

OCR A-LEVEL BIOLOGY B • H422

BIOLOGY



EXAM QUESTION PACK

2.1.3 PROTEINS AND ENZYMES

SCORE

/157

PERCENTAGE

%

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- 1 Avidin is a glycoprotein found in the whites of bird and reptile eggs. It has been investigated as an alternative insecticide for crop plants such as wheat.

Avidin acts as an insecticide by preventing wheat weevils from obtaining biotin in their diet. Biotin is an essential cofactor required by insects.

- (i) Suggest how avidin prevents insects from obtaining biotin.

----- [1]

- (ii) Suggest why lack of biotin leads to the death of wheat weevils.

----- [2]

2 Spermatogenesis in human males produces haploid gametes, called spermatozoa (sperm cells).

During spermatogenesis, the chromatin in the nuclei of sperm cells undergoes a complex transition where histone is replaced by another protein, protamine, which binds to the DNA.

(i) Protamine contains large quantities of the polar amino acid, arginine.

Suggest why having large quantities of arginine enables protamine to bind effectively to DNA molecules.

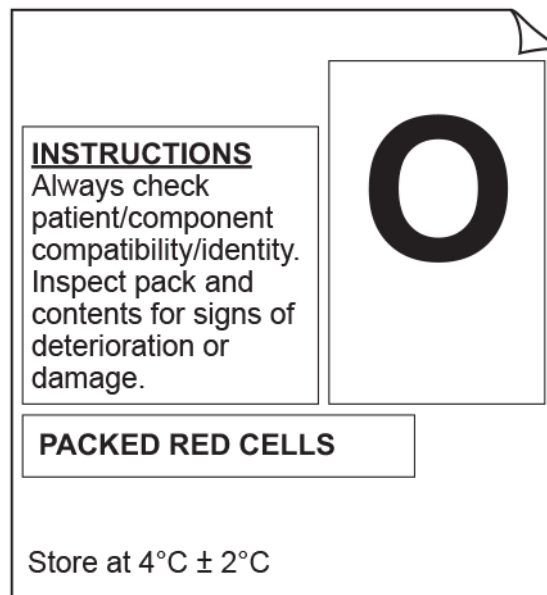
[2]

(ii) Substituting histone with protamine allows DNA to be more densely packaged.

Suggest **one** advantage of having densely packaged DNA in a sperm nucleus.

[1]

- 3 The diagram shows a blood bag label with information about the stored blood product contained in the bag.



Which of the options, **A** to **D**, about this stored blood product is correct?

- A** Contains plasma and erythrocytes with no A or B glycoprotein antigens in the plasma membrane.
- B** Contains plasma with anti- A and anti-B antibodies and erythrocytes.
- C** Contains concentrated erythrocytes with A and B glycoprotein antigens in the plasma membrane.
- D** Contains concentrated erythrocytes with no A and B glycoprotein antigens in the plasma membrane.

Your answer

[1]

- 4 Haemoglobin and myoglobin are respiratory pigments.

Complete the table below by placing a tick (✓) in the appropriate boxes to identify which pigment matches each description.

Description	Haemoglobin	Myoglobin
Can bind with four oxygen molecules		
Has higher affinity for oxygen		
Located inside skeletal muscle		

[2]

5(a) Fig. 4.1 shows a graph of rate of reaction plotted against substrate concentration for an enzyme that converts a colourless substrate into a coloured product.

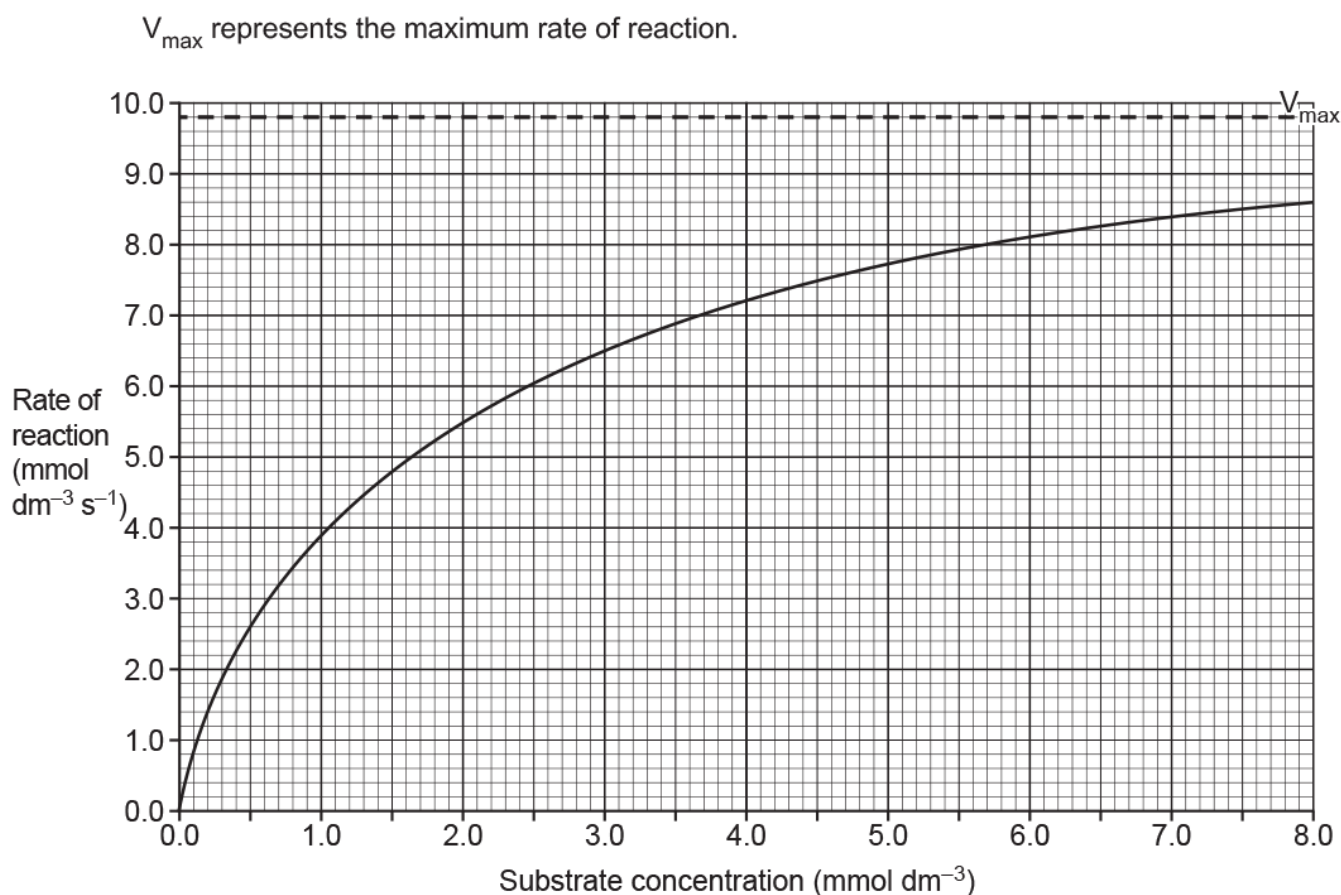


Fig. 4.1

(i) Describe how you could obtain the data for this graph.

----- [3]

- (ii) Explain why the experiments you have described should be carried out with excess enzyme.

----- [1]

- (iii) The Michaelis constant, K_M , is defined as the substrate concentration that gives half the maximum reaction rate $(\frac{1}{2} V_{\max})$.

Use Fig. 4.1 to obtain a value for K_M for this enzyme, including units.

$K_M =$ units [2]

- (iv) Suggest why it is often difficult to determine a value for $V_{\max}$ experimentally.

----- [2]

(b) Because of the difficulty in determining a value for $V_{\max}$, a double reciprocal plot can be used instead.

To prepare this plot, the rate of reaction, V , is measured at different substrate concentrations, $[S]$.

Then, a plot of $1/V$ against $1/[S]$ is made, as shown in Fig. 4.2.

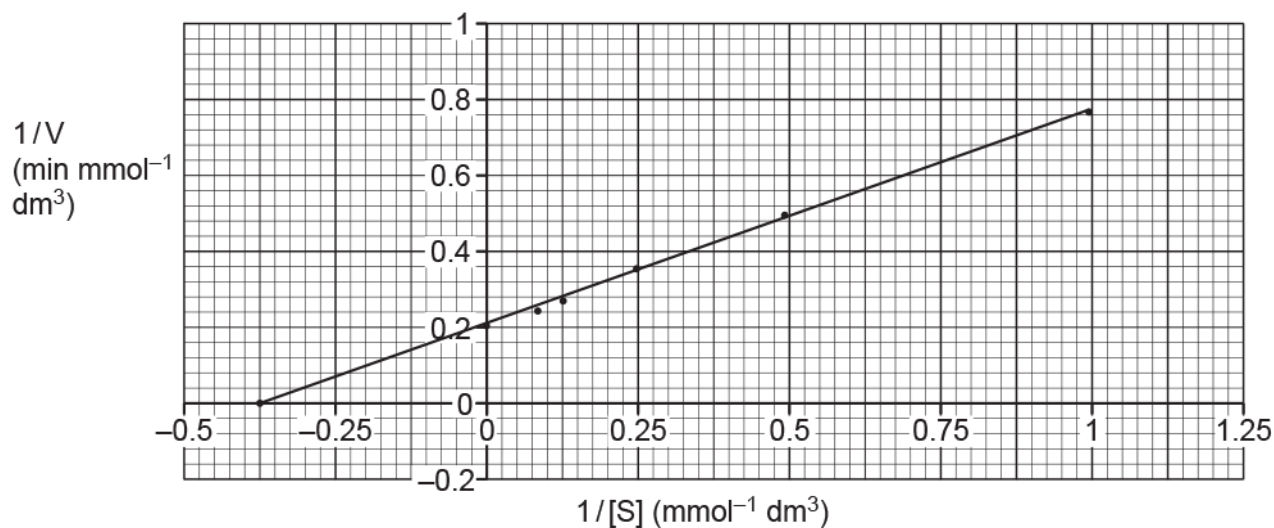


Fig. 4.2

The equation for the graph in Fig. 4.2 is:

$$\frac{1}{V} = \frac{K_M}{V_{\max}} \times \frac{1}{[S]} + \frac{1}{V_{\max}}$$

This equation is of the form $y = mx + c$ where

- $1/V$ represents y
- $K_M / V_{\max}$ represents m
- $1/[S]$ represents x
- $1/V_{\max}$ represents c

The double reciprocal plot therefore produces a straight line graph.

