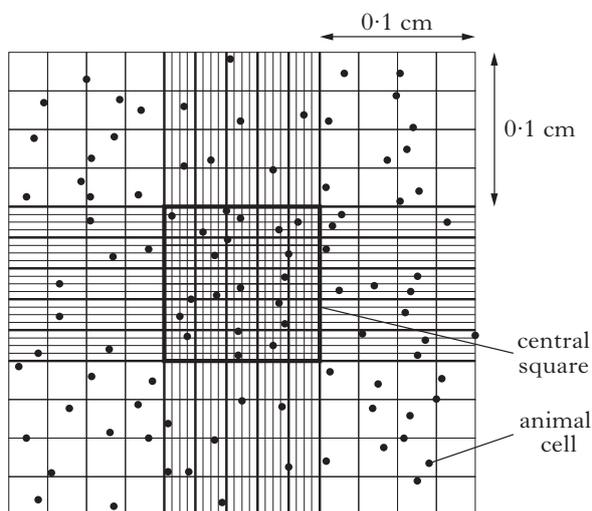
SECTION A

All questions in this section should be attempted.

Answers should be given on the separate answer sheet provided.

1. The diagram below shows a haemocytometer counting chamber containing animal cells.

The depth of the chamber is 0.01 cm.



The concentration of animal cells, based on the cell count from the central square, is

- A 2.0×10^4 cells per cm^3
 B 2.0×10^5 cells per cm^3
 C 2.0×10^6 cells per cm^3
 D 2.0×10^7 cells per cm^3 .
2. Which line in the table below correctly describes the charges on the two components of nucleosomes?

	<i>DNA</i>	<i>Histone proteins</i>
A	negative	negative
B	positive	negative
C	positive	positive
D	negative	positive

3. Which line in the table below correctly represents an allosteric enzyme binding with a positive modulator?

	<i>Modulator binding site</i>		<i>Affinity of enzyme for substrate</i>	
	<i>active site</i>	<i>secondary site</i>	<i>increased</i>	<i>decreased</i>
A	✓		✓	
B		✓		✓
C		✓	✓	
D	✓			✓

4. The stages of muscle contraction are listed below.

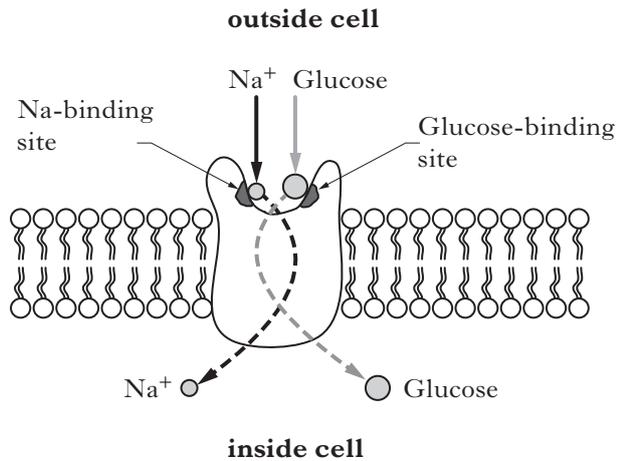
- 1 Phosphate ion released from myosin head.
- 2 ATP binds to myosin head and causes it to detach from actin filament.
- 3 Myosin head swings forward and attaches to actin filament.
- 4 Myosin head drags along actin filament.

The sequence in which these stages occur is

- A 2, 1, 3, 4
 B 2, 3, 1, 4
 C 3, 2, 1, 4
 D 3, 2, 4, 1.

[Turn over

5. The diagram below shows cotransport (symport) of sodium ions (Na^+) and glucose into a cell lining the gut.



Which line in the table below represents the relative concentrations of glucose and Na^+ on the two sides of the plasma membrane when cotransport occurs?

	<i>Sodium</i>		<i>Glucose</i>	
	<i>Outside cell</i>	<i>Inside cell</i>	<i>Outside cell</i>	<i>Inside cell</i>
A	high	low	low	high
B	high	low	high	low
C	low	high	low	high
D	low	high	high	low

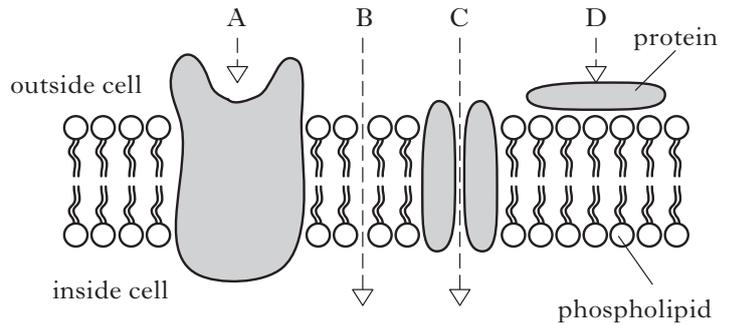
6. A typical cell is estimated to possess 4×10^{11} potassium ions. Only 10^7 of these are used in establishing membrane potential.

What fraction of the total potassium ions is involved in this function?

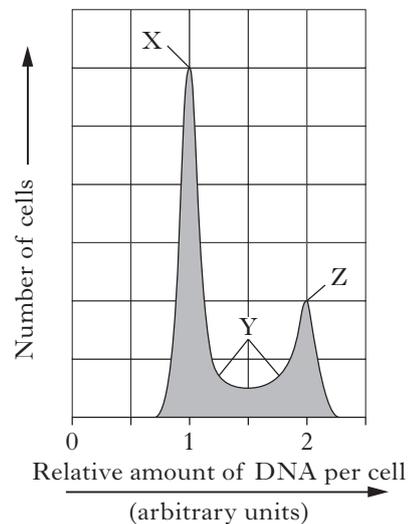
- A 1/250
- B 1/2500
- C 1/30000
- D 1/40000

7. Cortisol is a steroid hormone.

Which letter in the diagram below shows the first stage in cell signalling for this hormone?



