OCR
Oxford Cambridge and RSA

A Level Biology B (Advancing Biology)

H422/01 Fundamentals of biology

Monday 12 June 2017 – Afternoon

Time allowed: 2 hours 15 minutes

6821781136

You may use:
- a scientific or graphical calculator
- a ruler (cm/mm)

H422/01

First name									
Last name									
Centre number						Candidate number				

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

INFORMATION
- The total mark for this paper is **110**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*****).
- This document consists of **40** pages.

SECTION A

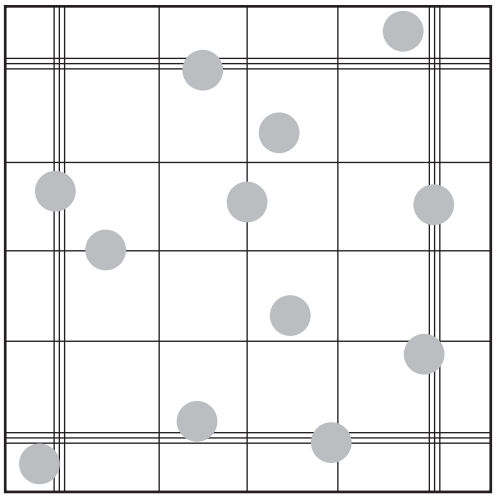
You should spend a maximum of 40 minutes on this section.

Write your answer to the question in the box provided.

Answer **all** the questions.

1 The diagram below represents a microscopic view of a haemocytometer.

A triple-ruled square is further divided into 16 smaller squares.



Which of the options, **A** to **D**, is the correct cell count for the triple-ruled square?

A 4

B 6

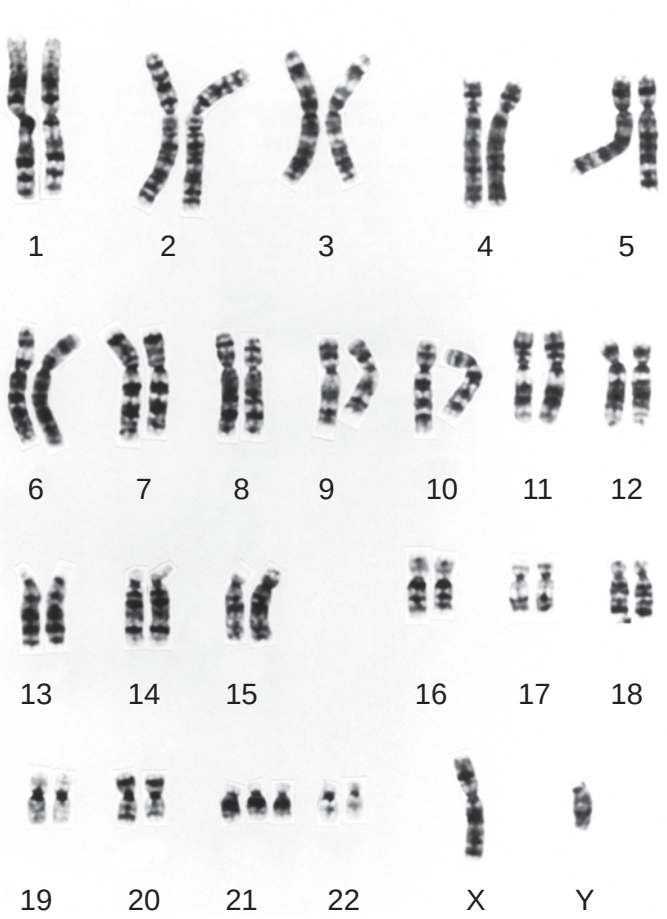
C 8

D 10

Your answer ☐

[1]

2 A karyotype of a person with a genetic disorder is shown below.



Which of the options, **A** to **D**, correctly identifies the genetic disorder shown in the karyotype?

A Down's syndrome

B Klinefelter's syndrome

C Nail-patella syndrome

D Turner's syndrome

Your answer ☐

[1]

3 The statements below relate to the epigenetic regulation of gene expression.

Which of the following statements is/are correct?

1 Methylation of DNA prevents gene transcription.

2 The most common base to undergo methylation is guanine.

3 Acetylation of histone proteins causes DNA to become less accessible to transcription factors.

A 1, 2 and 3 are correct

B Only 1 and 2 are correct

C Only 2 and 3 are correct

D Only 1 is correct

Your answer ☐

[1]

4 Some chemicals bind directly to haemoglobin.

Which of the options, **A** to **D**, correctly identifies two of these chemicals?

A CO_2 and H^+

B H^+ and HCO_3^-

C HCO_3^- and CO_2

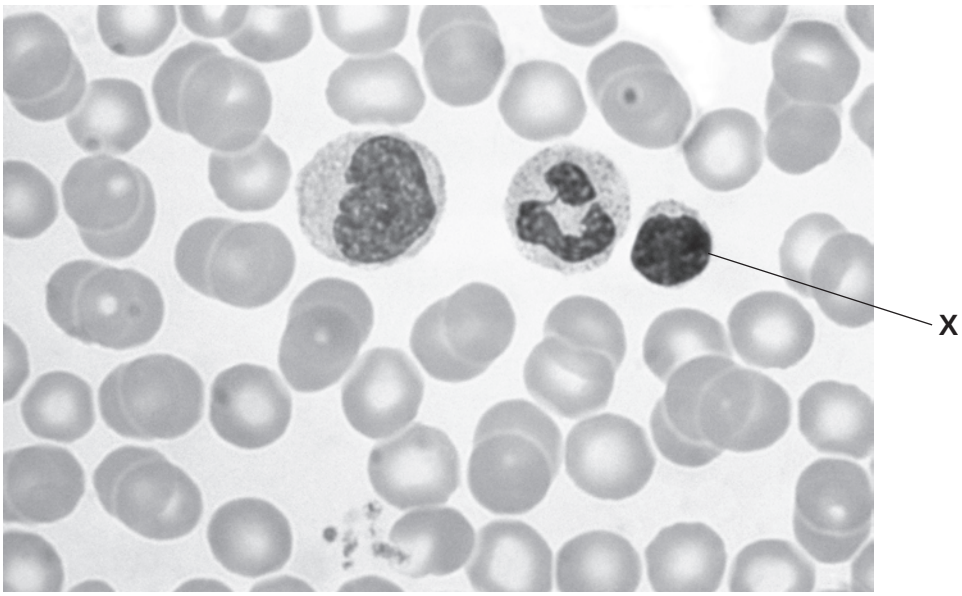
D H_2CO_3 and H^+

Your answer ☐

[1]

5 A magnified section of a human blood smear is shown in the light micrograph below.

The diameter of cell **X** in this image is 11 mm.



Magnification x750

Which of the options, **A** to **D**, is the actual diameter of cell **X**?