(i) Use Fig. 4.2 to determine the gradient of the line.

Gradient = ... [1]

(ii) Write an expression that connects the gradient of the line, K_M and V_{max} .

----- [1]

(iii) A student used Fig. 4.2 to determine that $V_{max} = 5$.

Use this value and your answer to part (i) to determine K_M for this enzyme.

$K_M =$ (units not required) [2]

6 Which of the following, A to D, describes the structure of haemoglobin?

- A each of the four polypeptide chains is combined with an identical haem group
- B each polypeptide chain has a quaternary structure
- C the quaternary structure of each polypeptide chain contains ionic bonds
- D two polypeptide chains contain an alpha haem group and two contain a beta haem group

Your answer

☐

[1]

7 Trisodium citrate is a compound used for the long-term preservation of whole blood. The compound prevents blood clotting by reacting with an ion.

Which of the options, A to D, is the ion with which trisodium citrate reacts to prevent blood clotting?

- A calcium (Ca^{2+})
- B chloride (Cl^-)
- C magnesium (Mg^{2+})
- D potassium (K^+)

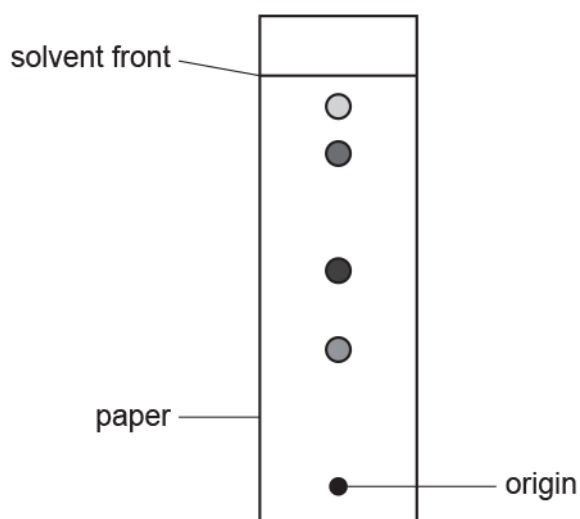
Your answer

☐

[1]

8 Photosynthetic pigments in a leaf were separated using paper chromatography.

The resulting chromatogram is shown below.



Which of the options, **A** to **D**, is the retention factor (R_f) for the most soluble pigment?

- A 0.33
- B 0.93
- C 1.07
- D 3.04

Your answer

[1]

- 9 The extracellular matrix (ECM) can be thought of as the 'glue' that holds together the cells in a tissue. The ECM consists of water, proteins and polysaccharides.

Matrix metalloproteinases (MMPs) are a group of proteases that hydrolyse proteins in the ECM.

Each MMP consists of a single polypeptide chain.

For each of the following features of MMP structure, draw a line connecting the feature to the correct description.

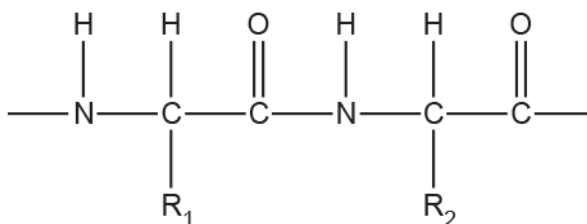
Feature	Description
The active site of MMP contains a Zn^{2+} ion that is required for substrate binding.	Primary structure
	Secondary structure
The enzyme contains a β -pleated sheet and three α -helices.	Tertiary structure
	Competitive inhibition
The amino acid histidine occurs in three places in the sequence making up the active site of all MMPs.	Cofactor

[3]

10(a) Antimicrobial peptides (AMPs) are peptides found in animals and plants that destroy a wide range of pathogenic bacteria, fungi and viruses.

The α -defensins are a group of AMPs that contain 18–45 amino acids.

The diagram below shows part of the structure of an α -defensin molecule.



- (i) Draw a circle around the part of the structure that represents the peptide bond.

[The response to this question should be drawn on the diagram.]

[1]

- (ii) Name the chemical reaction that joins the amino acids together in a peptide.

[1]

- (b) A student used paper chromatography to investigate the amino acid composition of a sample of α -defensin.

- (i) Suggest the importance of the following steps in the paper chromatography procedure.

1. The sample of α -defensin was heated with hydrochloric acid.

2. Care was taken not to touch the paper with fingers.

[2]

(ii) Fig. 2 shows the results of one analysis.

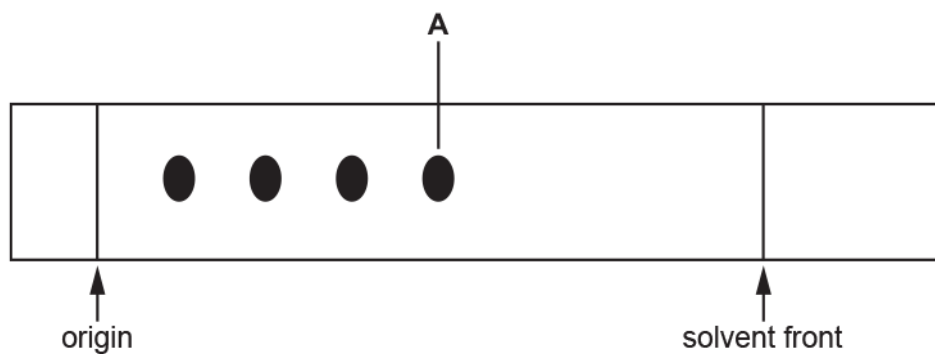


Fig. 2

Table 2 shows R_f values for six different amino acids.

Amino acid	R_f
Arginine	0.16
Cysteine	0.37
Glutamic acid	0.31
Isoleucine	0.53
Methionine	0.51
Tyrosine	0.55

Table 2

Using Fig. 2 and Table 2, calculate the R_f value for spot A and identify the amino acid.

R_f value for spot A = ...

amino acid = ...

[2]

11 Which of the options, **A** to **D**, is a molecule that requires vitamin C for its synthesis?

A collagen

B deoxyribonucleic acid

C haemoglobin

D rhodopsin

Your answer

[1]

12 Which of the rows, **A** to **D**, from the table below indicates the type of bond present (✓) or absent (✗) in the secondary structure of a protein?

	Disulfide	Hydrogen	Hydrophobic	Ionic	Peptide
A	✗	✓	✗	✗	✓
B	✗	✓	✗	✓	✓
C	✓	✓	✗	✗	✓
D	✓	✗	✓	✓	✓

Your answer

[1]

13

Studies have shown that HIV might increase the probability of clots forming inside blood vessels.

A student wrote the following notes about the process of blood clotting.

Complete the gaps in the student's notes using the most appropriate word or term.

Most clotting factors are that convert an inactive clotting factor into an active clotting factor. For example, ... converts prothrombin to thrombin, which then hydrolyses to form the protein fibrin. Because fibrin is a protein the molecules become entangled with red blood cells and form a clot.

[4]

Loss of blood 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.

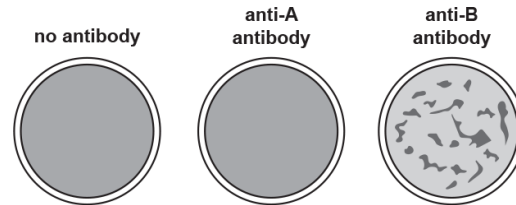


Fig. 37.2

- (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]

- 15 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?