8. The figure below shows the relative DNA content of cells from a culture.



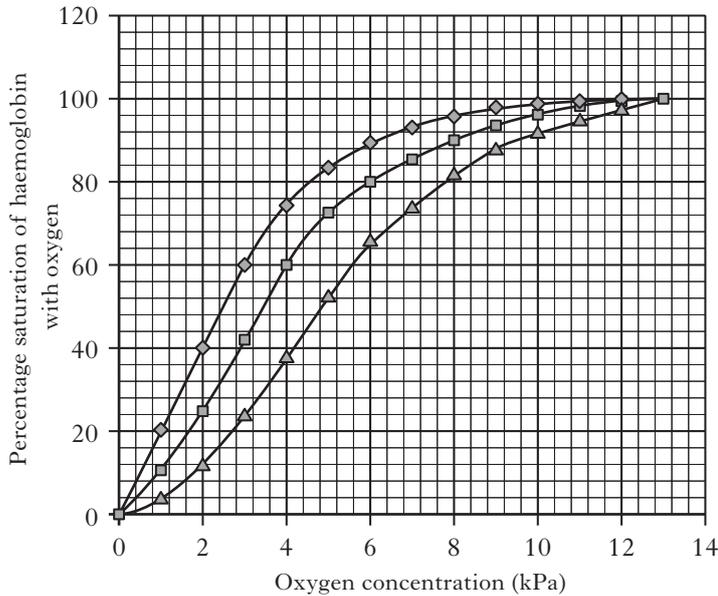
In which two phases of the cell cycle are cells in region Z?

- A G1 and S
- B S and G2
- C G2 and M
- D M and G1

9. Which of the following would **not** be a substrate for caspases?

- A DNA
- B actin
- C histone
- D tubulin

10. The graph below shows the effect of carbon dioxide concentration on the affinity of haemoglobin for oxygen at different concentrations of oxygen.



- ◇— carbon dioxide concentration = 2.7 kPa
- carbon dioxide concentration = 5.3 kPa
- △— carbon dioxide concentration = 10.7 kPa

A list of possible conclusions is given below.

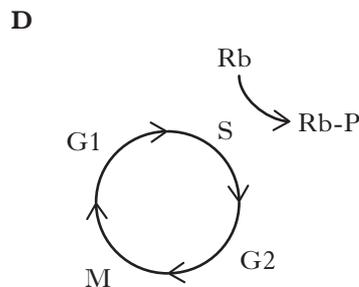
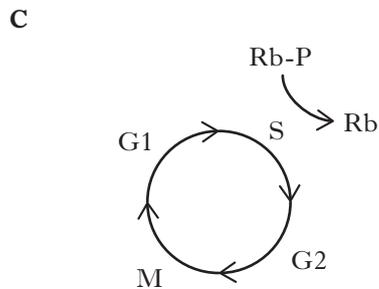
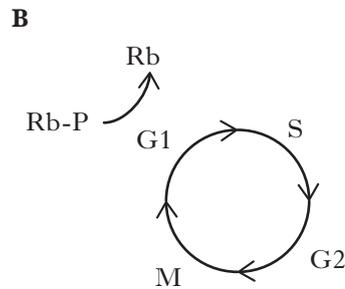
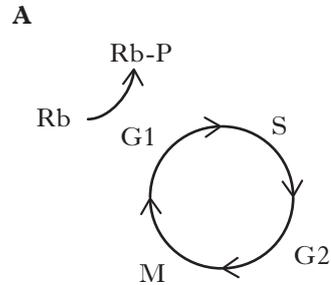
- 1 Increasing the concentration of carbon dioxide decreases the affinity of haemoglobin for oxygen.
- 2 Increasing the concentration of carbon dioxide increases the affinity of haemoglobin for oxygen.
- 3 Increasing the concentration of oxygen decreases the affinity of haemoglobin for oxygen.
- 4 Increasing the concentration of oxygen increases the affinity of haemoglobin for oxygen.

Which conclusions are valid for the data shown in the graph between oxygen concentrations of 2 kPa and 10 kPa?

- A 1 and 3
- B 1 and 4
- C 2 and 3
- D 2 and 4

11. Retinoblastoma protein (Rb) has a role in regulating progress through the cell cycle. It can be phosphorylated (Rb-P) or unphosphorylated (Rb).

Which of the following diagrams represents how the protein is altered to let the cycle progress?



[Turn over

12. Which line in the table below correctly describes processes underpinning evolution?

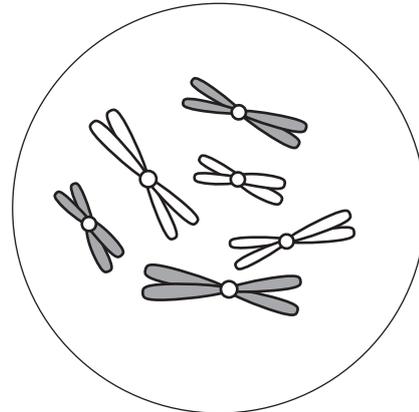
	<i>Random</i>	<i>Non-random</i>
A	Mutation	Genetic drift
B	Genetic drift	Mutation
C	Genetic drift	Sexual selection
D	Natural selection	Genetic drift

13. In evolutionary theory, fitness can be described in absolute or relative terms.

Absolute fitness is the ratio of

- A surviving offspring of one phenotype compared with other phenotypes
- B surviving offspring of one genotype compared with other genotypes
- C frequencies of a particular phenotype from one generation to the next generation
- D frequencies of a particular genotype from one generation to the next generation.
14. Chiasmata form when the chromosomes are arranged
- A as pairs during meiosis I
- B individually during meiosis I
- C as pairs during meiosis II
- D individually during meiosis II.

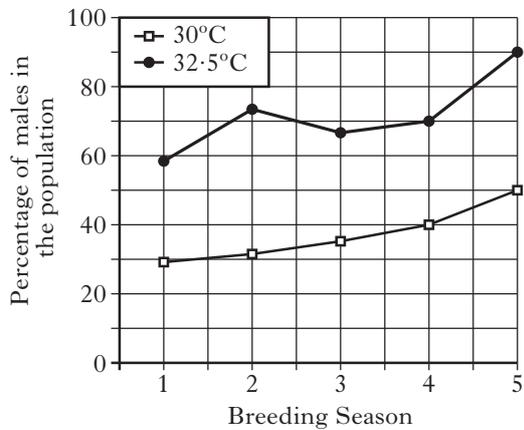
15. The figure below shows a nucleus in the early stages of meiosis I. Paternal chromosomes are shaded, maternal chromosomes are unshaded.