A 1.5×10^{-5} m

B 1.5×10^{-6} m

C 6.8×10^{-5} m

D 6.8×10^{-6} m

Your answer ☐

[1]

6 Which of the options, **A** to **D**, is a cellular target of a bacteriostatic antibiotic?

A cell wall

B plasma membrane

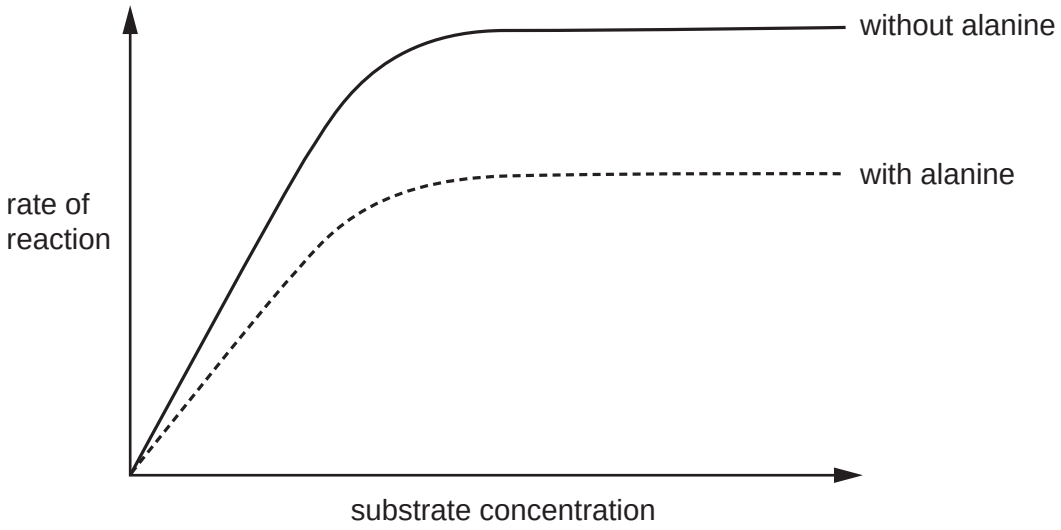
C 70S ribosome

D 80S ribosome

Your answer ☐

[1]

7 The graph below shows the effect of alanine on the rate of a reaction catalyzed by the enzyme, pyruvate kinase.



Which of the following statements is/are correct?

1 Alanine binds to an allosteric site of pyruvate kinase.

2 Pyruvate kinase is inactive when alanine is bound.

3 A change in pH could affect the rate of reaction both with and without alanine present.

A 1, 2 and 3 are correct

B Only 1 and 2 are correct

C Only 2 and 3 are correct

D Only 1 is correct

Your answer ☐

[1]

8 Photolysis is the process of splitting water using light energy.

Which of the options, **A** to **D**, is the region of the chloroplast in which this process takes place?

A outer membrane

B stroma

C thylakoid lumen

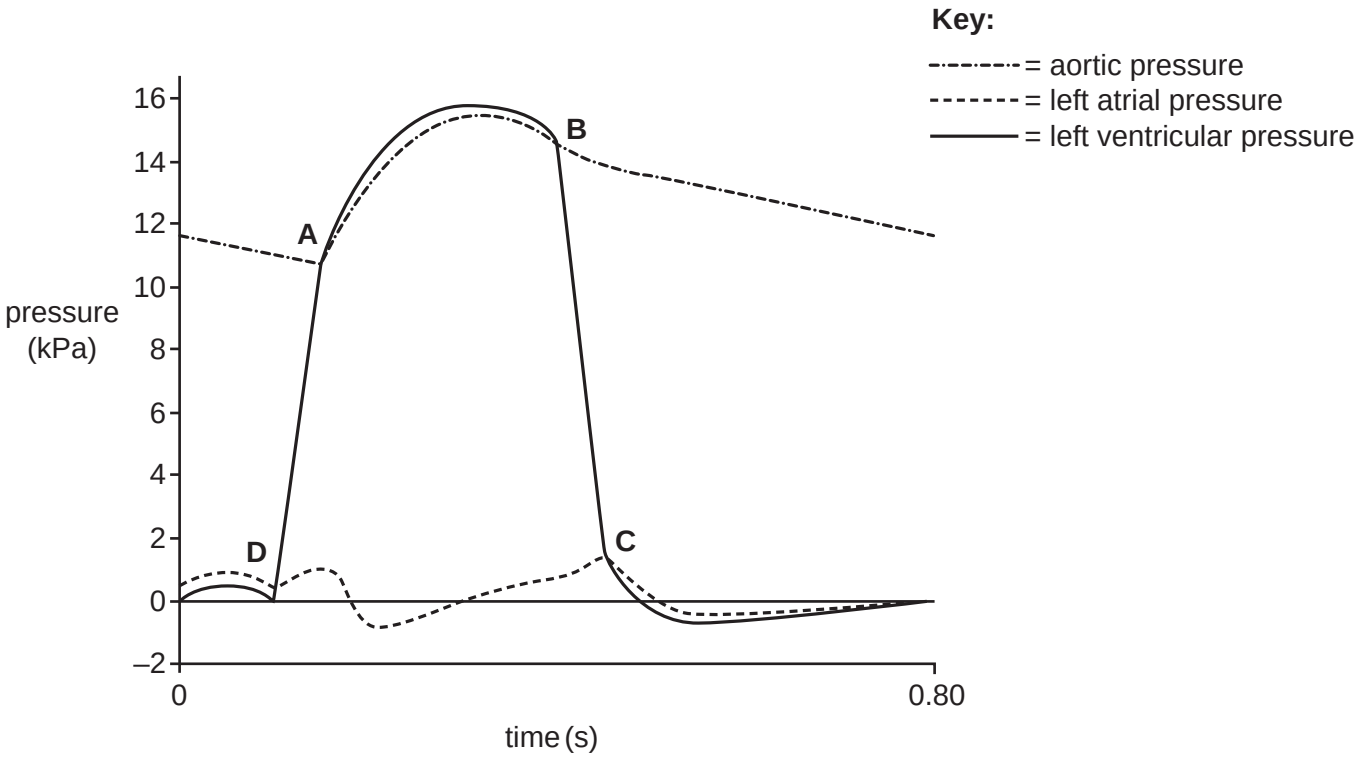
D thylakoid membrane

Your answer ☐

[1]

9 The graph below shows pressure changes in the left side of the heart during the cardiac cycle.

Four points on the graph are labelled **A** to **D**.



Which of the points, **A** to **D**, corresponds to closing of the semilunar valve?

Your answer ☐

[1]

10 In a plant, sucrose is loaded into a companion cell using a protein carrier that co-transports H^+ ions.

Which of the options, **A** to **D**, is a correct description of how H^+ ions are co-transported?

A into the companion cell against the concentration gradient

B into the companion cell down the concentration gradient

C out of the companion cell against the concentration gradient

D out of the companion cell down the concentration gradient

Your answer ☐

[1]

11 The statements below relate to the autonomic nervous system (ANS).

Which of the following statements is/are correct?