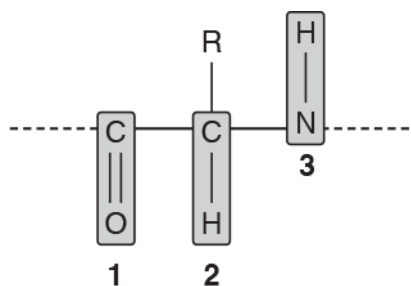
- A phospholipids and Ca^{2+} ions
- B platelets and K^+ ions
- C thrombin and Ca^{2+} ions
- D thromboplastin and K^+ ions

Your answer

[1]

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

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



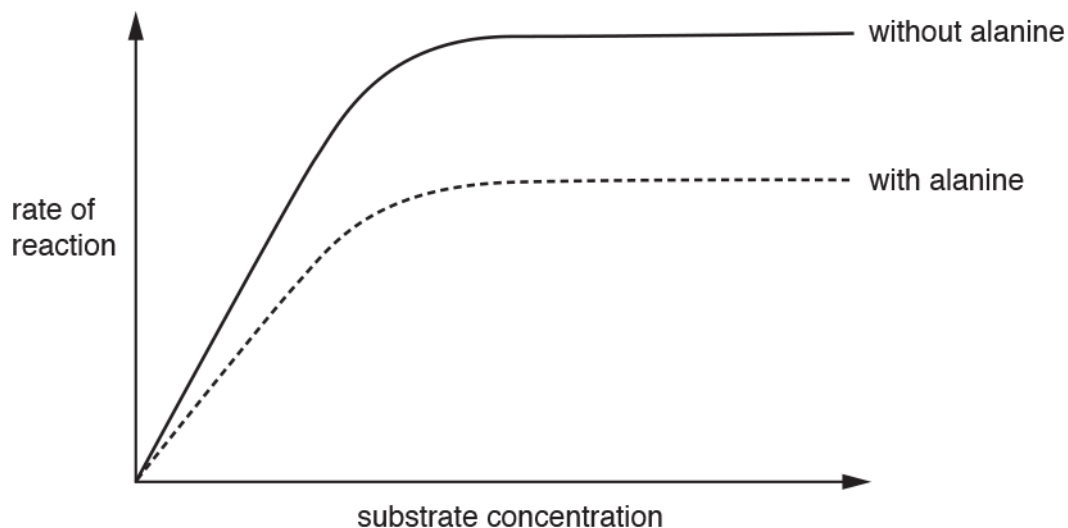
Which of the options, A to D, gives the regions that form bonds in the secondary structure of a protein?

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

Your answer

[1]

17 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]

18(a) Chymosin is a digestive enzyme found in the stomach of young ruminants. Its role in digestion is to coagulate (clot) milk by catalysing a reaction which results in the precipitation of milk proteins.

A student planned an investigation into the effect of temperature on the rate of the reaction catalysed by chymosin.

Fig. 1.1 is a page from the student's notebook showing the procedure used for this investigation.

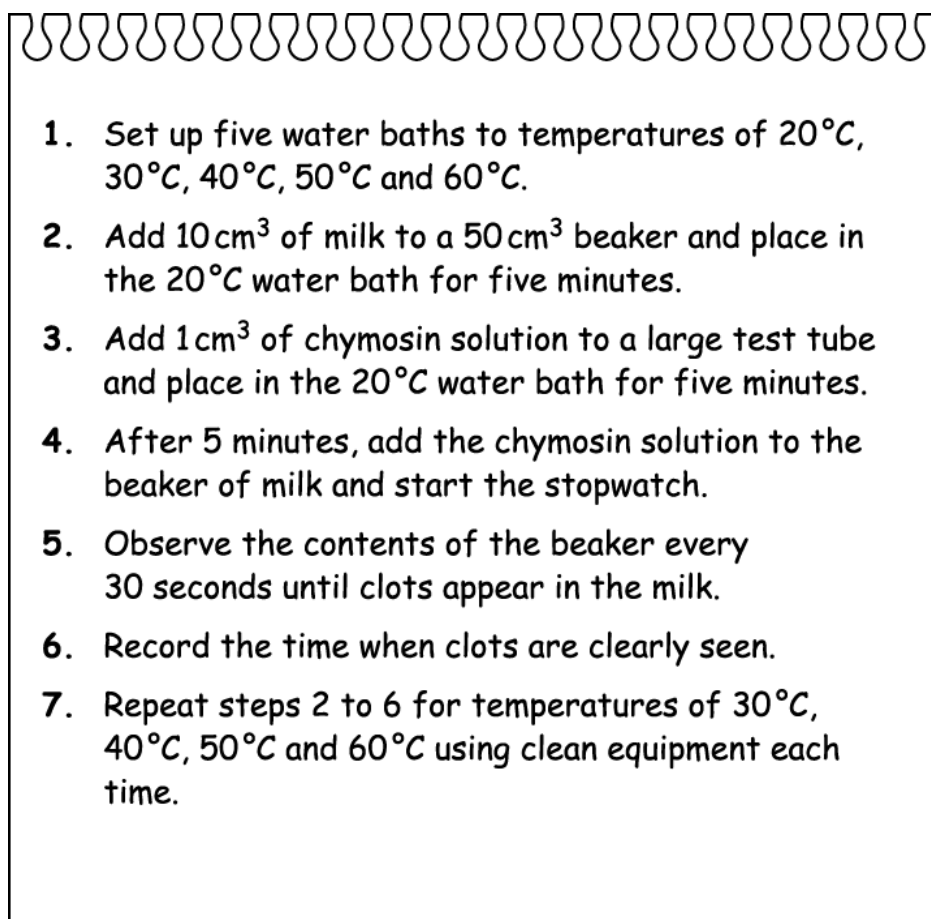


Fig. 1.1

(i) Name **two** pieces of equipment that could be used to accurately measure the volume of chymosin in the procedure.

1

[1]

(ii) Explain why the range of temperatures used in the procedure was suitable for this investigation.

[2]

(b) Another student was asked to repeat the investigation to obtain a set of replicate results.

Suggest **two** additional pieces of information that would be needed to obtain reproducible results. Give a reason for each of your suggestions.

suggestion 1 -----

reason -----

suggestion 2 -----

reason -----

[4]

(c) Chymosin is used in the commercial production of cheese.

- Chymosin acts on the proteins in the milk until it clots to form the curd (soft cheese).
- An enzyme inhibitor is then used to stop the reaction catalysed by chymosin.

(i) During the commercial production of cheese, it is important that the correct concentration of enzyme inhibitor is used to stop the reaction.

[2]

(ii) *Describe how the procedure used in (a) could be adapted to investigate the effect of concentration of enzyme inhibitor on the activity of chymosin.

[6]

61

- Fig. 1.2 shows the action of warfarin in inhibiting the enzyme epoxide reductase.

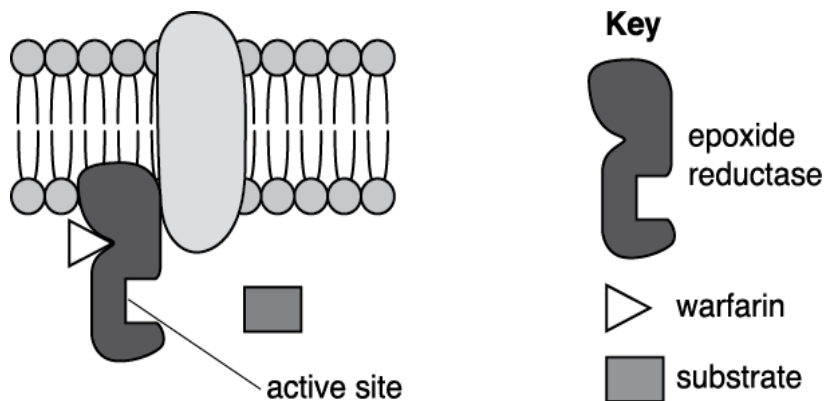


Fig 1.2

- (i) State the type of inhibition shown by warfarin and explain your answer.

Type of inhibition

Explanation

[1]

- (ii) Fig. 1.3 shows the effect of substrate concentration on the rate of the reaction catalysed by the enzyme epoxide reductase.

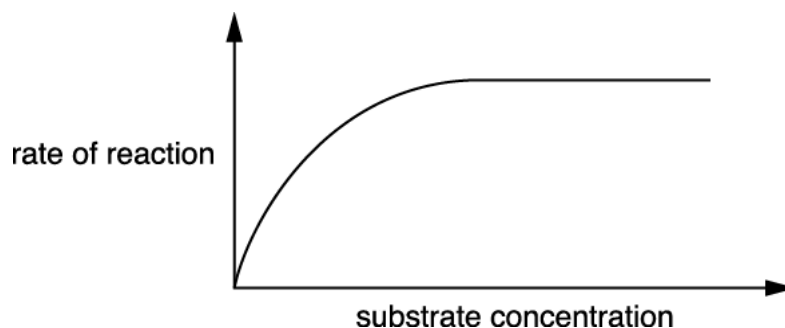


Fig. 1.3

On Fig. 1.3, draw a line to show the effect of a fixed concentration of warfarin on the rate of reaction as substrate concentration is increased.

Your answer should be drawn on Fig. 1.3.

[1]

19 Haemophilia A is a disease caused by a mutation in the gene coding for Factor VIII.

Factor VIII is involved in the blood clotting cascade.

(i) Scientists have found different types of mutation that can cause haemophilia A.

One type of mutation is a deletion of **two** bases. Suggest how this mutation causes the Factor VIII protein to lose its biological function.

----- [2]

(ii) Explain why haemophilia A is more common in males than in females.

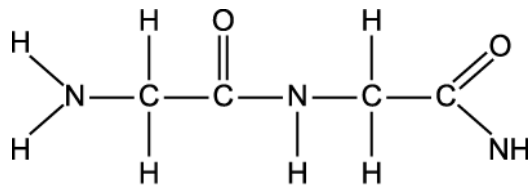
----- [2]

(iii) A male with haemophilia A and a female who carries the disease have a child.