How many different gametes would be produced as a result of independent assortment?

- A 2
- B 6
- C 8
- D 12
16. In mammals, some genes are present on the Y chromosome but not on the X chromosome. An allele of one such gene causes deafness. What is the chance of a male with deafness caused in this way having a child who inherits his condition?
- A 0%
- B 25%
- C 50%
- D 100%
17. In some species of bird the females are larger than the males. This is described as
- A lekking
- B reversed sexual dimorphism
- C sexual dimorphism
- D female choice.

18. Eggs from leopard geckos kept in breeding cages were collected and incubated at two temperatures over five breeding seasons. When each new gecko hatched, its gender was noted. The graph below shows how temperature affected gender in the population.



How many females would be present in a population of 500 leopard geckos after four seasons at 32.5 °C?

- A 150
 B 200
 C 300
 D 350
19. The beef tape worm (*Taenia saginata*) lives within the small intestine of humans. For part of its life cycle, it does not have a digestive system. Therefore, the parasite is said to
- A be degenerate
 B be a micro-parasite
 C occupy its fundamental niche
 D co-exist by resource partitioning.
20. Which line in the table below correctly describes the ecological niche of a parasite?

	<i>Niche</i>	<i>Host specificity</i>
A	Wide	High
B	Wide	Low
C	Narrow	High
D	Narrow	Low

21. The virulence of an infectious organism is defined as the *case fatality risk* (CFR). CFR can be represented as the percentage of infections that result in death. The table below shows the numbers of people infected by the “bird flu” virus (H5N1) and the numbers who died from it over a five year period.

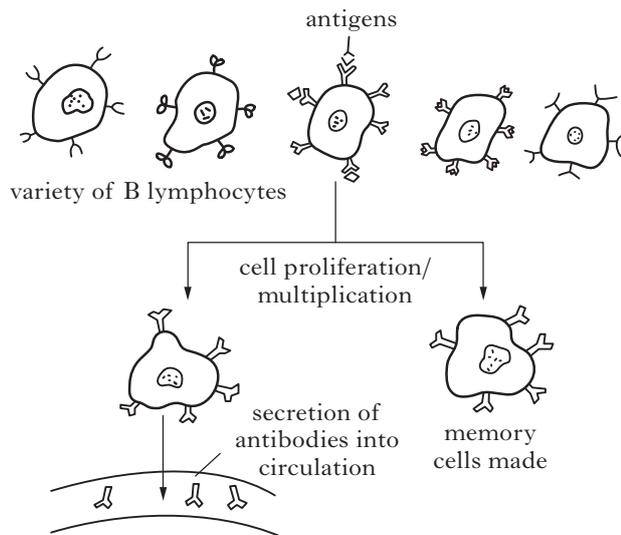
<i>Year</i>	2004	2005	2006	2007	2008
Total infections of H5N1	46	98	115	88	44
Number dying from H5N1 infection	32	43	79	59	33

In which year was H5N1 most virulent?

- A 2004
 B 2006
 C 2007
 D 2008

[Turn over

22. The diagram below shows a response to foreign antigens.



Which of the following correctly identifies this cellular response?

- A apoptosis
 B phagocytosis
 C clonal selection
 D inflammatory response
23. NHS Scotland vaccinates as many children as possible with measles vaccine. This helps to reduce the spread of measles, and provides a level of protection to those vulnerable children who do not get the vaccine.
- The protection of non-vaccinated, vulnerable children is an example of
- A epidemiology
 B herd immunity
 C immune surveillance
 D immunological memory.

24. Rabbits can be infested with nematode parasites in their gut.

Infestation by nematodes may be a major factor controlling population density of rabbits.

Which of the following procedures would test this hypothesis?

Comparing rabbit population densities in

- A infested populations from areas with different food supplies
 B rabbits infested with nematodes or with other parasites
 C areas with and without competition from other herbivores
 D infested and non-infested rabbit populations.
25. The following formula can be used to estimate population size from mark and recapture data.

$$N = MC/R$$

Where N = population estimate

M = number first captured, marked and released

C = total number in second capture

R = number marked in second capture

In a survey to estimate a rabbit population, the following data were obtained:

Rabbits captured, marked and released	= 240
Marked rabbits in second capture	= 80
Unmarked rabbits in second capture	= 280

The estimated population of the rabbits was

- A 560
 B 600
 C 840
 D 1080.

[END OF SECTION A]

Candidates are reminded that the answer sheet MUST be returned INSIDE the front cover of the answer book.

[Turn over for SECTION B on *Page ten*

SECTION B

All questions in this section should be attempted.

All answers must be written clearly and legibly in ink.

1. Two types of muscle, red and white, can be distinguished by their colour in samples of fresh tissue and can be easily separated. Red muscle cells obtain energy mainly using aerobic respiration: they have many large mitochondria and a good supply of oxygen. White muscle cells obtain energy mainly by anaerobic respiration: they have fewer mitochondria and a poorer oxygen supply. In both muscle types, glucose is the substrate for respiration. It is widely thought that the mechanism of glucose transport into these cells is the step that limits their ability to use glucose, and it is considered that red muscle cells have a greater capacity for glucose transport than white muscle cells.

Glucose diffuses into cells through glucose transporters (GLUTs), which are protein molecules embedded in cell membranes. There are several types of GLUT. GLUT1 is responsible for glucose uptake in all cells; the membranes of muscle and fat cells also contain GLUT4.

The study below investigated the contribution of these two GLUTs to glucose uptake in red and white muscle cells, before and after exposure to insulin. Figure 1 shows the effect of insulin on glucose transport in the two types of muscle.