1 The ANS is a division of the peripheral nervous system.

2 Autonomic neurones between the CNS and the ganglia are myelinated.

3 Sympathetic neurones use acetylcholine and noradrenaline as neurotransmitters.

A 1, 2 and 3 are correct

B Only 1 and 2 are correct

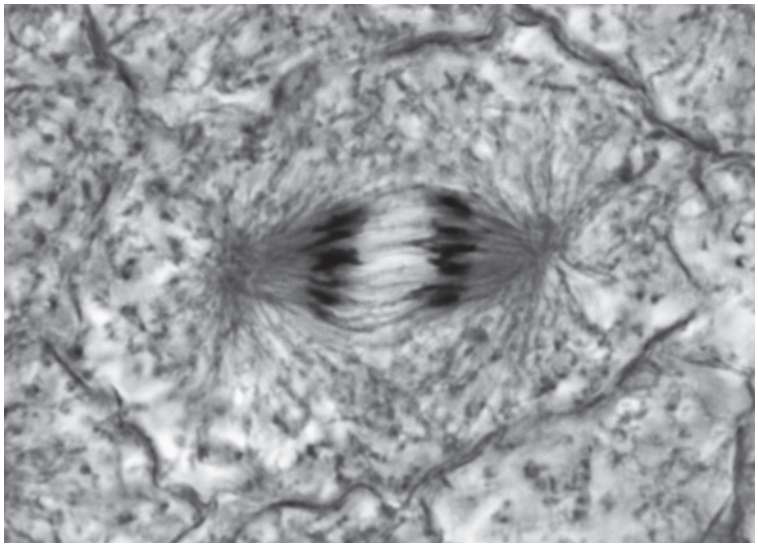
C Only 2 and 3 are correct

D Only 1 is correct

Your answer ☐

[1]

12 The micrograph below shows a cell in mitosis.



Which of the options, **A** to **D**, identifies the stage of mitosis shown in the micrograph?

A anaphase

B metaphase

C prophase

D telophase

Your answer ☐

[1]

13 Three diagnostic tests were performed on a solution containing a biological molecule.

The results of the tests are shown in the table below.

	Colour of test reagent	
	Before	**After**
Benedict's test (with hydrolysis)	blue	green
Biuret test	blue	purple
Iodine test	yellow-brown	yellow-brown

Which of the options, **A** to **D**, is the biological molecule that was tested?

A glucose

B glycoprotein

C glycolipid

D starch

Your answer ☐

[1]

14 Fertilisation in a flowering plant involves two pollen nuclei.

The first nucleus fuses with the ovule and the second nucleus fuses with the polar nuclei.

Which of the options, **A** to **D**, is the seed structure formed after fusion of the second nucleus with the polar nuclei?

A aleurone layer

B embryo

C endosperm

D seed coat

Your answer ☐

[1]

15 The chi-squared (χ^2) test was used to determine whether the inheritance pattern of a dihybrid cross was statistically significant.

Four phenotypes were produced from the cross.

χ^2 was calculated as 8.62 and the significance level (p) was 0.05.

A table of χ^2 values is shown below.

	Probability (p)							
df	**0.99**	**0.95**	**0.90**	**0.50**	**0.10**	**0.05**	**0.01**	**0.001**
1	0.0016	0.0039	0.016	0.46	2.71	3.84	6.63	10.83
2	0.02	0.10	0.21	1.39	4.60	5.99	9.21	13.82
3	0.12	0.35	0.58	2.37	6.25	7.81	11.34	16.27
4	0.30	0.71	1.06	3.360	7.78	9.49	13.28	18.46

Which of the statements, **A** to **D**, is correct?

A *df* is 3 and χ^2 is not significant

B *df* is 3 and χ^2 is significant

C *df* is 4 and χ^2 is not significant

D *df* is 4 and χ^2 is significant

Your answer ☐

[1]

16 ATP is required for the contraction of skeletal muscle.

Which of the options, **A** to **D**, is the result of ATP binding to the myosin head?

A attachment of the myosin head to actin

B detachment of the myosin head from actin

C return of the myosin head to the original (cocked) position

D tilting of the myosin head

Your answer ☐

[1]

17 The statements below relate to the Calvin cycle.

Which of the following statements is/are correct?

1 Molecules of triose phosphate are required for the synthesis of nucleic acids.

2 The production of triose phosphate from glycerate-3-phosphate requires ATP and reduced NAD.

3 Reactions of the Calvin cycle occur at a faster rate when stomata are closed.

A 1, 2 and 3 are correct

B Only 1 and 2 are correct

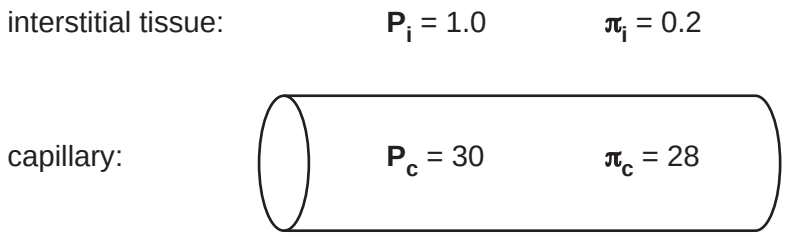
C Only 2 and 3 are correct

D Only 1 is correct

Your answer ☐

[1]

18 The diagram below represents a capillary (**c**) surrounded by interstitial tissue (**i**). Hydrostatic pressures (**P**) and oncotic pressures (π) are shown.



The net movement of fluid between the capillary and interstitial tissue is determined by the net driving force (NDF):

$$NDF = (P_c - P_i) - (\pi_c - \pi_i)$$

When NDF > 0, fluid leaves the capillary.
When NDF < 0, fluid enters the capillary.

Which of the statements, **A** to **D**, is correct?

A NDF = −1.7, favouring the production of tissue fluid

B NDF = −1.7, favouring a loss of tissue fluid

C NDF = 1.2, favouring the production of tissue fluid

D NDF = 1.2, favouring a loss of tissue fluid

Your answer ☐

[1]

19 The balanced equation for the aerobic respiration of a substrate is given below.

$$2C_{18}H_{34}O_2 + 51O_2 \rightarrow 36CO_2 + 34H_2O$$

Which of the statements, **A** to **D**, gives the correct respiratory quotient (RQ) and identity of this substrate?

A RQ = 0.68, and the substrate is a carbohydrate

B RQ = 0.71, and the substrate is a fatty acid

C RQ = 0.76, and the substrate is a carbohydrate

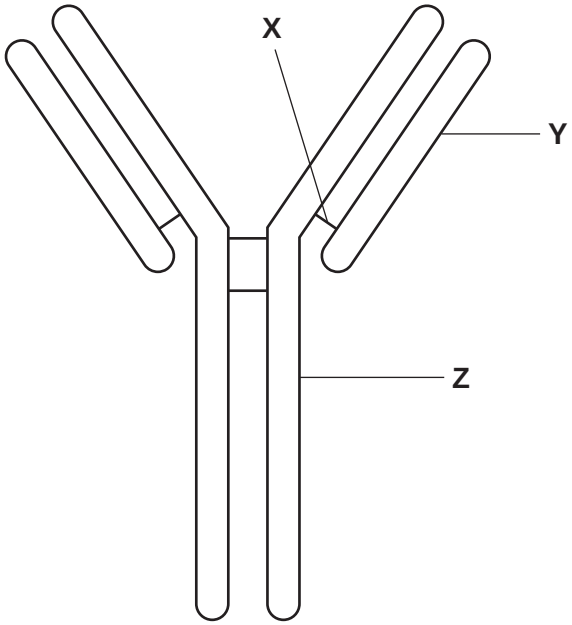
D RQ = 1.00, and the substrate is a fatty acid

Your answer ☐

[1]

20 The general structure of an antibody is shown below.

Three features are labelled **X**, **Y** and **Z**.



Which of the statements, **A** to **D**, is correct?

A **X** is a disulfide bond that connects the constant region of **Y** and the variable region of **Z**.

B **X** is a disulfide bond that connects the constant regions of **Y** and **Z**.

C **X** is a hydrogen bond that connects the constant region of **Y** and the variable region of **Z**.

D **X** is an ionic bond that connects the constant regions of **Y** and **Z**.