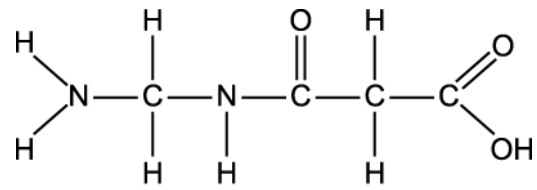
Complete the Punnett square below to determine the probability that the child will have haemophilia A. Use H/h to represent the alleles coding for Factor VIII.

		male	
			
female			
			

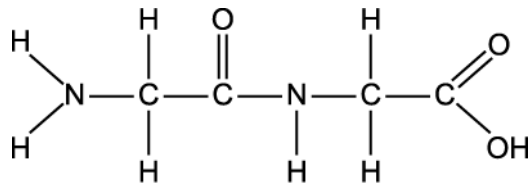
20 Which of the diagrams, A to D, represents a dipeptide molecule?



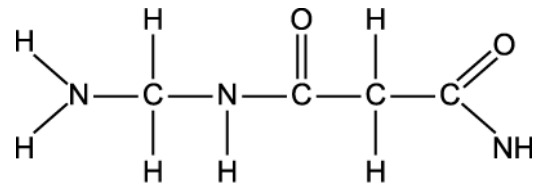
A



B



C

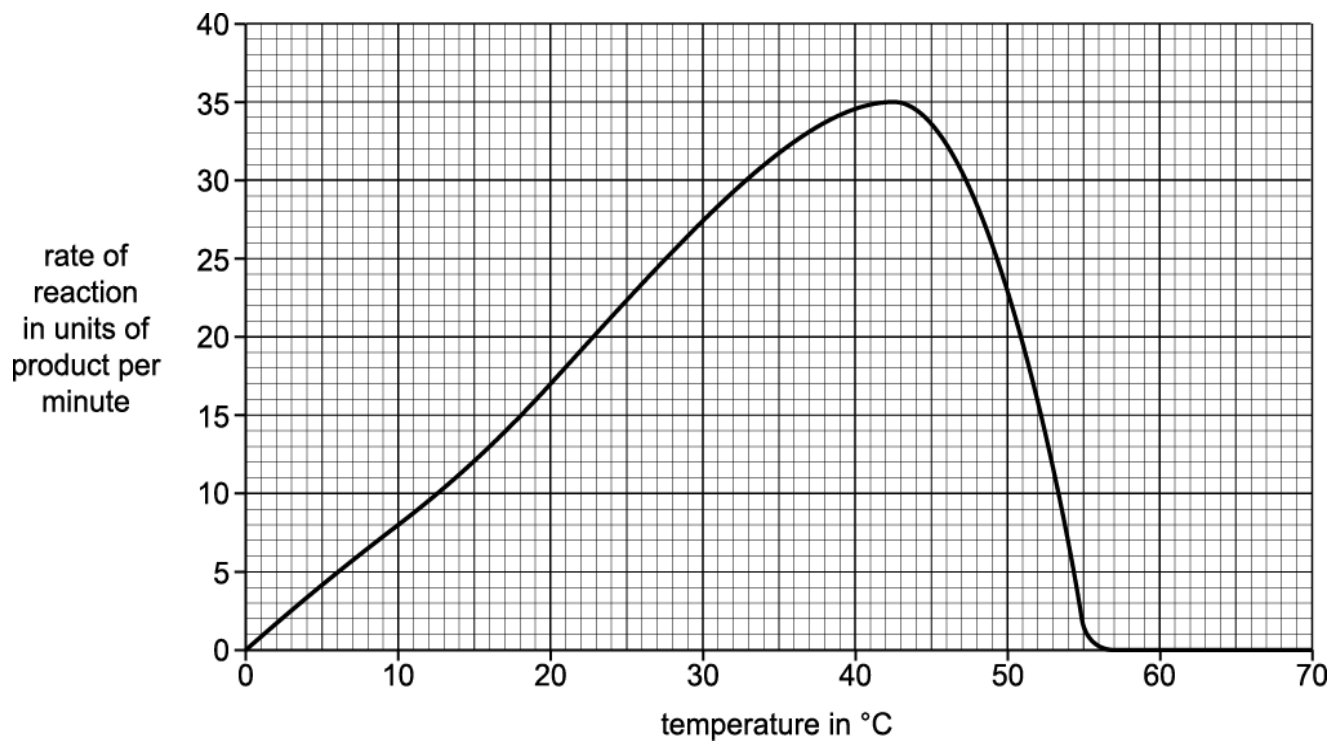


D

Your answer

[1]

21 The graph below shows the effect of temperature on the rate of an enzyme-controlled reaction.



Which of the following statements is/are correct?

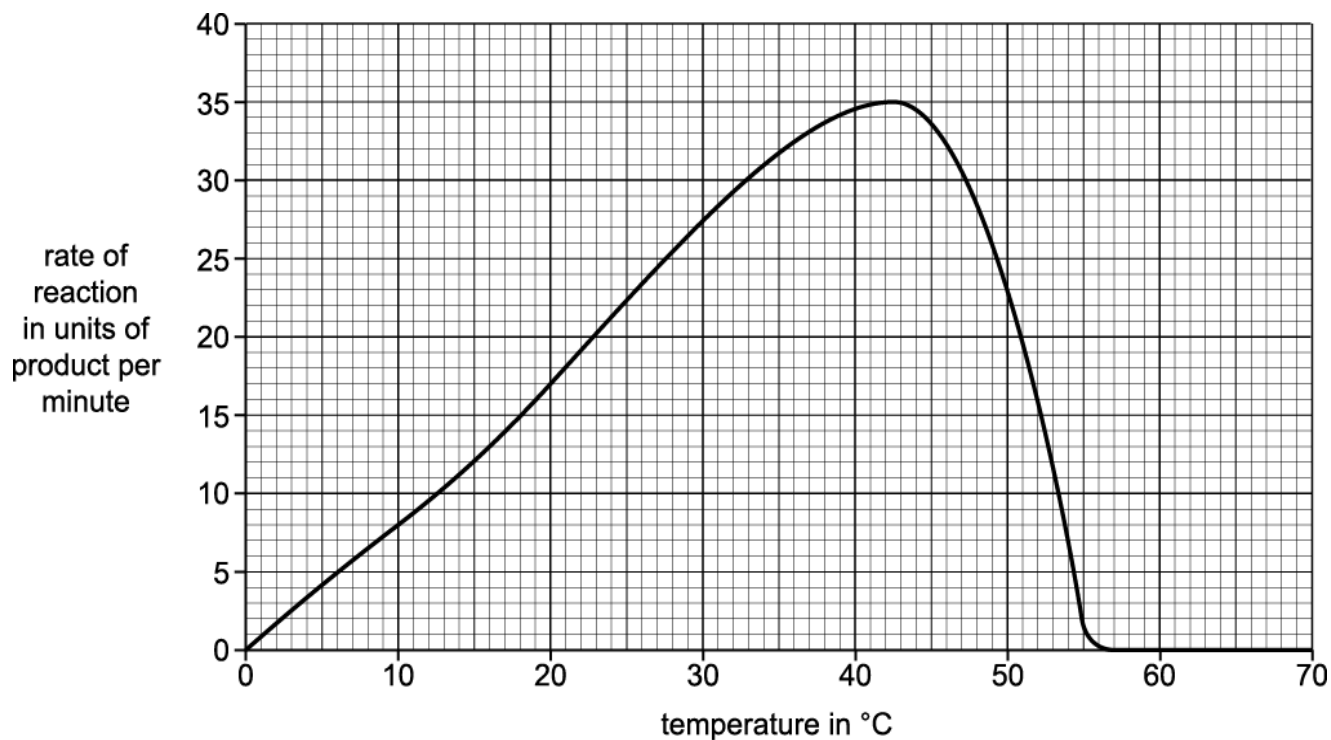
- 1 The kinetic energy of enzyme **and** substrate molecules increases with increasing temperature.
- 2 At 43 °C, all enzyme molecules have a substrate molecule bound to the active site.
- 3 Covalent bonding in enzyme molecules is disrupted by temperatures greater than 43 °C.

- 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]

- 22 The graph below shows the effect of temperature on the rate of an enzyme-controlled reaction.



Q_{10} is a measure of the increase in the rate of reaction with a 10 °C increase in temperature.

It is calculated with the formula below, where t is any given temperature.

$$Q_{10} = \frac{\text{rate at } t + 10\text{ }^{\circ}\text{C}}{\text{rate at } t\text{ }^{\circ}\text{C}}$$

Which of the options, **A** to **D**, is the correctly calculated value for Q_{10} where $t = 10\text{ }^{\circ}\text{C}$?

- A 0.44
- B 0.47
- C 2.13
- D 2.43

Your answer

[1]

23 Three drugs used in the treatment of patients diagnosed with mild or moderate symptoms of Alzheimer's disease underwent clinical trials.

- Patients were tested using an Alzheimer's disease assessment scale (ADAS), which assessed cognitive performance.
- Patients were tested at intervals of 6 weeks.

The results are shown in Fig. 4.1.