An extract of membranes from the muscle cells was centrifuged to separate it into two portions, plasma membrane (PM) and the internal membranes (IM) from the cytoplasm. The protein components of the membranes were separated by gel electrophoresis and blotted. The blots were exposed to radioactively-labelled antibodies specific for each of the two GLUT proteins, to allow identification and quantification.

Figure 2 shows the percentage change in total GLUT level in the two membrane fractions following the insulin treatment. In Figure 3, the blots indicate the changing abundances of the two GLUTs. Figure 4 shows the relative amount of GLUT4 in the two muscle types in response to insulin. Error bars show *standard error*.

Figure 1: Glucose transport with and without insulin

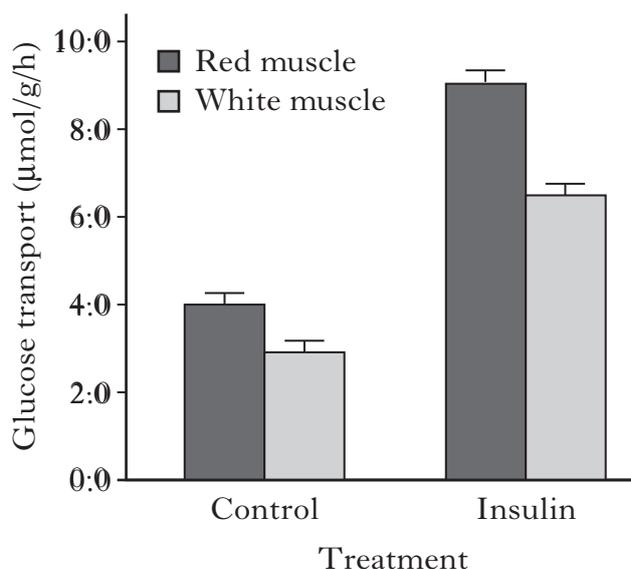
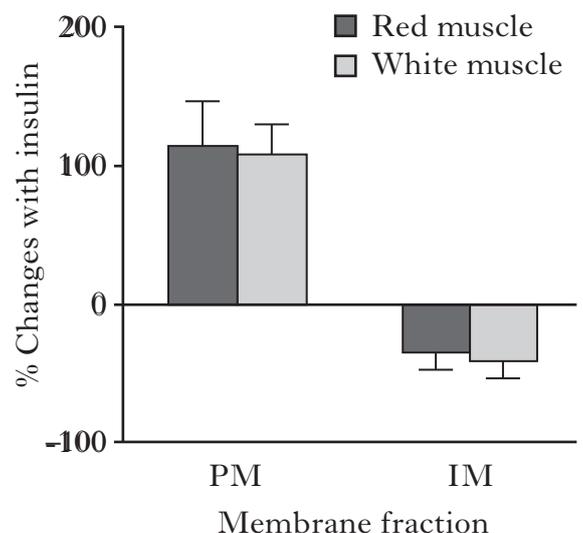


Figure 2: Effect of insulin on total GLUT levels



Question 1 (continued)

Figure 3: Blots showing the effect of insulin on the distribution of GLUTs 1 and 4

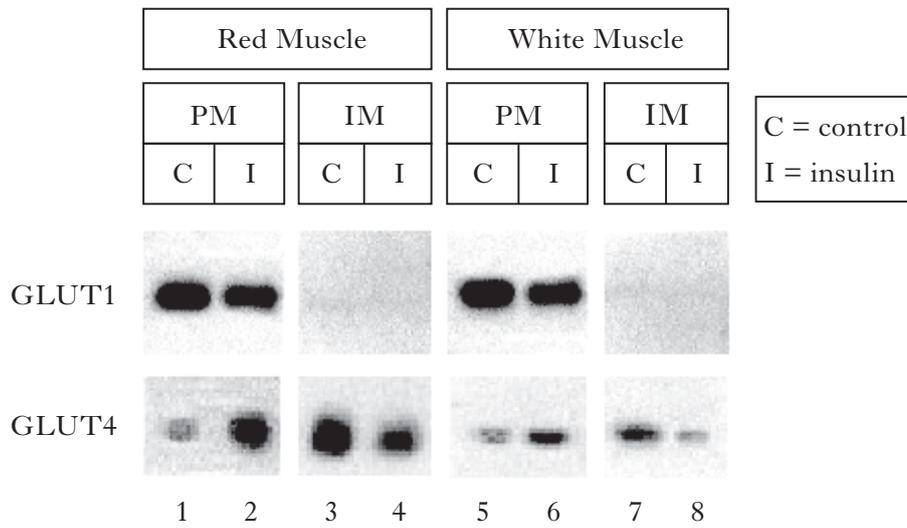
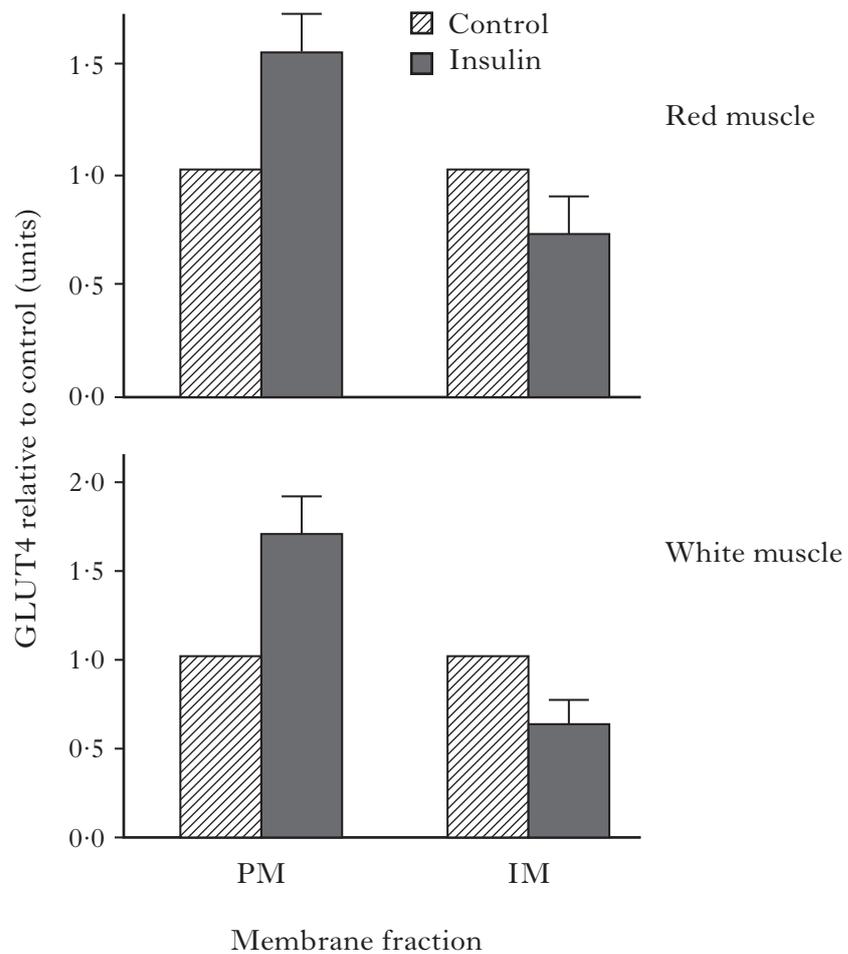


