Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

A-level
BIOLOGY

Paper 3

Monday 17 June 2019 Morning Time allowed: 2 hours

Materials

For this paper you must have:
- a ruler with millimetre measurements
- a scientific calculator.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions in **Section A**.
- Answer **one** question from **Section B**.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Show all your working.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for the questions are shown in brackets.
- The maximum mark for this paper is 78.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	

Do not write outside the box

Section A

Answer **all** questions in this section.

You are advised to spend no more than one hour and 15 minutes on this section.

0 1 . 1 Describe how ultrafiltration occurs in a glomerulus.

[3 marks]

0 1 . 2 Glucose and water are reabsorbed by the proximal convoluted tubule of a nephron.

Put a tick (✓) in the box next to the correct ways in which glucose and water are reabsorbed.

[1 mark]

Glucose by active transport and water against a water potential gradient ☐

Glucose by diffusion and water down a water potential gradient ☐

Glucose by facilitated diffusion and active transport and water against a water potential gradient ☐

Glucose by facilitated diffusion and active transport and water down a water potential gradient ☐

Do not write outside the box

0 1 . 3 The equation shows the relationship between urine concentration in arbitrary units (y) and mean length of the loop of Henle in mm (x).

$$y = 0.72x + 4$$

Calculate the mean length of the loop of Henle in an organism that produces urine with a concentration of 16.56 arbitrary units.

[1 mark]

Answer = _____ mm

Question 1 continues on the next page

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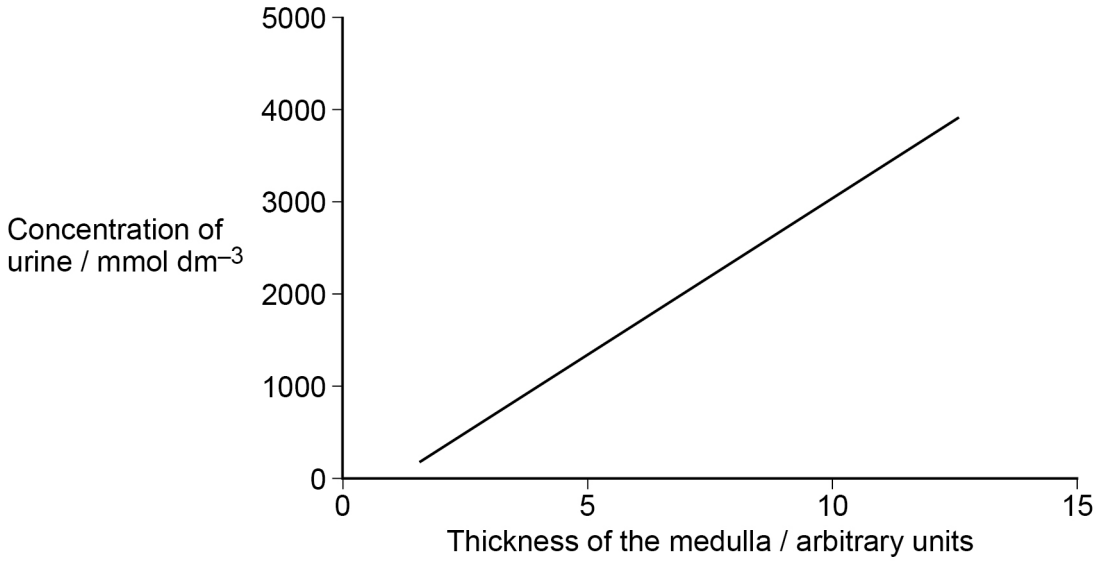
0 1 . 4 Scientists investigated the relationship between the thickness of the kidney medulla of different species of mammals and the concentration of their urine.

Figure 1 shows their results.

Figure 1



Explain the pattern shown by the results in **Figure 1**.

[3 marks]

8

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0 2 . 1 Describe the role of saprobionts in the nitrogen cycle.

[2 marks]

0 2 . 2 One environmental issue arising from the use of fertilisers is eutrophication. Eutrophication can cause water to become cloudy.

You are given samples of water from three different rivers.

Describe how you would obtain a quantitative measurement of their cloudiness.