Your answer ☐

[1]

21 Which of the options, **A** to **D**, is a cancer therapy that damages **only** cancer cells?

A chemotherapy

B immunotherapy

C radiotherapy

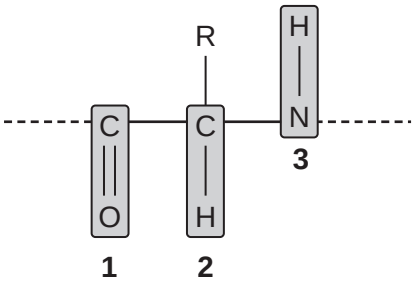
D surgery

Your answer ☐

[1]

22 The diagram below represents an amino acid within a polypeptide sequence.

Three regions of the amino acid are labelled **1** to **3**.



Which of the options, **A** to **D**, gives the regions that form bonds in the secondary structure of a protein?

A 1 and 2

B 1 and 3

C 2 and 3

D 1, 2 and 3

Your answer ☐

[1]

23 Which of the options, **A** to **D**, correctly identifies the products of anaerobic respiration in yeast?

A CO_2, NAD, ATP and ethanol

B CO_2, NAD, ADP and lactic acid

C CO_2, reduced NAD, ATP and ethanol

D CO_2, reduced NAD, ADP and lactic acid

Your answer ☐

[1]

24 The statements below relate to the causes and effects of emphysema.

Which of the following statements is/are correct?

1 Ventilation is impaired due to the destruction of elastic lung tissue.

2 The partial pressure of oxygen in the blood is decreased.

3 Tissue destruction is mediated by monocytes.

A 1, 2 and 3 are correct

B Only 1 and 2 are correct

C Only 2 and 3 are correct

D Only 1 is correct

Your answer ☐

[1]

25 A gene mutation causes part of a DNA sequence to change from TAC to TAA.

TAA is a stop codon.

Which of the statements, **A** to **D**, is a correct explanation of why the stop codon may **not** affect translation of the mRNA sequence?

A TAA also codes for an amino acid

B TAA stops transcription, not translation

C the mutation in the mRNA sequence may be repaired

D the stop codon may not be present in the mature mRNA sequence

Your answer ☐

[1]

26 Fibrin is involved in the blood clotting cascade.

Which of the options, **A** to **D**, identifies the factors required for the conversion of fibrinogen to fibrin?

A phospholipids and Ca^{2+} ions

B platelets and K^{+} ions

C thrombin and Ca^{2+} ions

D thromboplastin and K^{+} ions

Your answer ☐

[1]

27 In spermatogenesis, crossing over of the chromatids of homologous chromosomes gives rise to genetic variation.

Which of the options, **A** to **D**, is the cell type in which crossing over occurs?

A primary spermatocyte

B secondary spermatocyte

C spermatogonium

D spermatid

Your answer ☐

[1]

28 Oxidative phosphorylation is the process in which the transfer of electrons from reduced NAD or reduced FAD to oxygen results in the production of ATP.

Which of the options, **A** to **D**, is the number of ATP molecules gained from the oxidation of **two** molecules of reduced NAD?

A 2

B 3

C 4

D 5

Your answer ☐

[1]

29 The statements below relate to photoreceptor cells in the retina.

Which of the following statements is/are correct?

1 The inner segment of a photoreceptor cell contains many mitochondria.

2 Rod cells are absent in the fovea.

3 A cone cell contains three photosensitive pigments, each sensitive to a different wavelength of light.

A 1, 2 and 3 are correct

B Only 1 and 2 are correct

C Only 2 and 3 are correct

D Only 1 is correct

Your answer ☐

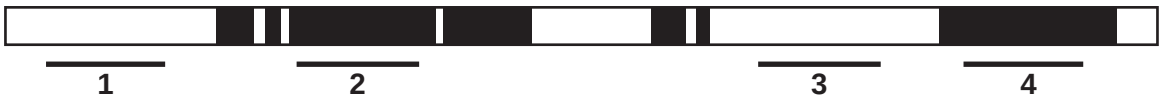
[1]

30 Scientists can identify an unknown species as follows:

- extract DNA from tissue, e.g. skin or hair
- amplify a length of DNA, known as a barcode, using the polymerase chain reaction (PCR)
- read the base sequence of the DNA.

The strip below represents a length of extracted DNA before PCR. Lines **1** to **4** represent primers.

Key:
white = same DNA sequence in all species
black = variable DNA sequence between species



Which of the options, **A** to **D**, gives the pair of primers that could be used to amplify DNA from **all** species?

A 1 and 3

B 1 and 4

C 2 and 3

D 2 and 4

Your answer ☐

[1]

SECTION B

Answer **all** the questions.

31 The gene, *HBB*, codes for the beta polypeptide in haemoglobin.

A person with sickle cell anaemia has a mutation in *HBB*. This causes a change to the sixth amino acid in the beta polypeptide.

(a) Describe the type of DNA mutation that causes the amino acid change in the beta polypeptide.

..... **[1]**

(b) A couple with no symptoms of sickle cell anaemia want to have a child. Both individuals have close relatives with the disease.

(i) Explain how a genetic counsellor can use knowledge of family history to provide genetic advice to the couple.

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..... **[2]**

(ii) Suggest **two** ethical concerns that may be associated with the genetic testing of embryos for sickle cell anaemia.

1 .....

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2 .....

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[2]

(c)* Scientists carried out a study to investigate the effect of the sickle cell allele on the survival rate of children in Kenya.

Data were collected using questionnaires completed by health workers visiting families with young children. The questionnaires were collected from health centres in both urban and rural parts of Kenya.

The data were analysed and 867 children were grouped based on their *HBB* genotypes, which the health centres supplied, as shown in Table 31.

***HBB* genotype**	**Number of children**
H^AH^A	392
H^AH^S	374
H^SH^S	101

Table 31

H^A is the healthy allele and **H^S** is the sickle cell allele.

The percentage of children surviving with each *HBB* genotype was recorded from birth at 60-day intervals until day 600.

Fig. 31 shows the data from this study.