Figure 4: Relative amounts of GLUT4 quantified from several blots



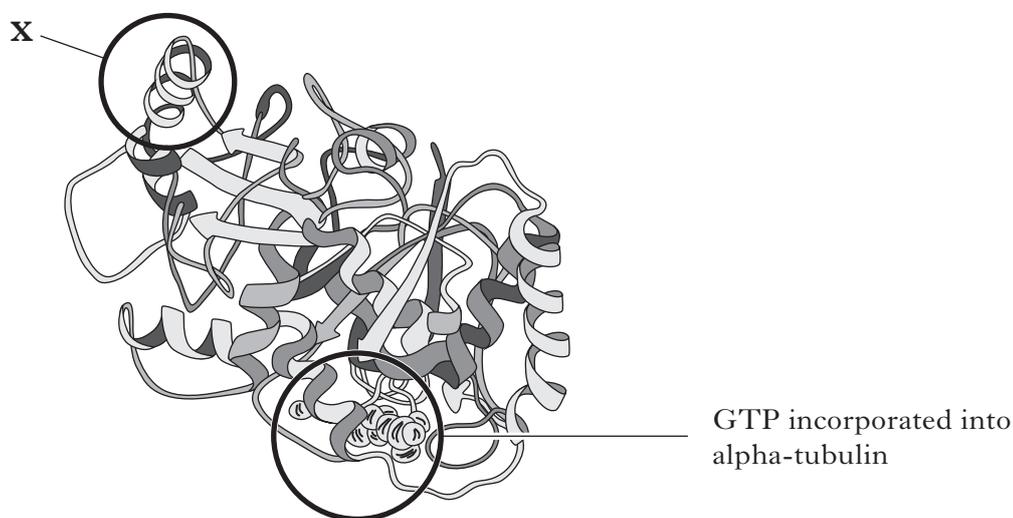
[Question 1 continues on Page twelve

Question 1 (continued)

- (a) Use data from Figure 1 to support the statement that “red muscle cells have a greater capacity for glucose transport than white muscle cells”. 2
- (b) Figure 2 shows that GLUT increases in the PM fraction and decreases in the IM fraction after insulin treatment. It was concluded that both muscle types have the same underlying GLUT response to insulin.
Explain how the error bars confirm this conclusion is valid. 1
- (c) Refer to Figure 3.
- (i) Describe the distribution of GLUT1 in muscle cells before insulin treatment. 1
- (ii) Give **one** conclusion about the effect of insulin treatment on GLUT1. 1
- (iii) What evidence is there that the effect of insulin on the distribution of GLUT4 is the same in both types of muscle? 1
- (d) It was hypothesised that insulin triggers the transport of additional GLUT4 to the plasma membrane from storage on membranes in the cytoplasm, and that this “recruitment” mechanism is greater in red muscle cells.
How do the results from Figures 3 and 4 support this hypothesis? 2
- (e) Explain how glucose uptake by cells is reduced in Type 2 diabetes. 2
- (10)**

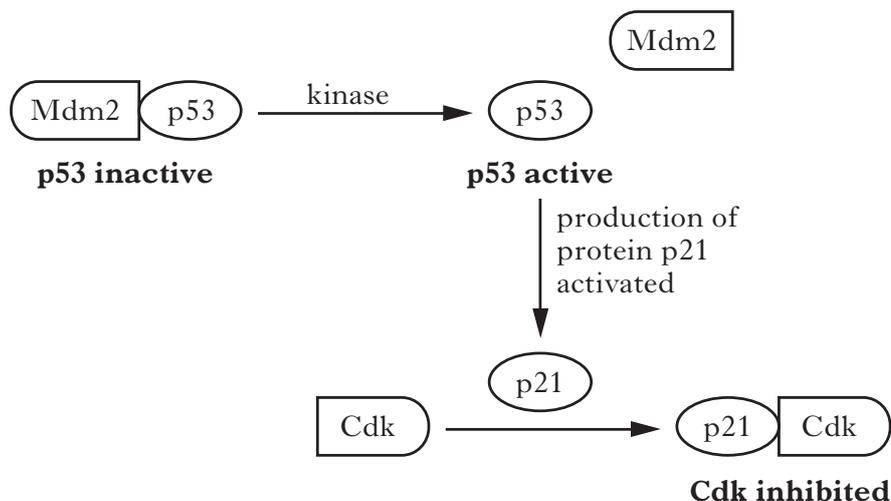
[Question 2 is on fold-out Page thirteen

2. Tubulin is described as a *dimer* because it is made of two polypeptide subunits, alpha-tubulin and beta-tubulin. Both subunits contain GTP, a molecule that is similar to ATP but has the base guanine instead of adenine. A representation of alpha-tubulin is shown below.