[3 marks]

5

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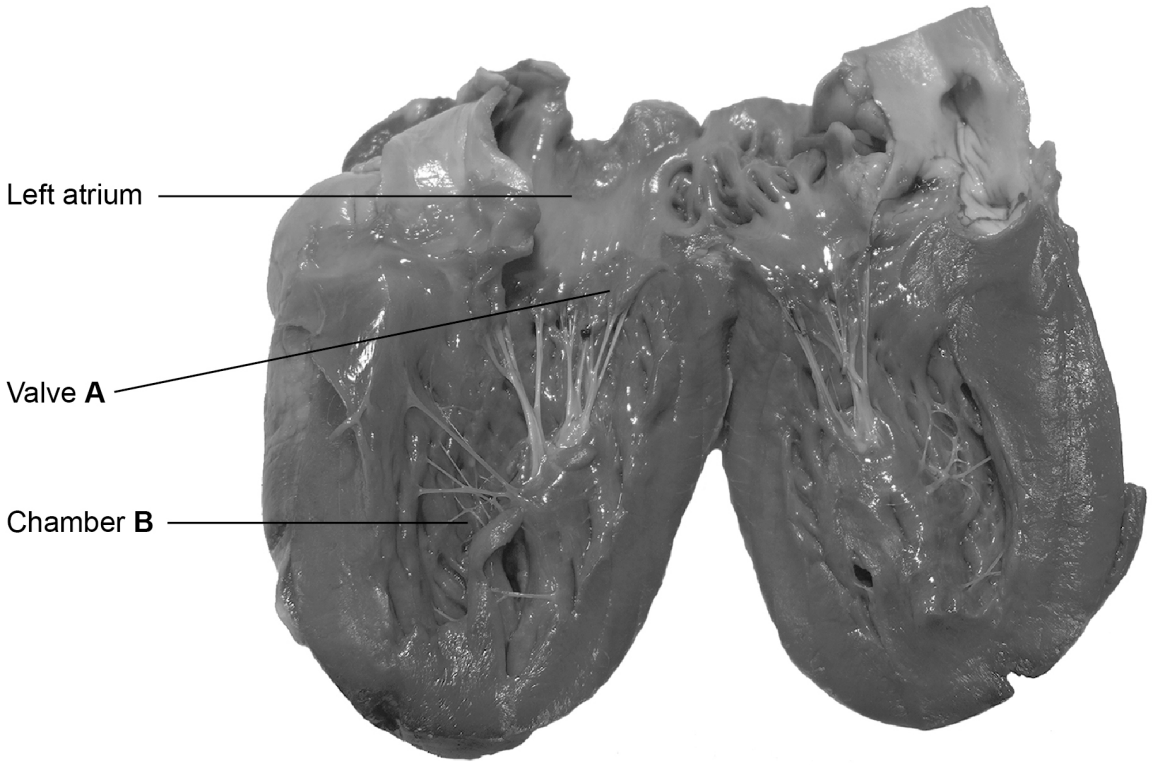
0 3 **Figure 2** shows a photograph of a dissected heart.

Figure 2



0 3 . 1 Name valve **A** and chamber **B**.

[1 mark]

Valve **A** _____

Chamber **B** _____

0 3 . 2 Give **two** safety precautions that should be followed when dissecting a heart.

[1 mark]

1 _____

_____

_____

_____

2 _____

_____

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0 3 . 3 Explain how valve **A** in **Figure 2** maintains a unidirectional flow of blood.

[2 marks]

Question 3 continues on the next page

Do not write outside the box

A research scientist investigated the effect of caffeine on heart rate in human volunteers.