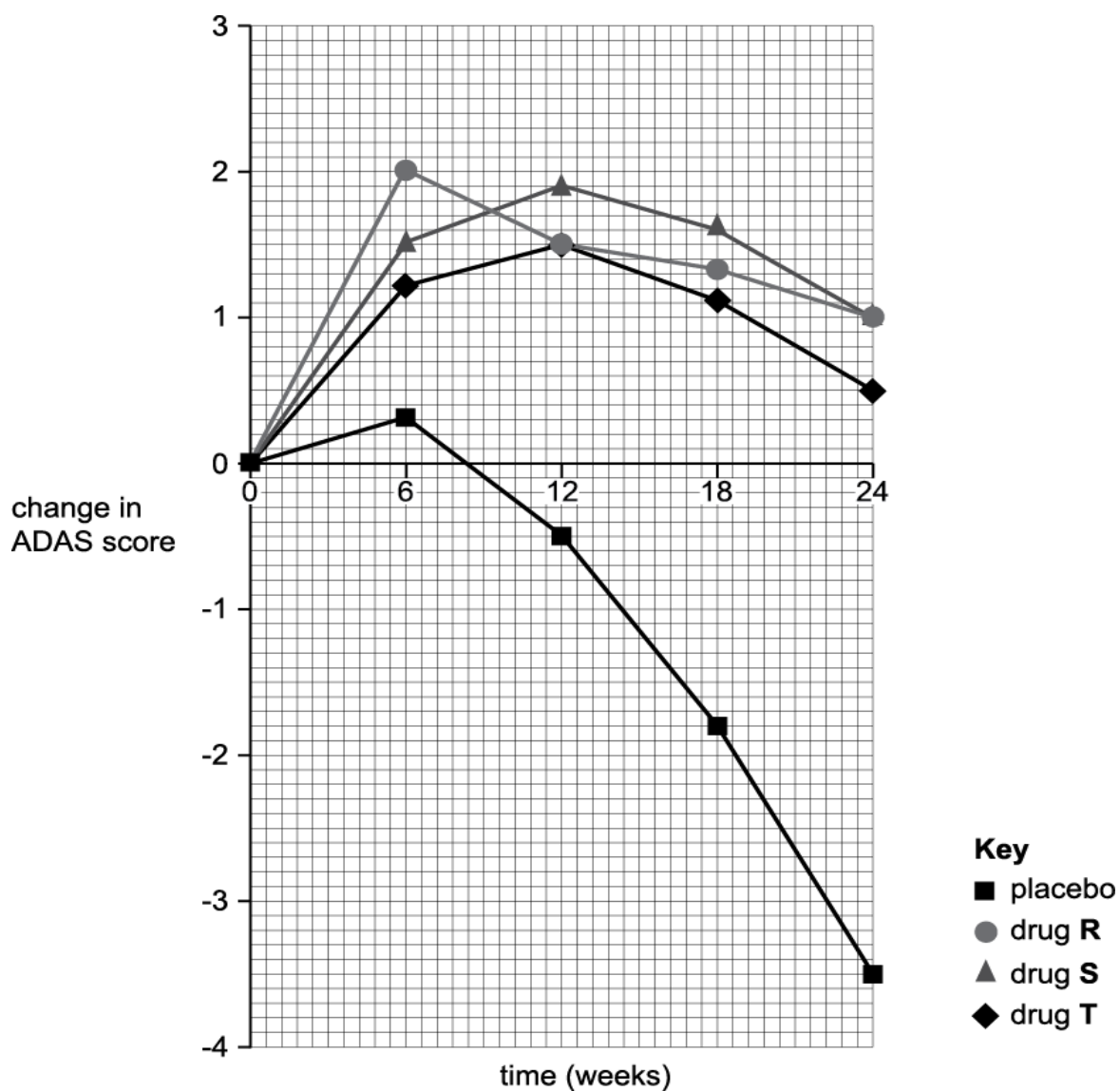


Fig. 4.1

- (i) Calculate the percentage decrease in ADAS score between 12 and 24 weeks for those patients who did not receive a drug treatment.

Show your working.

Answer % [2]

- (ii) Using the data in Fig. 4.1, evaluate the effectiveness of the three drugs in the treatment of the symptoms of Alzheimer's over the trial period.

.....

.....

.....

.....

..... [2]

- (iii) All three of the tested drugs act as inhibitors of the enzyme acetylcholinesterase.

- Drug **R** acts as an irreversible inhibitor of acetylcholinesterase.
- Drugs **S** and **T** act as competitive inhibitors.

Fig. 4.2 shows the effect of increasing acetylcholine concentration on the rate of reaction of acetylcholinesterase in the presence of drug **S**.

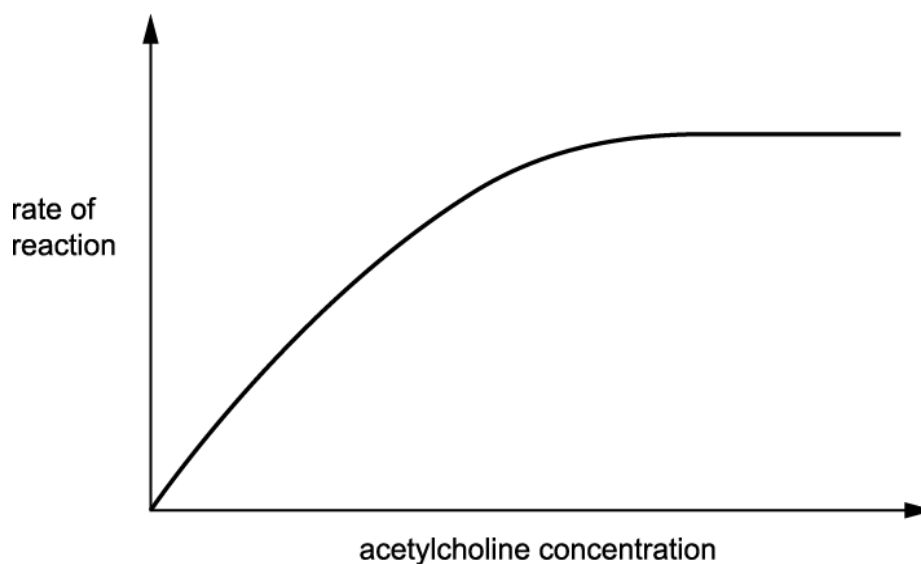


Fig. 4.2

Drug **R** was then used instead of drug **S**. Describe how the curve obtained from drug **R** would be different to the curve shown in Fig. 4.2.

----- [1]

24(a) A student used the enzyme urease to investigate the concentration of urea in samples of mock urine. Urease breaks down urea to produce the alkaline gas ammonia. The procedure used was as follows:

- 1 cm³ of urease solution was placed in a test tube.
- 2 drops of a pH indicator and one drop of dilute hydrochloric acid were added to the test tube. The solution turned yellow.
- 5 cm³ of a urine sample was added to the tube.
- The colour of the solution changed from yellow to red as the ammonia produced from the breakdown of urea neutralised the hydrochloric acid.
- The time taken for the solution to turn from yellow to red was recorded.

(i) Suggest how the student could minimise any uncertainty in:

measuring the volumes used in the procedure _____

measuring the time taken for a solution to change colour _____

[2]

(ii) Identify **two** ways in which the validity of the investigation could be improved.

_____ [2]

(b) The results obtained from the investigation of two different urine samples are given in Table 3.

Replicate	Time taken for tube to change colour(s)	
	Urine sample A	Urine sample B
1	200	50
2	195	65
3	203	60
4	200	55
5	205	62
6	202	66
7	195	50
8	190	55
9	210	60
10	205	63
Mean time taken	200.5	
Standard deviation	5.9	

Table 3

(i) Calculate the mean time and standard deviation for urine sample B. The formula for calculating the standard deviation is given below. Show your working.

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

mean = _____

standard deviation = _____

[3]

(ii) Which of the two samples contained the highest concentration of urea? Use your knowledge of urease action to justify your conclusion.

sample _____

justification _____

[2]

25(a) This question is based on the Advance Notice article **CATALASE**.

Catalase is a homotetramer molecule found in human cells. Homotetramers are molecules that contains four identical subunits.

(i) What evidence in the Advance Notice article confirms that human catalase must be a homotetramer? Explain your answer.

[2]

(ii) Name one other tetrameric protein molecule found in human cells **and** state one similarity and one difference between the structure of this protein molecule and the structure of catalase.

protein -----

similarity -----

difference -----

[3]

(b) Electrophoresis can be used to separate proteins. This technique has been used to investigate the different catalase isoenzymes present in some plant tissues.

Fig. 1.3 shows the appearance of a gel following the electrophoresis of a catalase isoenzyme purified from plant tissue.