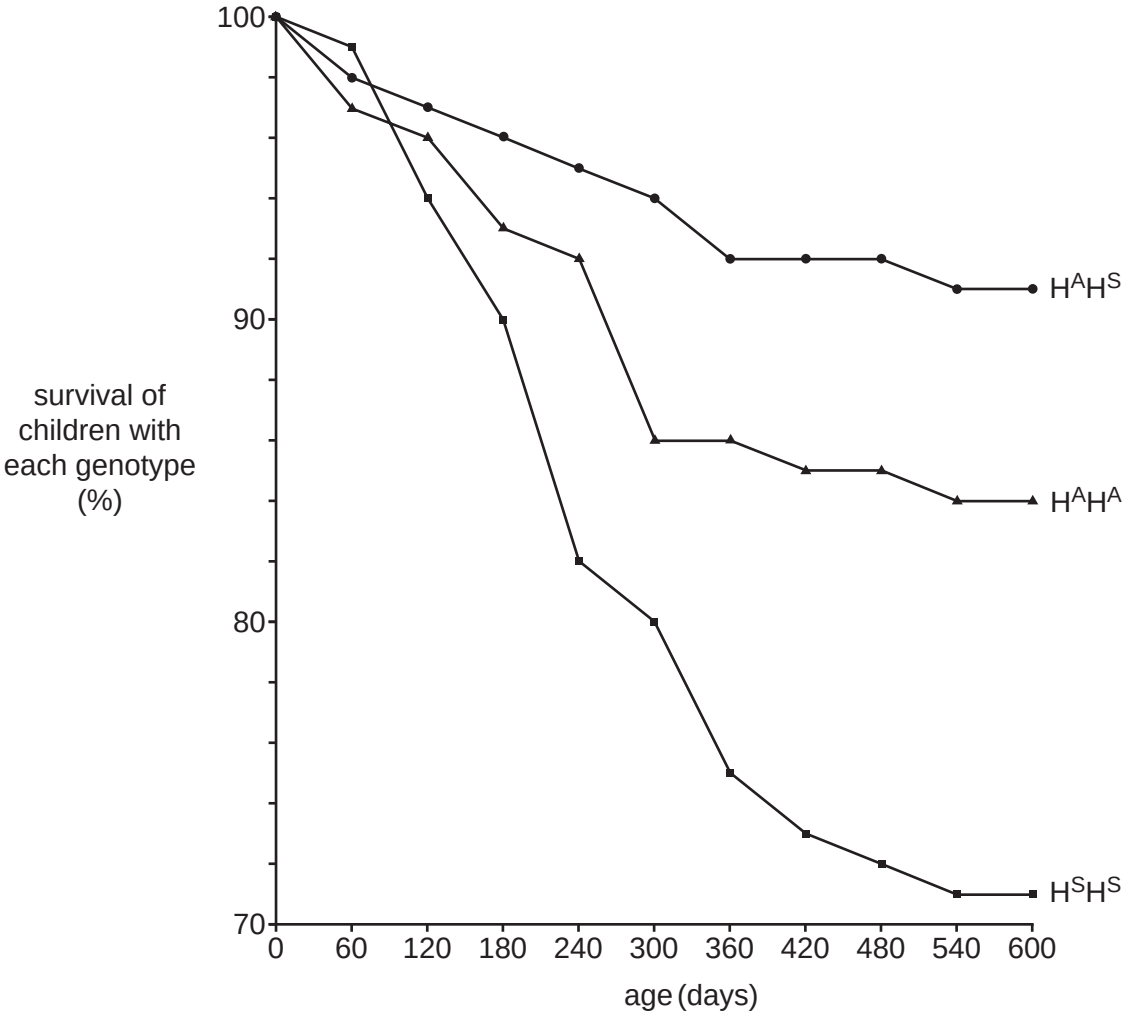

Fig. 31

21

Malaria is a leading cause of mortality in Kenya.

Using this information and your own knowledge, describe and explain the data in Fig. 31 and comment on its quality.

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..... **[6]**

32 This question is about the hormonal control of blood glucose concentration in health and disease.

(a) Complete the missing words in the paragraph below to explain the role of insulin in blood glucose homeostasis.

When the concentration of blood glucose rises above a set point, ... cells in the ..... of the pancreas are stimulated to release insulin. Effector cells respond to insulin by increasing the expression of ..... proteins in the cell surface membrane. This increases the uptake of glucose. Liver cells store some excess glucose in a process known as ..... . The concentration of blood glucose then falls.

[4]

(b) The oral glucose tolerance test (OGTT) is used to diagnose diabetes.

A result from an OGTT measuring blood glucose and insulin concentrations is shown in Fig. 32.

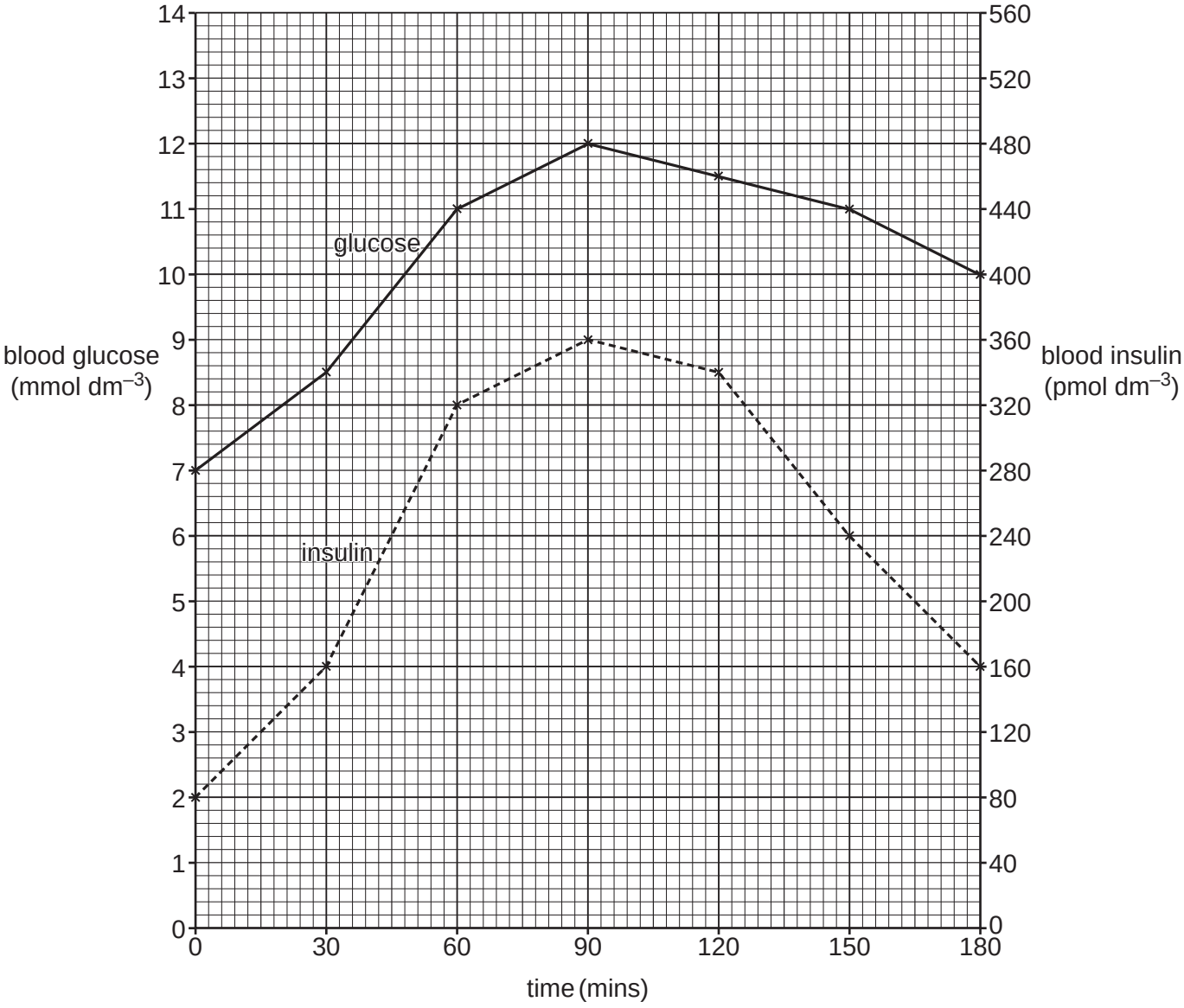

Fig. 32

(i) The OGTT result in Fig. 32 shows evidence of diabetes. State which type of diabetes the patient has and explain how this can be concluded.

type .....

explanation .....

.....