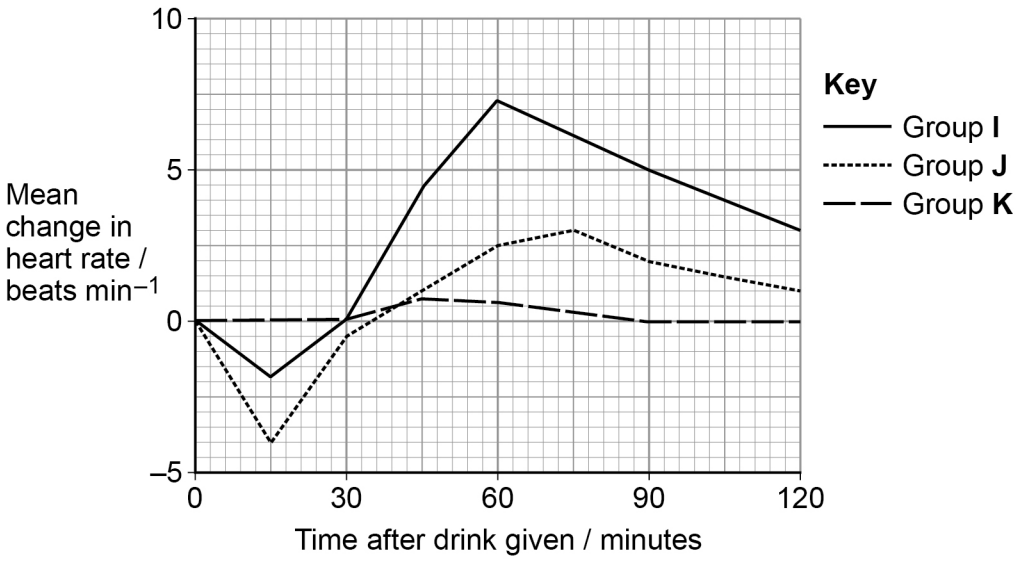
The scientist divided volunteers into three groups. Each group was given the same volume of fluid.

- Each member of Group **I** was given a sports drink containing caffeine and sugar.
- Each member of Group **J** was given a sports drink containing caffeine and no sugar.
- Each member of Group **K** was given water.

The scientist recorded the volunteers' heart rate before the drink was given and for 120 minutes after the drink was given.

Her results can be seen in **Figure 3**.

Figure 3



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0 3 . 4 Caffeine affects the autonomic nervous system.

Suggest how caffeine could account for the results of Group **I** in **Figure 3** at 60 minutes.

[2 marks]

_____

_____

_____

_____

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_____

_____

_____

0 3 . 5 Before taking the drink, the mean heart rate of Group **J** was 68 beats per minute.

Fifteen minutes after taking the drink, the mean volume of blood leaving the hearts of Group **J** was 4700 cm^3 per minute.

Calculate the mean volume of blood leaving the heart at each beat fifteen minutes after taking the drink.

[1 mark]

Answer = _____ cm^3

Question 3 continues on the next page

Do not write outside the box

0 3 . 6 The increase seen in Group **I** could be due to the combination of caffeine and sugar.

Suggest **one** drink to be given to an **additional** group that should be investigated to find out if this is true.

Give a reason for your answer.

[2 marks]

Group to be given _____

_____

_____

Reason _____

_____

_____

_____

_____

_____

_____

9

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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0 4 Mitochondrial DNA (mtDNA) is a small circular DNA molecule located in mitochondria. It is 16 569 nucleotides long and contains 37 genes and a control region.

Sports scientists investigated whether a mutation in the control region of mtDNA in human males was related to an ability to exercise for longer.

- The males in Group **T** had thymine at nucleotide position 16 519
- The males in Group **C** had a mutation resulting in cytosine at nucleotide position 16 519

0 4 . 1 The control regions of Group **T** and Group **C** were the same length.

Name the type of gene mutation that is most likely to have occurred at nucleotide position 16 519

[1 mark]

Group **T** and Group **C** completed the same 8-week training programme. The following measurements were taken at the start of the 8-week programme, and again at the end.

1. $VO_{2\,max}$ (a measure of maximal oxygen uptake).
2. Citrate synthase (CS) activity (CS is an enzyme involved in the Krebs cycle).

The scientists then calculated the percentage increase in each measurement in both groups.

Figure 4 and **Figure 5** show their results.

Figure 4

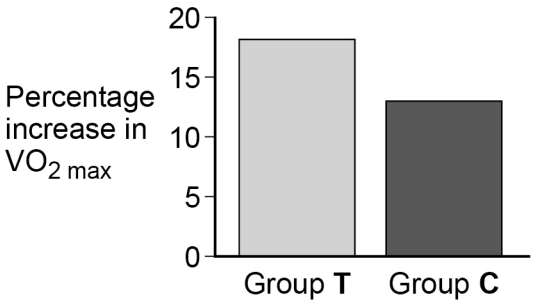
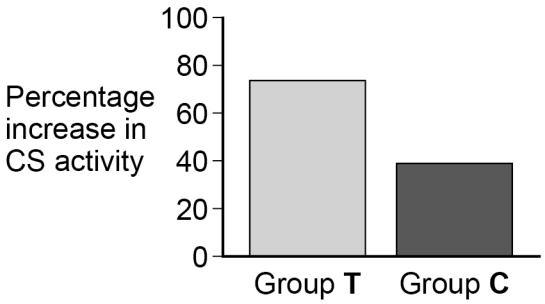


Figure 5



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0 4 . 2 A student concluded from **Figure 4** and **Figure 5** that training has a positive effect on $VO_{2\,max}$ and CS activity.