- (a) (i) Name the type of bonding that maintains the secondary structure component labelled X. 1
- (ii) What term is used to describe a component, such as GTP, embedded in a polypeptide? 1
- (b) Microtubules are straight, hollow rods that extend by the addition of more dimers in columns at the 'growing' end.
- (i) During mitosis, to which structures do the two ends of a spindle fibre normally attach? 1
- (ii) What is the role of spindle microtubules in cell division? 1
- (iii) Various drugs, introduced into the bloodstream during chemotherapy, treat cancer by blocking the formation of microtubules.
- Suggest **one** disadvantage of treating tumours with drugs that target microtubule formation. 1
- (5)**

3. The protein p53 plays an important role in controlling cell division. The diagram below represents how the activation of p53 can result in arrest of the cell cycle.

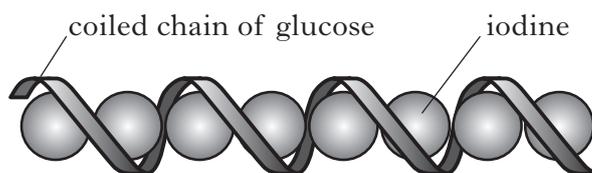


- (a) Explain why binding of p21 protein to cyclin dependent kinase (Cdk) prevents the cell cycle from progressing. 2
- (b) Give **one** trigger that would stimulate the activation of p53. 1
- (c) Apart from arrest of the cell cycle, give one other fate of a cell that has had p53 activated. 1
- (d) Explain why it is important that the cell cycle is controlled in a multicellular organism. 2

(6)

4. Starch consists of glucose molecules in long coiled chains, periodically joined at branching points. In the iodine test for starch, the iodine lies within the coils and the solution has a blue/black colour.

Marks

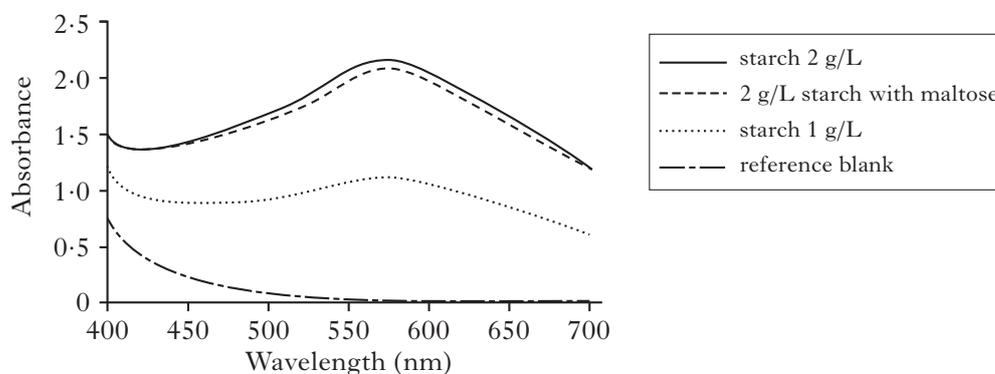


The enzyme alpha amylase (α -amylase) hydrolyses starch into maltose and *dextrins* (short chains of glucose molecules). Samples taken from an α -amylase/starch mixture, when reacted with iodine solution, will show changes in colour as hydrolysis proceeds. Different reaction products contribute different colours, as shown below.



Within an investigation to test the effect of an inhibitor on the rate of amylase activity, researchers needed to develop a quick way to measure starch concentrations. They produced a colorimetric method based on the starch-iodine colour change. Part of the experiment to find the best wavelength is outlined below.

Amylase buffered at pH7 was incubated with different reaction mixtures at optimum temperature. After 30 minutes, hydrochloric acid was used to stop any enzyme action and then the iodine solution was added to produce the colour. Absorbance was measured across a range of wavelengths for different reaction mixtures, as shown in the graph below.



- (a) What term describes an experiment, like the one outlined, that is developing a technique within a larger investigation? 1
- (b) To serve its purpose as a control, what would be left out of the reference blank? 1
- (c) The researchers concluded that 580 nm would be the best wavelength for quantifying amylase activity by this method.
- (i) Explain how they arrived at this conclusion. 1
- (ii) The results show that the presence of the reaction product maltose is not a confounding variable. Explain what is meant by the term confounding variable. 1
- (iii) How do the results show that the method will be valid in investigating the effect of amylase inhibitor on the rate of starch breakdown? 1

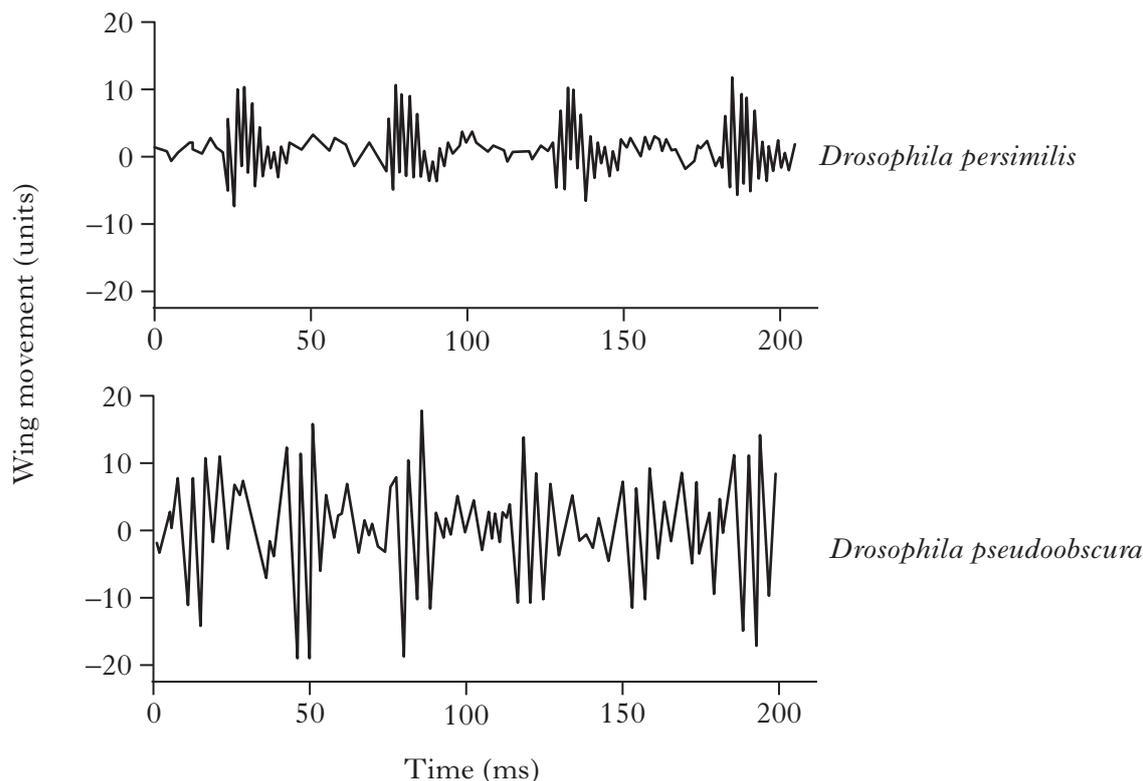
(5)