[1]

(ii) Calculate the percentage increase in blood glucose concentration after 90 minutes compared to time 0.

Give your answer to **two** significant figures.

Answer = ... % **[2]**

(c)* Some patients with diabetes are treated with regular insulin injections.

Most insulin is now produced using recombinant DNA technology. Outline this process.

You should refer to the role of specific enzymes in your answer.

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..... **[6]**

33 (a) A potometer was used to investigate the effect of wind speed on the rate of transpiration in a leafy shoot.

The investigation was set up as shown in Fig. 33.

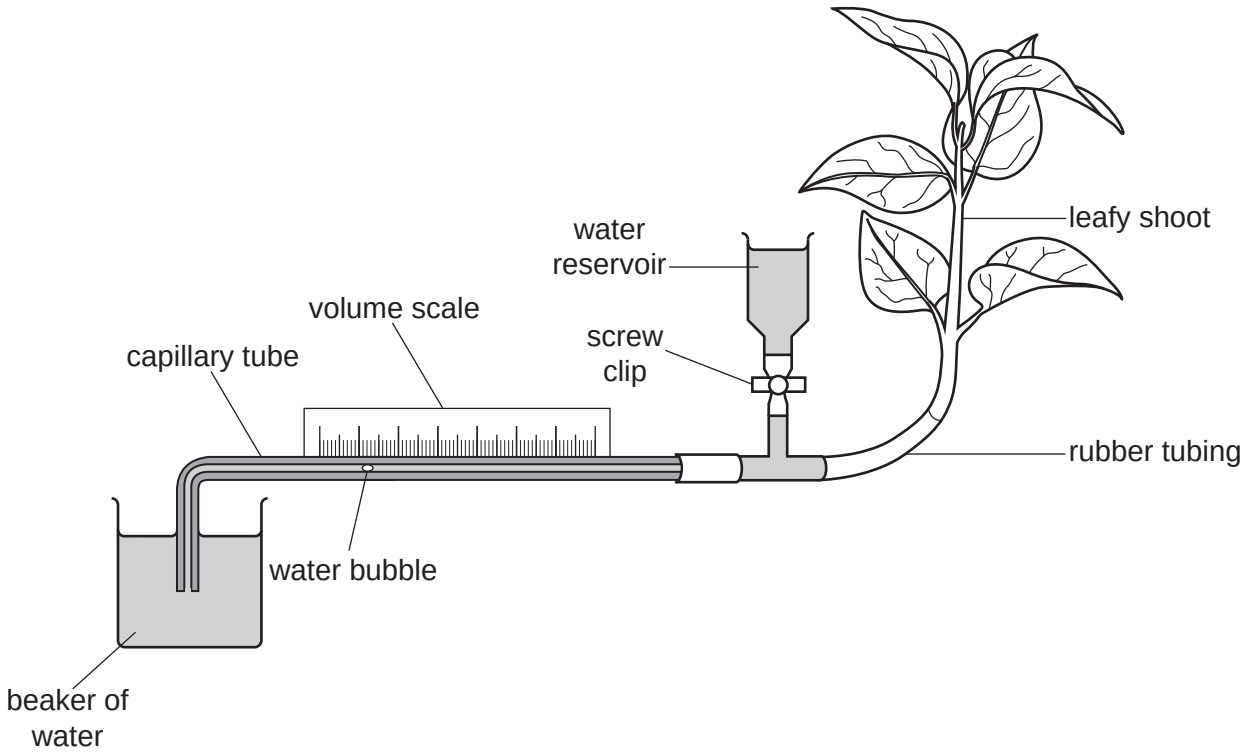

Fig. 33

To vary wind speed, a fan with five different speeds was positioned at a fixed distance from the leafy shoot.

The results of the investigation are shown in Table 33.

	Wind speed ($m\,s^{-1}$)	Rate of water uptake ($mm\,min^{-1}$)				
		Replicate 1	Replicate 2	Replicate 3	Mean	Standard deviation
1	0	0.3	0.3	0.3	0.30	0.00
2	2	2.6	2.5	2.5	2.53	0.06
3	4	5.0	4.8	4.9	4.90	0.10
4	6	7.0	7.0	7.2	7.07	
5	8	9.4	9.5	9.4	9.43	0.06

Table 33

(i) Give **one** piece of advice when setting up the potometer to ensure a continuous stream of water between the capillary tube and the shoot.

.....

..... **[1]**

(ii) Using information in Table 33, calculate the standard deviation for the data from **row 4** (wind speed of $6\,m\,s^{-1}$).

$$s = \sqrt{\frac{\Sigma(x-\bar{x})^2}{n-1}}$$

standard deviation = ... **[2]**

(iii) Describe **and** explain the data trend in Table 33.

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..... **[3]**

(iv) State **two** environmental variables that should have been controlled during this investigation.

1 .....

2 .....

[2]

(v) Explain why the potometer only gives an estimate of the rate of transpiration.

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..... **[2]**

(b) Plants take up water into the root hairs. The water is then transported into the vascular tissue via the root cortex.

Describe how water travels through the root cortex in the apoplastic **and** symplastic pathways.

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..... **[3]**

34 The human papillomavirus (HPV) can infect the skin and mucous membranes of the body.

Most cases of HPV infection are eradicated naturally by the immune system.

(a) (i) Statements **A** to **F** below summarise, in random order, the stages of an immune response to the virus.

A	T helper cells are activated and divide by mitosis.
B	B cells are activated, divide by mitosis and then differentiate.
C	Viral antigens are presented.
D	T helper cells release cytokines.
E	Plasma cells synthesise and release antigen-specific antibodies.
F	The virus is engulfed and digested.

Place the letters **A** to **F** representing the statements into the correct order in the boxes below. Statement **D** has been done for you.

			D		

[2]

(ii) Describe the role of T killer cells in the immune response to HPV.

.....

..... **[1]**

(b) Sometimes HPV cannot be eradicated naturally by the immune system. Persistent HPV infection is the main cause of cervical cancer.

A vaccine against the **HPV-16** and **HPV-18** strains is offered to females aged 12 to 14 years.

Scientists wanted to determine whether the vaccine should be given over two or three doses.

They compared the effectiveness of two-dose and three-dose regimes by measuring antibody levels in the blood one month and three years after completion.

The results are summarised in Table 34 below.

Data group	Number of subjects	HPV-16 antibody level ($mMU\,dm^{-3}$)		HPV-18 antibody level ($mMU\,dm^{-3}$)	
		Median	Range	Median	Range
Two-dose regime after one month	102	830	761–882	812	704–866
Two-dose regime after three years		739	729–755	214	101–483
Three-dose regime after one month	116	829	781–893	820	794–860
Three-dose regime after three years		731	718–754	747	709–773

Table 34

(i) Using the information in Table 34, evaluate the effectiveness of different vaccination regimes.

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..... **[4]**

(ii) Antibody levels were also measured two weeks after the first dose of vaccine. They were significantly lower than those measured after the second and third doses of vaccine.

Explain why.

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..... **[3]**

Turn over for the next question

35 *Miscanthus* and reed canary grass are crops that are reported to promote species diversity.

A field trial was carried out to determine which crop promotes the greater diversity of bird species:

- two fields (**M** and **R**) were sampled
- *Miscanthus* was grown in field **M**
- reed canary grass was grown in field **R**
- the number of each bird species (***n***) was recorded for both fields
- the Simpson's Index of Diversity was calculated for both fields.