Evaluate the student's conclusion.

[3 marks]

0 4 . 3 The mitochondrial DNA (mtDNA) control region is an area of mtDNA that is non-coding. This region stimulates the synthesis of both mtDNA and mitochondrial messenger RNA.

Use this information to suggest **two** reasons why the mutation at nucleotide position 16 519 could lead to the differences seen in **Figure 5**.

[2 marks]

1

2

Question 4 continues on the next page

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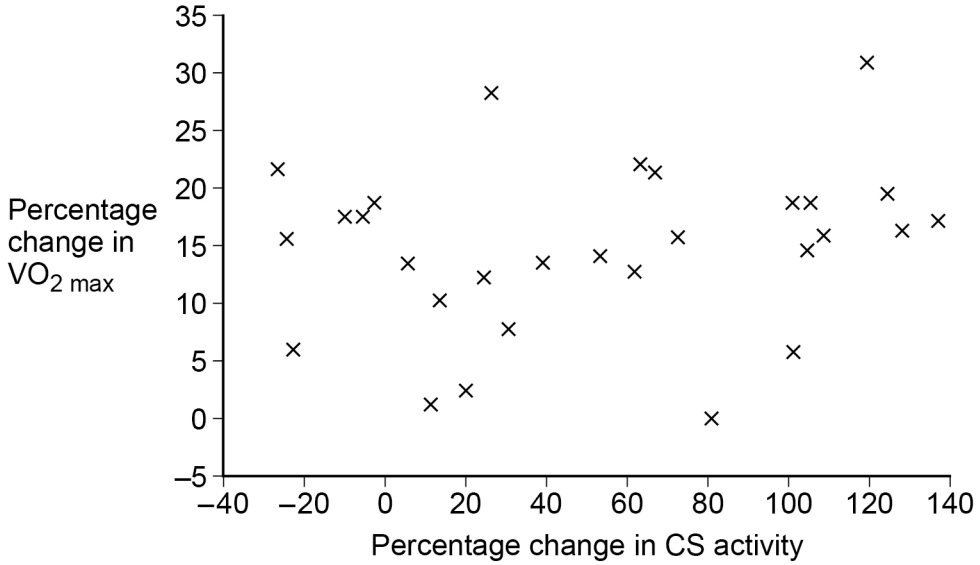
The sports scientists investigated whether there was a correlation between the percentage change in $VO_{2\,max}$ and percentage change in CS activity in Group **T**.

Figure 6 shows their results.

Figure 6



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0 4 . 4 'Having thymine at nucleotide position 16 519 in Group **T** causes an increase in ability to exercise for longer.'

Evaluate this conclusion.

Use **all** the data in this question.

[3 marks]

[**Extra space]**

9

Turn over for the next question

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0 5 The crown-of-thorns starfish (COTS) is one of the main causes of the decline of the world's coral reefs.

Marine biologists used a choice chamber to investigate the effects of flashing and constant light on the behaviour of COTS.

Table 1 shows their results as they presented them. The P values show results from a statistical test.

Table 1

Behaviour of COTS	**Type of light used in choice chamber**	
	Flashing	**Constant**
COTS moving towards the stimulus	22	12
COTS moving away from the stimulus	28	38
P value	0.69	0.02

0 5 . 1 State a null hypothesis the marine biologists tested in this investigation.

[1 mark]

_____

_____

_____

_____

0 5 . 2 The natural habitat of COTS is coral reefs of tropical oceans.

Suggest **two** factors that should be kept constant in the choice chambers so that COTS display normal behaviour.

[1 mark]

1 _____

2 _____

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0 5 . 3 A journalist studying **Table 1** suggested that **either** type of light could be used to cause COTS to move away from coral reefs.

Evaluate the journalist's suggestion.