6. The 'songs' produced by male fruit flies (*Drosophila* spp.) are important courtship stimuli. The songs are produced by patterns of rapid wing vibration in short pulses.

(a) For a male fruit fly, what would constitute 'successful' courtship?

1

- (b) The figure below shows recorded courtship songs of two related species of fruit fly, *Drosophila persimilis* and *Drosophila pseudoobscura*. These two species have similar distributions in western North America. Each song can be seen as a series of 'pulses' separated by short time intervals.



- (i) Use the figure to compare pulse frequencies of the two species.

1

- (ii) Females of both species discriminate against males that are not of their own species, whilst males will court females of either species.

Use the concept of investment to explain the importance of courtship songs to females.

2

- (iii) Why can the courtship song of male *Drosophila* flies be regarded as a characteristic that has undergone sexual selection?

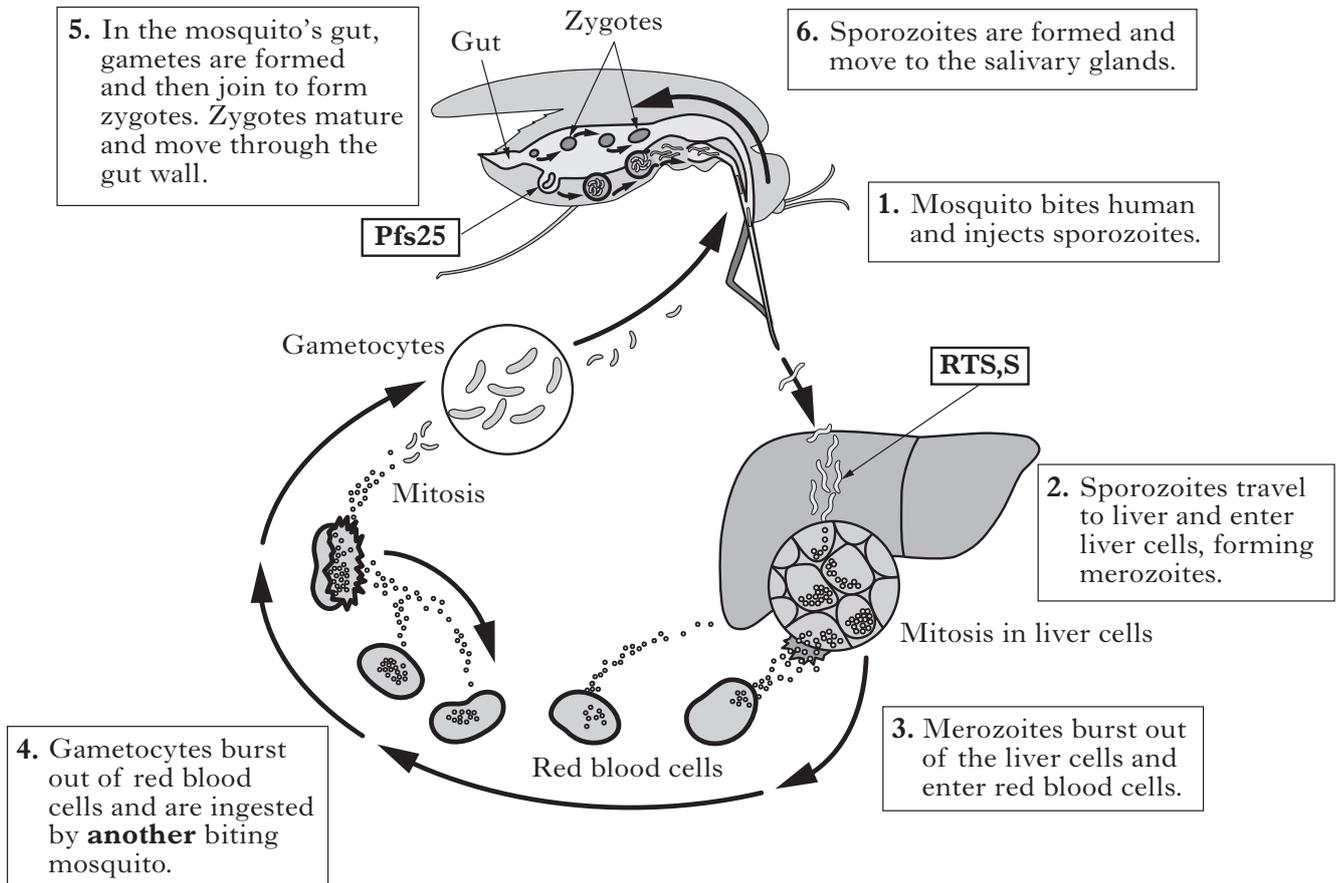
1

(5)

[Turn over

7. The figure below shows the life cycle of *Plasmodium falciparum*, a parasite that causes malaria in humans. The figure also shows stages in its life cycle targeted by two human vaccines, the zygote stage by **Pfs25** and the sporozoite stage by **RTS,S**. Marks

Pfs25 is a protein produced by *P. falciparum* when in the mosquito's gut. It allows the mature zygote stage of the parasite to get through the gut wall so that it can pass back to the mosquito's salivary glands. RTS,S vaccine induces the production of antibodies against the main coat protein of the sporozoite stage and stimulates T lymphocyte formation.