(a) (i) Explain what is meant by the term species diversity.

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.....

..... **[2]**

(ii) State **two** variables that should have been controlled to ensure a **valid** comparison between fields **M** and **R**.

1 .....

.....

2 .....

.....

[2]

(b) The incomplete results for field **M** are shown in Table 35.

Bird species	***n***	***n*** / ***N***	$(n/N)^2$
Dunnock	3	0.03	0.0009
Song thrush	40	0.40	0.1600
Reed bunting	23	0.23	0.0529
Meadow pipit	12		
Willow warbler	4		
Common redstart	18		
	N =		$\sum(n/N)^2$ =
			$1 - (\sum(n/N)^2)$ =

Table 35

(i) Complete Table 35 and use the formula below to calculate the Simpson's Index of Diversity (*D*) for field **M**.

$D = 1 - (\sum(n/N)^2)$

Where:
n = number of individuals of each species
N = total number of individuals in all species

Simpson's Index of Diversity (*D*) = ... **[3]**

(ii) The Simpson's Index of Diversity for field **R** is 0.54.

Using this information and your answer to **(b)(i)**, conclude which crop promotes the greater diversity of bird species. Justify your conclusion.

.....

..... **[1]**

(c) Modern agricultural methods involve the use of chemical fertilisers added to the soil to increase crop yield.

However, the use of chemical fertilisers can have an impact on organisms within aquatic ecosystems such as ponds and streams.

The lifecycle of a dragonfly is shown in Fig. 35.

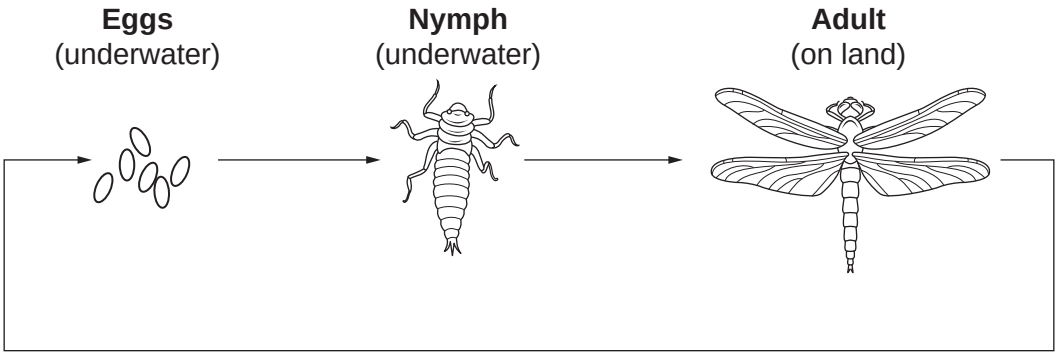

Fig. 35

Explain how the use of chemical fertilisers on agricultural land may threaten the survival of dragonflies.

.....

.....

.....

.....

.....

..... **[3]**

36 The recovery time of the heart is a good indicator of aerobic fitness.

A widely-publicised training programme claimed to improve aerobic fitness for various exercises after three months. To evaluate this claim, an investigation was conducted:

- 20 volunteers completed a series of test exercises at increasing intensities
- recovery time was recorded after each exercise
- the volunteers followed the training programme for three months
- after three months, the test exercises and measurements were repeated.

(a) (i) State **two** factors, other than **intensity of exercise**, that must be considered before an exercise is included in a training programme.

1 .....

2 .....

[2]

(ii) Suggest **one** safety precaution that should have been taken before any volunteers took part in the exercises.

.....

..... **[1]**

Question 36(b) begins on page 34

(b) The results of the investigation are shown in Fig. 36.

The columns represent the mean recovery times before and after the training. The error bars represent the standard deviation above and below the mean.

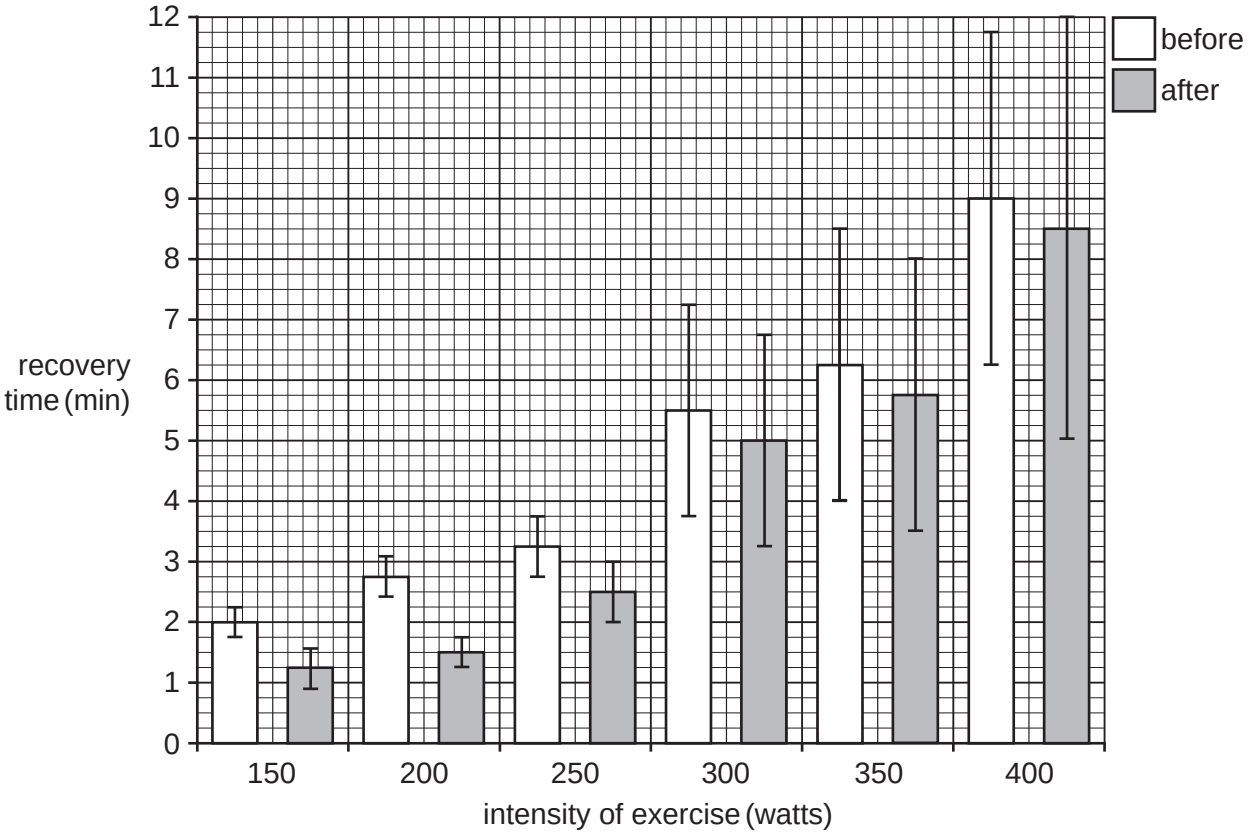

Fig. 36

(i) Name **one** statistical test that could be used to analyse the data in Fig. 36. Justify your choice.

.....

..... **[2]**

(ii) Comment on how well this training programme improved fitness.

.....

.....

.....