[3 marks]

0 5 . 4 One of the reasons COTS can destroy coral reefs in a short time is because COTS move quickly, allowing them to move from one reef to another.

Table 2 shows the maximum speeds recorded of COTS in constant light.

Table 2

Response to light	**Maximum speed / mm min^{-1}**
COTS moving towards constant light	259
COTS moving away from constant light	564

Calculate the shortest time one COTS would take to move up a coral reef from 66 m under water to 18 m under water in hours of daylight.

Give your answer to the nearest hour.

[2 marks]

Answer = _____ hours

7

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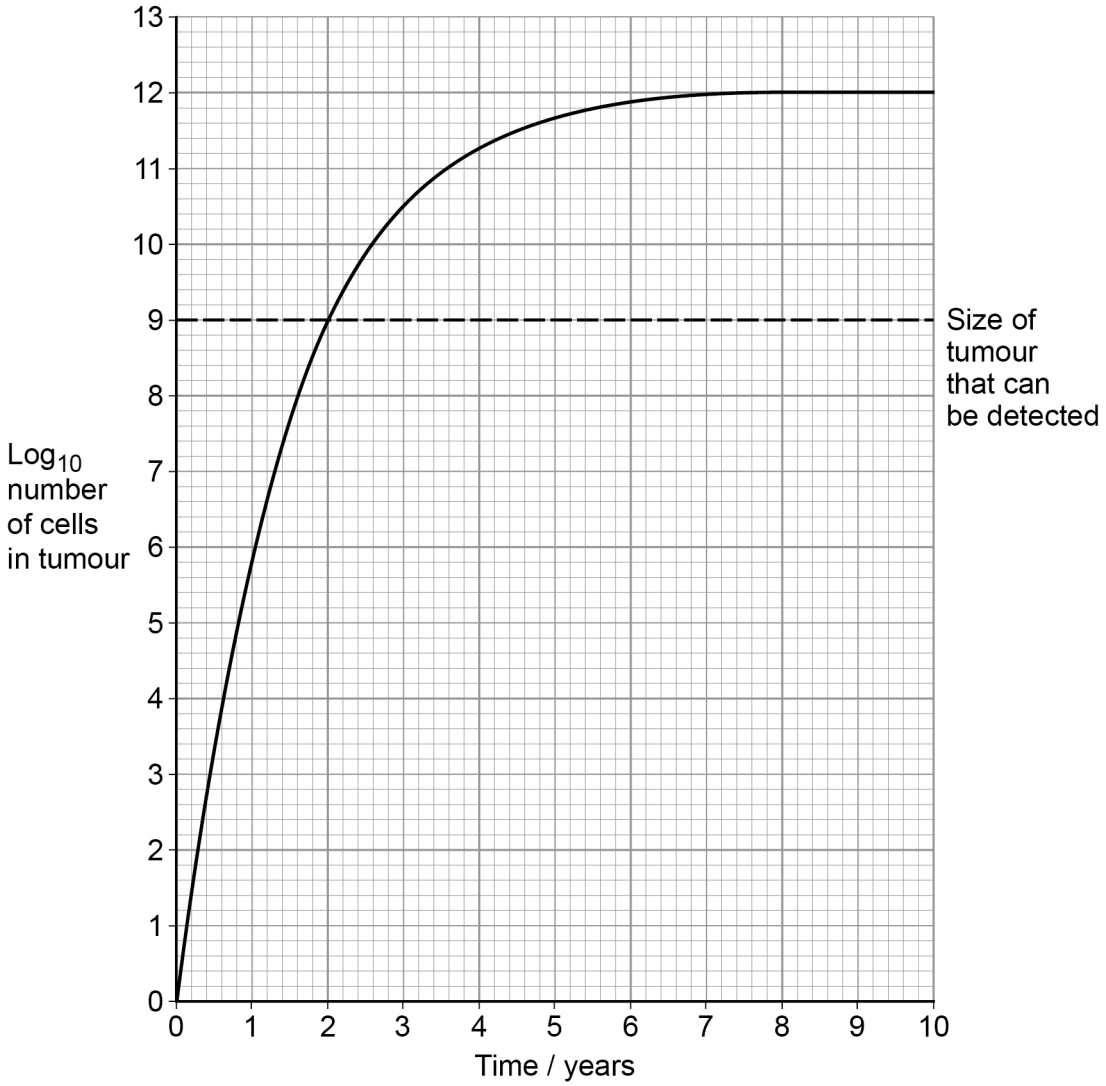
0 6 Uncontrolled cell division can cause tumours to form.