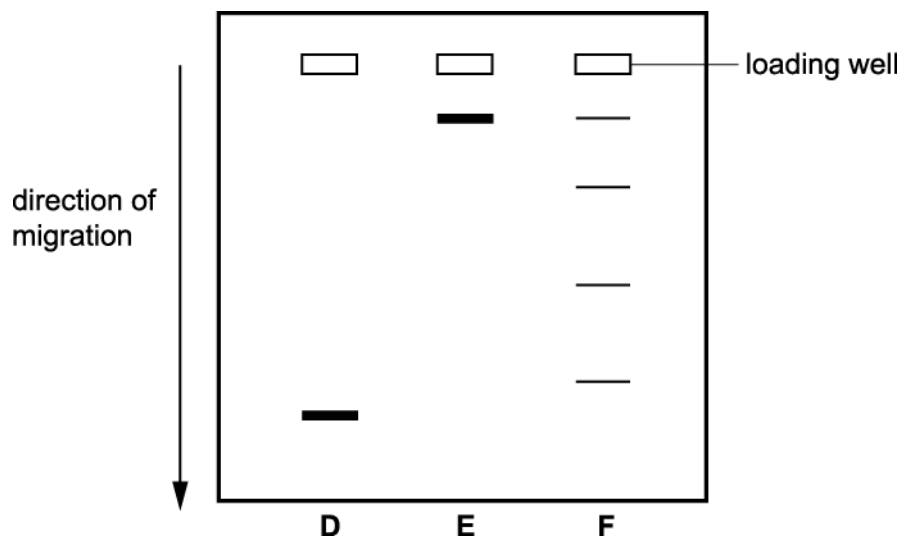


Fig. 1.3

- The distance moved by protein molecules depends on both the charge on the molecule and its size.
- The proteins are first treated with a detergent.
- The detergent covers the protein molecule, which denatures the protein and gives it a negative charge.
- The denatured proteins are loaded onto a gel and placed in an electric field and the molecules migrate.
- The gel is stained and molecules appear as separate bands.

Using this information, suggest which of the three tracks, D, E or F, represents the result obtained following the detergent treatment and electrophoresis of this catalase isoenzyme.

Explain your choice.

track _____

explanation _____

[3]

26 **GABA** (gamma-aminobutyric acid) is one of the most common neurotransmitters in the human central nervous system.

GABA is synthesised from the amino acid glutamate.

Fig. 3.1 is a diagram of GABA.

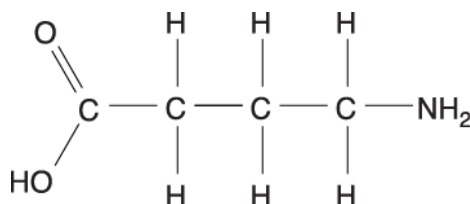


Fig. 3.1

GABA could also be described as an amino acid.

On Fig. 3.1, circle and name the **two** chemical groups on the GABA molecule which indicate that it is also an amino acid.

----- the answer must be drawn on Fig. 3.1 -----

[1]

27 *Spirulina* are photosynthetic bacteria belonging to a group known as the Cyanobacteria. Unlike other Cyanobacteria, *Spirulina* do not fix nitrogen.

Spirulina are widely grown in some parts of the world for use as food for humans and animals.

Fig. 3.1, shows the green bacterial 'mats' being harvested. Once harvested these are dried and processed.



Fig. 3.1

Spirulina is also sold in the United Kingdom as a dietary supplement in the form of capsules, tablets or powder.

Fig. 3.2 below is an extract from a leaflet promoting the benefits of *Spirulina* as a dietary supplement.

- *Spirulina* is one of the most concentrated and nutritious food sources in nature.
- *Spirulina* contains all the amino acids.
- *Spirulina* is a rich source of many vitamins such as B3 (nicotinamide), B9 (folate), C and D.
- *Spirulina* is rich in all essential minerals.
- *Spirulina* is rich in essential fatty acids.
- *Spirulina* is a good source of antioxidants.

Fig. 3.2

Using the information given in Fig. 3.2 about the substances found in *Spirulina*:

(i) identify **one** substance which is necessary for the synthesis of haemoglobin;

-----[1]

(ii) identify **one** substance which forms part of a respiratory co-enzyme;

-----[1]

(iii) identify **one** substance which may prevent DNA damage;

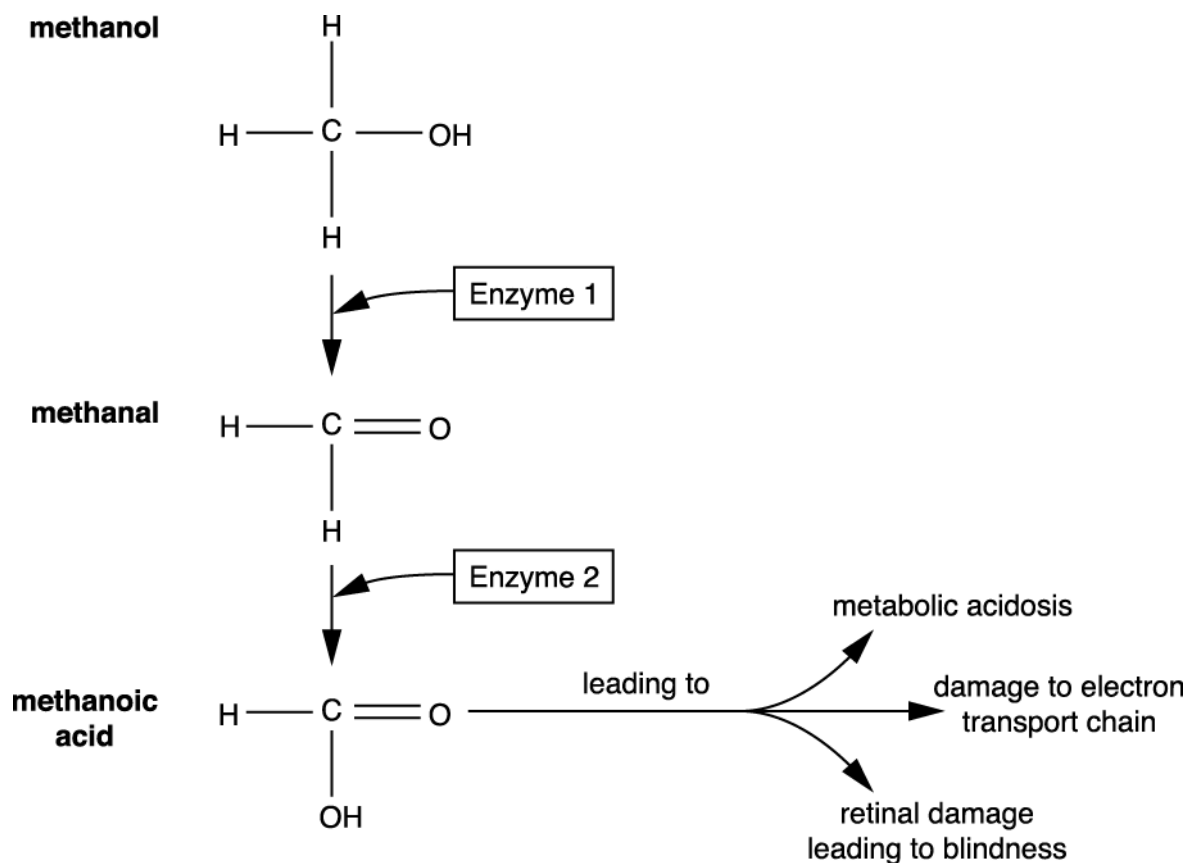
-----[1]

(iv) identify **one** substance which is recommended in routine pre-conceptual care.

-----[1]

Methanol is not toxic, but it is metabolised in liver cells to produce toxic substances such as **methanal** and **methanoic acid**.

The metabolic pathway for methanol breakdown is shown in the figure.



- (i) Metabolic acidosis refers to the build up of organic acids in the blood plasma.

The methanoic acid formed from the metabolism of methanol is only slowly broken down, leading to a build up of this acid in the blood plasma.

Using the information in the figure, suggest one further organic acid that also builds up in the blood plasma. Explain your suggestion.

Name of acid _____

Explanation _____

-----[3]

- (ii) Enzyme 1 in the figure is alcohol dehydrogenase. Alcohol dehydrogenase also breaks down ethanol in liver cells.

Using your knowledge of enzyme activity, suggest why administering ethanol is one method of treating methanol poisoning.

-----[2]

- (iii) There are several different alleles that code for the production of alcohol dehydrogenase in humans. The activity of the enzyme varies with the allele. Some of these alleles are linked to an increased risk of alcohol dependency.

What type of dependency is associated with variation in the alleles for alcohol dehydrogenase?

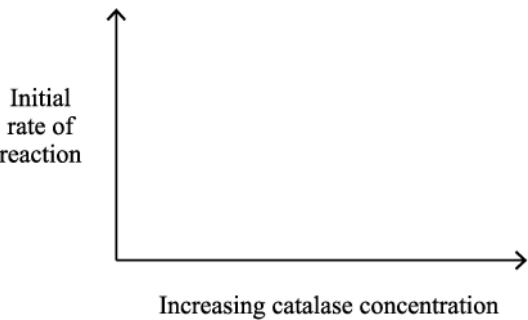
Explain your answer.

-----[1]

29(a) Catalase is an enzyme that is often used in school laboratories. Catalase acts on hydrogen peroxide.

On the axes below, sketch the curve you would expect if a reaction was carried out in optimum conditions with catalase and hydrogen peroxide.

Excess substrate is available.



[1]

(b) A student wanted to investigate the effect of substrate concentration on the rate of hydrogen peroxide breakdown.

There are many different sources of catalase, including ground liver and blended celery stalk. Both of these tissues could be used but each has advantages and disadvantages.

Evaluate the suitability of each of the tissues and justify which tissue is best for the student to use.

[3]

(c) The student set up the investigation using a source of catalase as shown in Fig. 1.1.