..... **[2]**

(iii) Promoters of the training programme claimed that it was good for training **weightlifters**. Comment on the **validity** of this statement.

.....

.....

.....

..... **[2]**

Turn over for the next question

37 Dialysis is a common treatment for kidney failure.

(a) Fig. 37.1 shows a haemodialysis machine at the beginning of a dialysis session.

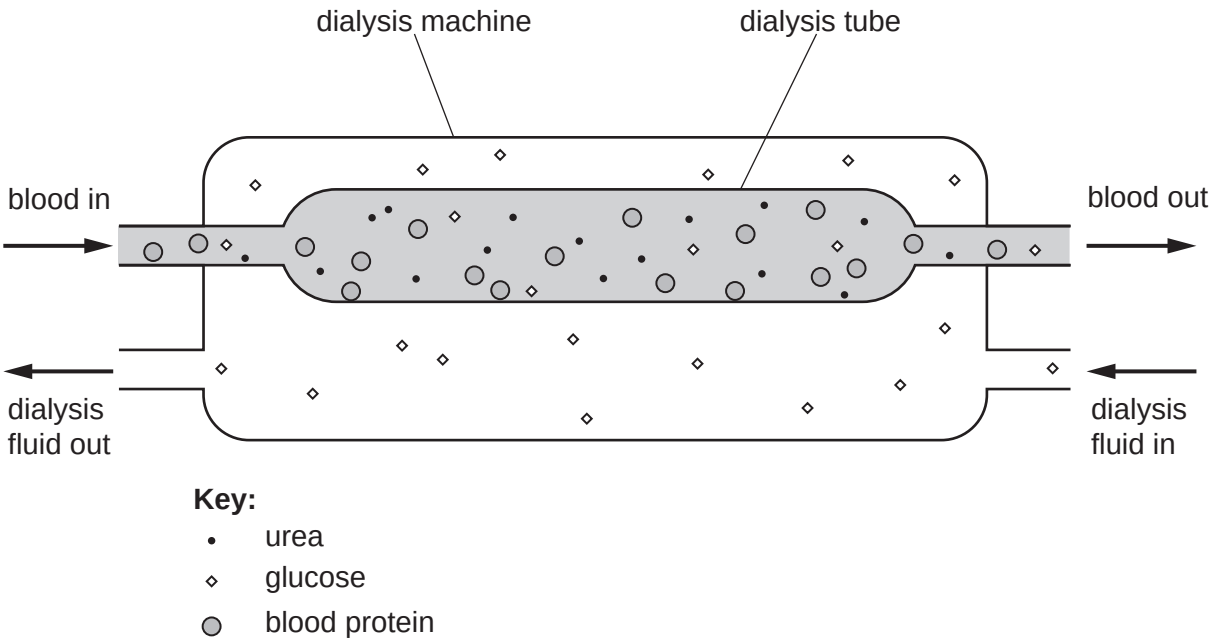

Fig. 37.1

(i) With reference to Fig. 37.1, describe how the composition of the blood changes over time.

.....

.....

.....

..... **[2]**

(ii) Explain the changes described in **(i)**.

.....

.....

.....

.....

.....

..... **[3]**

(b) Peritoneal dialysis is another form of dialysis that is used to treat kidney failure.

State **one** advantage and **one** disadvantage of peritoneal dialysis compared with haemodialysis.

advantage .....

.....

disadvantage .....

.....

[2]

(c) Loss of blood in dialysis sessions can lead to anaemia if left untreated. In cases of severe anaemia, patients may need a blood transfusion.

Before a blood transfusion is given, the patient's blood group must be tested.

The patient's blood is mixed with anti-A antibodies and anti-B antibodies. The result of the test is visible by eye.

An example result is shown in Fig. 37.2.

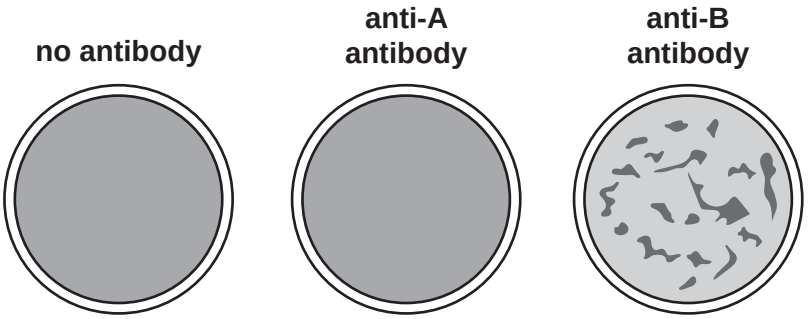

Fig. 37.2

(i) State which type of stored blood product would be required for a blood transfusion to treat severe anaemia.

..... **[1]**

(ii) Identify the blood group of the patient tested in Fig. 37.2 and state which donor blood group(s) can be safely transfused to this patient.

blood group of patient .....

blood group(s) for transfusion .....

[2]

(d) A patient with kidney failure requires treatment in the form of either haemodialysis or a kidney transplant.

Some medical notes about the patient are shown in Fig. 37.3.

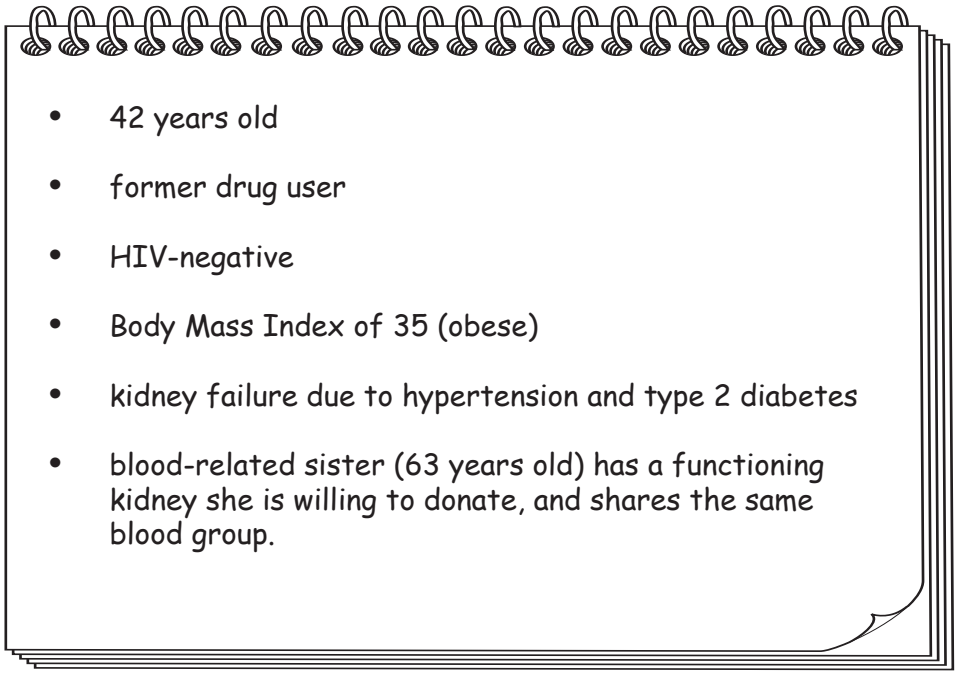

Fig. 37.3

Using the information in Fig. 37.3, discuss the suitability of each treatment option for this patient.

.....

.....

.....

.....

.....

..... **[3]**

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).