Figure 7 shows the growth pattern followed by a type of tumour.

Figure 7



0 6 . 1 Use **Figure 7** to calculate the percentage of maximum growth this type of tumour reaches before it can be detected.

You will need to use the 10^x button on your calculator.

[1 mark]

Answer = _____ %

Do not write outside the box

0 6 . 2 **Figure 7** can also be used to calculate the age of this type of tumour.

At diagnosis, a patient had a tumour of 3.98×10^{11} cells.
Calculate the age of the tumour.

You will need to use the $\log_{10}$ button on your calculator.

[1 mark]

Answer = _____ years

Question 6 continues on the next page

Do not write outside the box

Trexall is a drug that can be used to slow the development of various forms of cancer.

Trexall slows cell division by interacting with an enzyme called dihydrofolate reductase (DR).

DR is involved in making nucleotides; the substrate for DR is folic acid.

Figure 8 shows the chemical structure of Trexall.

Figure 9 shows the chemical structure of folic acid.

Figure 8

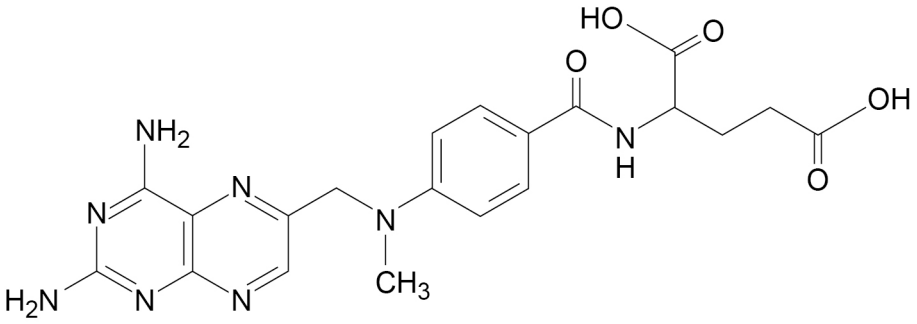
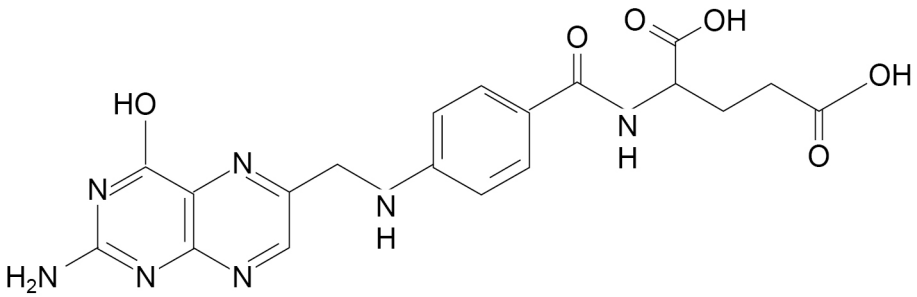


Figure 9



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0 6 . 3 Use the information provided to suggest how Trexall slows cell division.

[3 marks]