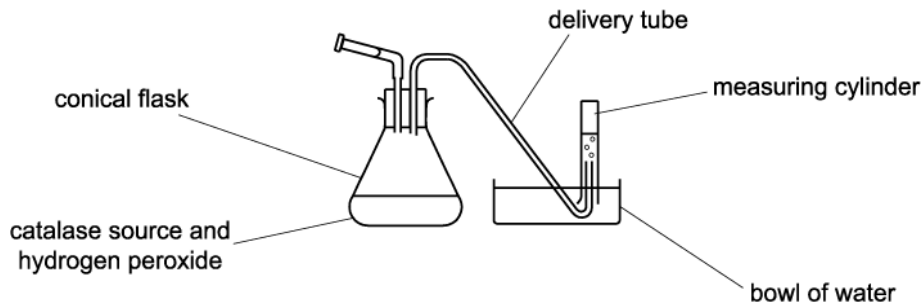


Fig. 1.1

The oxygen gas produced is collected in a 100 cm³ measuring cylinder. The gas produced was measured at two minute intervals.

The student collected data for two different concentrations of hydrogen peroxide (H₂O₂):

- 2 arbitrary units H₂O₂
- 4 arbitrary units H₂O₂.

At the start of each test, 5.0 cm³ of air was already present in the measuring cylinder.

Fig. 1.2 shows the results seen by the student.

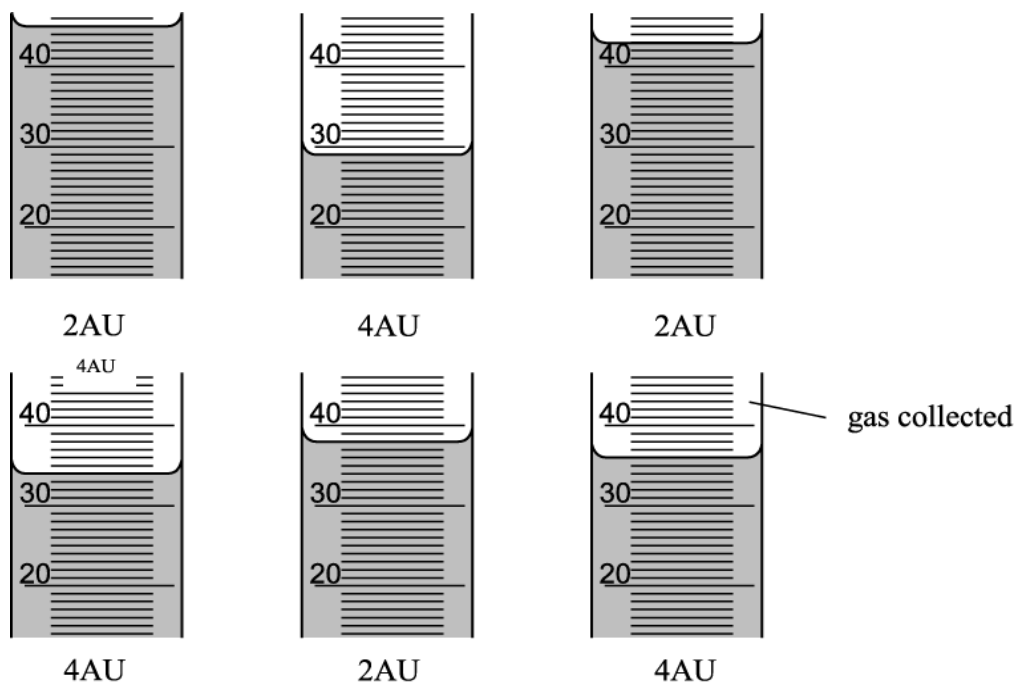


Fig. 1.2

Construct an appropriate table and enter:

- the **raw** data to the most appropriate level of precision for this apparatus
- the **mean values**.

[3]

- (d) Catalase activity can vary between different tissues within the same organism. A second student carried out an investigation using catalase from different muscle tissues. All the samples were taken from the same individual organism.

The results are shown in **Table 1.1** below.

	Time for muscle tissue to produce 2 cm ³ oxygen from hydrogen peroxide (s)	
	Chicken leg muscle	Chicken wing muscle
1	76	98
2	78	96
3	84	85
4	86	78
5	94	102
6	79	104
7	83	116
8	85	94
9	78	89
10	86	112
Mean ($\bar{x}$)	82.9	97.4
SD (s)	5.4	11.7
Variance (s ²)		

Table 1.1

- (i) Complete **Table 1.1**, by calculating the variance for each set of data.

- (ii) The student decided to carry out a t -test to determine if the two sets of data were significantly different from each other.

Calculate the t value for the data in Table 1.1. Use the formula.

$$t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}}}$$

Show your working.

$t =$ [3]

- (iii) The student stated that “there is no significant difference in the time it took to collect 2 cm^3 oxygen so the activity of the catalase in both types of tissue was the same”.

Use Table 1.2 below to decide if the student is correct. Explain your answer.

Degrees of freedom	Level of probability		
	0.05	0.01	0.001
1	12.71	63.66	636.6
2	4.303	9.925	31.60
18	2.101	2.878	3.922
20	2.086	2.845	3.850

Table 1.2

.....

 [3]

- (iv) Comment on the precision of the data obtained for the two types of muscle in Table 1.1.

.....

-----[1]

- (v) Hydrogen peroxide is produced in cells as an intermediate compound when oxygen is converted to water. It can interact with and destroy other molecules in the cell. The enzyme catalase is present in cells to reduce the damage.

Muscles consist of bundles of muscle cells (fibres).

Suggest which muscle, chicken leg or chicken wing, contains cells with a high number of mitochondria.

Explain your suggestion.

-----[1]

30 As part of antenatal care, a pregnant woman will be tested for the presence of **atypical** red blood cell antibodies such as antibodies to the Rhesus antigen.

(i) If a pregnant woman is blood group O, which blood group antibodies would be **expected** in her blood plasma?

-----[1]

(ii) Rhesus antibodies in maternal blood plasma can cross the placenta and enter the fetal circulation. The antibodies can cause fetal red blood cells to agglutinate.

How do antibody molecules cause agglutination of red blood cells with the Rhesus antigen on their cell surface membrane?

-----[2]

- 31 Hormones such as luteinising hormone (LH) and human chorionic gonadotrophin (hCG) play a key role in the control of the menstrual cycle and in the establishment of a pregnancy.

LH and hCG are large glycoproteins each consisting of two protein subunits.

- The alpha subunit is identical in both hormones and is a chain of 92 amino acids.
- The beta subunit of LH contains 121 amino acids.
- The beta subunit of hCG contains 145 amino acids.
- LH can be detected in urine using a test strip containing monoclonal antibodies.
- Monoclonal antibodies are complementary to one specific area on a large antigen molecule. This area is known as an **epitope**.

- (i) Suggest which part of the LH molecule acts as an epitope for the production of the monoclonal antibodies in urine testing kits. Explain your reasoning.

[2]

- (ii) Fig. 6.1 is a diagram of an LH testing strip.

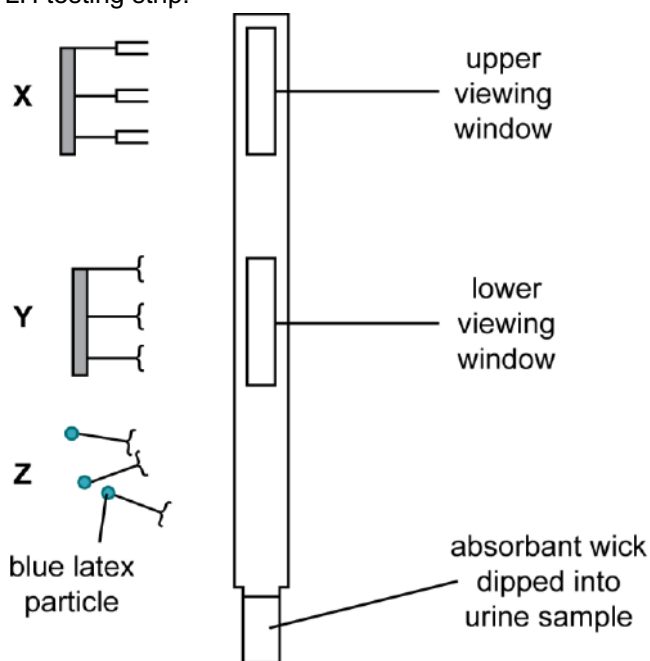


Fig. 6.1

The molecules X, Y and Z represent the monoclonal antibody molecules used in the test strip.

Which molecule(s) would be specific to LH?

-----[1]

32 Haemoglobin is a molecule that is found in most vertebrate species.

A student outlined the structure of haemoglobin using the description below.

A molecule of haemoglobin consists of two alpha and two beta chains. Each polypeptide chain has a coenzyme called haem associated with it. The four polypeptide chains form a 3D tertiary structure consisting of 574 amino acids.

State **two** errors the student has made in their description above and suggest how the student should correct his statement.

Error 1:

Correction 1:

Error 2:

Correction 2:

[2]

- 33 Follicle-stimulating hormone (FSH), gonadotropin-releasing hormone (GnRH) and luteinising hormone (LH) have a role in the development and release of female gametes.

FSH is a globular protein. Fig. 35.1 shows another typical globular protein.