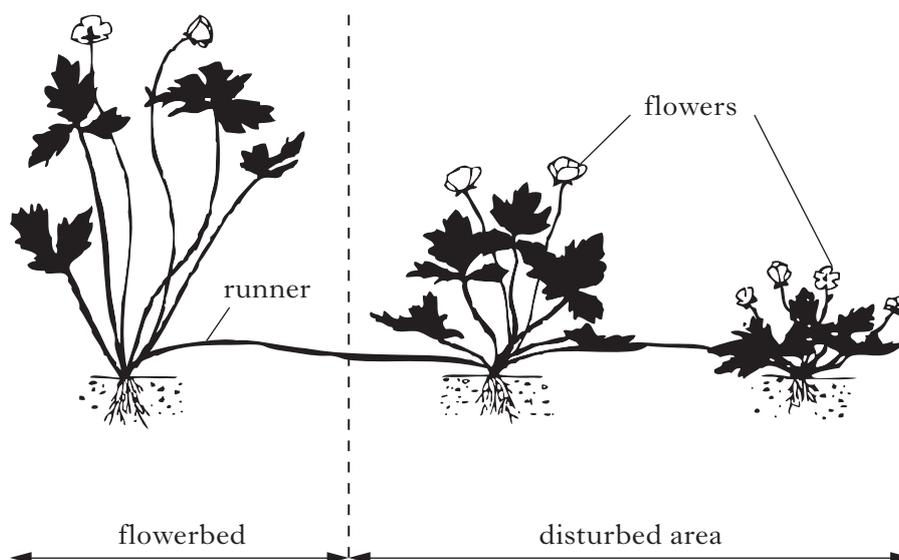
- (a) Explain why the mosquito is described as a vector. 1
- (b) Which of the two hosts involved in this life cycle may be described as the *definitive host*? Justify your answer. 1
- (c) (i) From the information given, describe how *P. falciparum* manages to avoid exposure to the human immune system. 1
- (ii) Describe **one** other way in which parasites in general can reduce their chance of being destroyed by the host immune responses. 1

Question 7 (continued)

- (d) A great deal of research is taking place to develop vaccines that can protect people from malaria by stimulating the human immune system.
- (i) A preparation of Pfs25 protein stimulates antibody production in the human host.
 1. State how these antibodies reach the mosquito gut. 2
 2. Describe the effect of these antibodies in the mosquito. 2
 - (ii) Explain why the Pfs25 vaccine does not prevent malaria in the individual taking it but could reduce the occurrence of disease in the population. 2
 - (iii) The aim with RTS,S is to reduce the ability of *P. falciparum* to infect and survive in the liver. How will antibodies and T cells differ in their attack on the sporozoite stage of the malarial parasite? 2

(10)

8. (a) The spread of a buttercup plant, *Ranunculus repens*, from an established flowerbed into a nearby disturbed area, is shown in the illustration below.



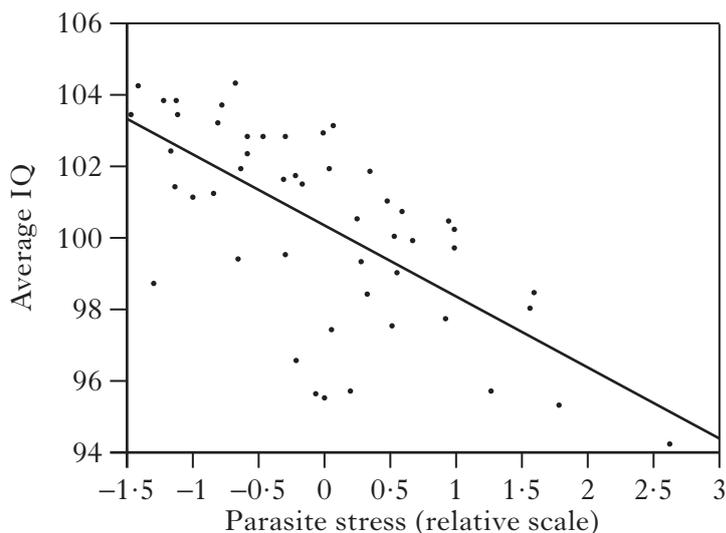
- (i) What is meant by the term *hermaphroditic* as it applies to plants, such as the buttercup? 1
 - (ii) Explain how asexual reproduction is of advantage to the buttercup in the colonisation of this disturbed area. 1
- (b) What term describes the mode of asexual reproduction in arthropods where offspring arise from unfertilised eggs? 1

(3)

9. The *parasite – stress hypothesis* states that children who contract parasites have reduced cognitive abilities (on average). Some research has shown that parasites alone account for 67% of the worldwide variation in intelligence (IQ) and that there is a significant negative correlation between the prevalence of parasitic infection in a country and the average IQ of its population.

To test this hypothesis, researchers examined data from each of the states making up the USA. Results from their study are shown in the scatterplot below.

Correlation between average US state IQ and relative values for infectious disease stress



- (a) Explain why parasitic infections might result in lower intelligence in a developing individual. 2
- (b) Explain why the results are thought to have low reliability. 1
- (c) As a criticism of the parasite-stress hypothesis, it has been argued that “correlation does not necessarily indicate causation”.

With reference to the scatterplot, explain the phrase “correlation does not necessarily indicate causation”. 2

- (d) If the parasite-stress hypothesis is accepted, predict what should happen to the average IQ of a nation undergoing economic development. Justify your prediction. 1

(6)

10. Answer **either A or B**.

A. Discuss photoreception in animal eyes under the following headings:

(i) photoreceptor system proteins;

6

(ii) triggering of a nerve impulse.

4

OR

(10)

B. Discuss the movement of ions across membranes under the following headings:

(i) mechanism and functions of Na/KATPase;

6

(ii) nerve transmission.

4

(10)

[END OF SECTION B]

[END OF QUESTION PAPER]

ACKNOWLEDGEMENT

Section B Question 5 – 110220368 Shutterstock.com