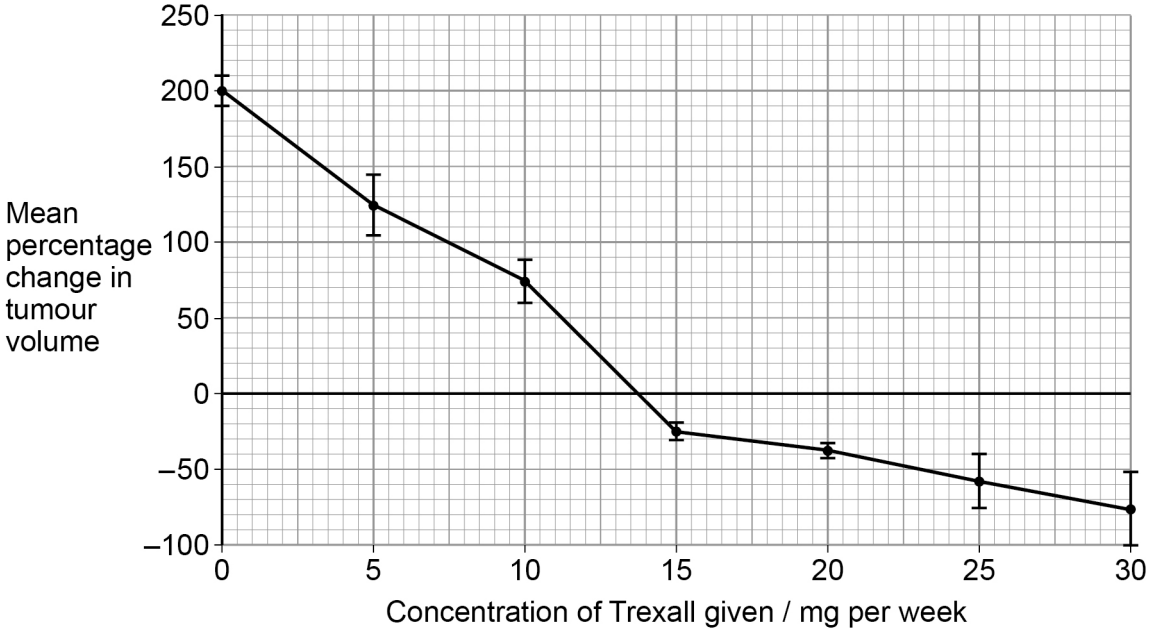
Question 6 continues on the next page

Do not write outside the box

Doctors investigated how the concentration of Trexall given to patients affected the growth of lung tumours. The doctors measured the volume of tumours at the beginning of the study and after 8 months.

Figure 10 shows the results of this investigation. The bars represent ± 2 standard deviations. A value of ± 2 standard deviations from the mean includes over 95% of the data.

Figure 10



0 6 . 4 The scientists measured the percentage change in tumour volume.

Suggest why they recorded both percentage change **and** tumour volume.

[2 marks]

Percentage change _____

_____

_____

_____

Tumour volume _____

_____

_____

_____

Do not write outside the box

0 6 . 5 A lung cancer patient received 15 mg of Trexall per week. After treatment, the diameter of his lung tumour was 35.8 mm

Assuming the tumour was spherical, use the mean percentage change in tumour volume shown in **Figure 10** to calculate the volume of the patient's tumour **before treatment** with Trexall.

The formula for the volume of a sphere is $\frac{4}{3}\pi r^3$ where $\pi = 3.14$

[2 marks]

Answer = _____ mm^3

0 6 . 6 To reduce the size of tumours, would it be better to use 30 mg of Trexall per week, or 20 mg of Trexall per week?

Explain your answer.

[2 marks]

_____

_____

_____

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_____

Question 6 continues on the next page

Do not write outside the box

Trexall can also be used to slow the development of rheumatoid arthritis (a pain-causing joint disease).

Scientists investigated the effectiveness of Trexall as a pain relief treatment in 12 rheumatoid arthritis patients. All of the patients were female. They randomly divided the patients into two groups:

- Group **R** received Trexall tablets for 35 days
- Group **S** was a control group.

They asked both groups to rate their pain on a scale of 0–10 (0 being no pain and 10 being the worst pain possible) at the start and then every 7 days for 35 days. They calculated mean scores for each group.

Their results can be seen in **Table 3**.

Table 3

Number of days of treatment	Mean score for severity of pain (scale 0–10)	
	Group R	Group S
0	9.7	9.8
7	8.2	9.1
14	8.4	8.6
21	7.6	7.2
28	6.3	7.5
35	5.1	7.8

0 6 . 7 Apart from age and general health, give **two** important factors when choosing patients for this investigation.

[1 mark]

1 _____

2 _____

Do not write outside the box

0 6 . 8 A student analysed **Table 3** and concluded that Trexall was effective in reducing pain in arthritis patients.

Evaluate the student's conclusion.

[3 marks]

15

Turn over for Section B

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Section B

Answer **one** question.

You are advised to spend no more than 45 minutes on this section.

0 7 Write an essay on **one** of the topics below.

EITHER

0 7 . 1 The importance of DNA as an information-carrying molecule **and** its use in gene technologies.

[25 marks]

OR

0 7 . 2 The importance of bonds and bonding in organisms.

[25 marks]

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25

END OF QUESTIONS

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