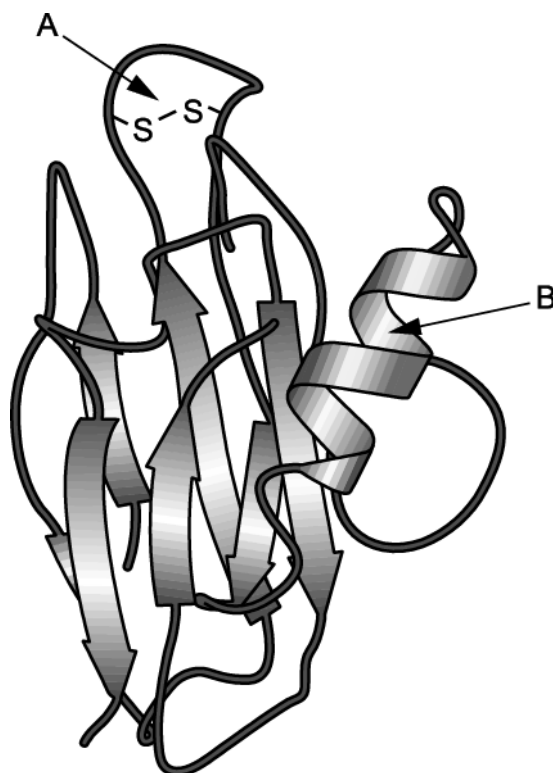


Fig. 35.1

- (i) Identify **and** describe the structural features labelled **A** and **B** in Fig. 35.1.

[4]

- (ii) FSH is a glycoprotein.

After synthesis, the polypeptides of FSH are folded in the lumen of the endoplasmic reticulum.

Describe how FSH is processed further and then secreted from a pituitary cell.

[3]

34 A length of template DNA has the following sequence: GATACTCCTAG.

Which of the options, **A** to **D**, is the mRNA sequence that would be transcribed from this length of DNA?

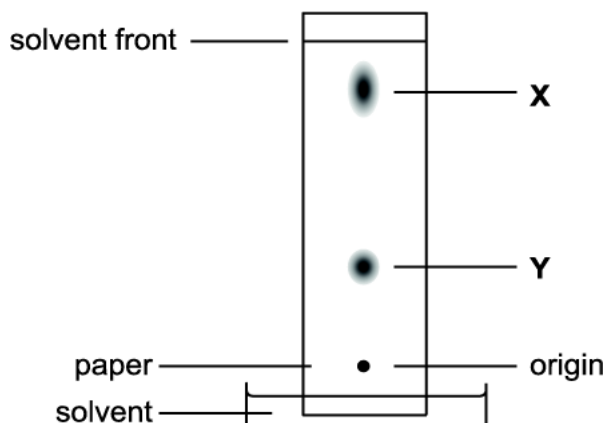
- A CTAGGAGTATC
- B CUAGGAGUAUC
- C CTATGAGGATC
- D CUAUGAGGAUC

Your answer

[1]

35 Amino acids X and Y were separated from a solution by paper chromatography.

The resulting chromatogram is shown below.



Which of the following statements is / are correct?

Statement 1: X has a greater R_f value than Y.

Statement 2: The rates at which X and Y migrate are determined by their relative affinities for the paper and the solvent.

Statement 3: The pH of the solvent influences the rates at which X and Y migrate.

- 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]

The sequence of cellular events which happens in a normal erection is described below:

- stimulation of tissue causes the release of a cell signalling molecule (nitrogen monoxide) from nerve endings
- nitrogen monoxide diffuses into neighbouring cells and causes the production of an intracellular messenger molecule, cyclic **GMP**
- cyclic GMP causes smooth muscle in cells in blood vessel walls to relax
- cyclic GMP is then broken down by an enzyme **PDE-5**.

(i) Comment on the properties of nitrogen monoxide as a cell signalling molecule.

----- [2]

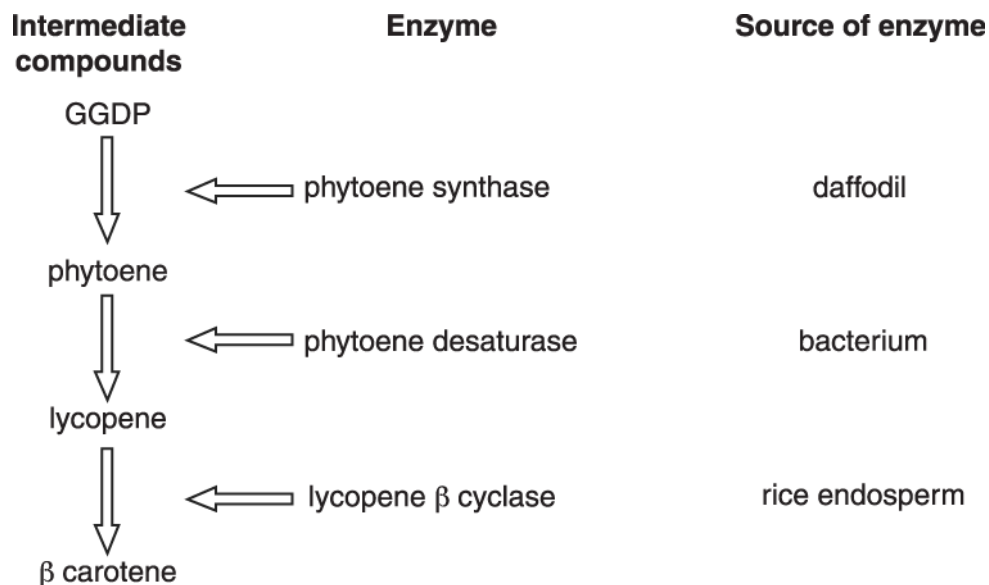
(ii) The chemical sildenafil citrate (Viagra®) binds to the active site of the enzyme **PDE-5**.

Suggest how the action of Viagra® makes it an effective treatment for erectile dysfunction.

----- [3]

38 Scientists used a transformed plasmid to insert genes into Golden Rice™, via the plantinfecting *Agrobacterium*.

The figure outlines the metabolic pathway by which early types of Golden Rice™ made β carotene, the precursor of vitamin A.

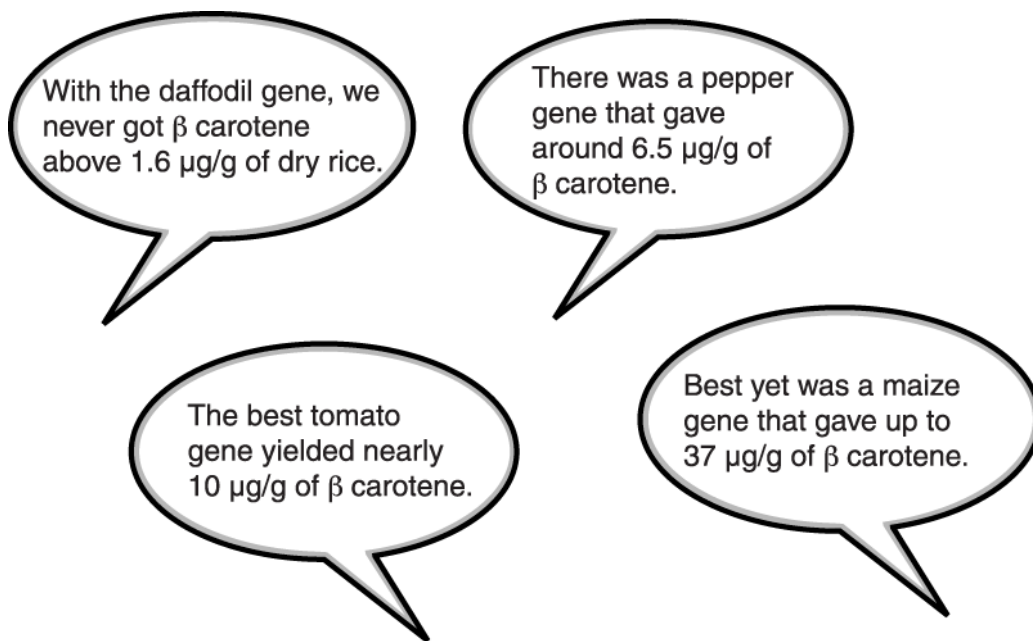


At first, conversion to β carotene was very inefficient. Analysis of quantities of intermediate compounds in the rice showed a build-up of GGDP and little phytoene.

- (i) Explain how the information above shows that the enzymes phytoene desaturase and lycopene β cyclase were **not** limiting the manufacture of β carotene.

[2]

- (ii) Phytoene synthase genes from other sources were then tried with these results:



The gene that makes phytoene synthase enzymes has slight differences between the species.

Suggest explanations for the different performances of these enzymes.

[2]

39 Specialised biotechnology companies have managed to culture some nitrifying bacteria. The bacteria are sold in water-suspension by aquarium suppliers. Aquarium owners use these bacteria to prevent fish death due to toxic levels of ammonia.

(i) With reference to the role of *Rhizobium* in the nitrogen cycle, why would the aquarium suppliers be unlikely to sell *Rhizobium*?

----- [1]

(ii) Explain why the use of nitrifying bacteria by aquarium owners is an example of biotechnology.

----- [1]

(iii) One of the organisms cultured for sale to aquarium owners is *Nitrosomonas europaea*.
This bacterium is highly sensitive to pH.

With reference to the desired product, explain why biotechnology companies need to control pH when culturing *N. europaea*.

----- [3]

END OF QUESTION PAPER

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance												
1		i	binds to biotin preventing absorption ✓ inhibits channels / carriers / enzymes in the membrane ✓ breaks down biotin before it can be used ✓	1 max(AO 2.1)													
		ii	cofactor / biotin , required for enzyme activity ✓ lack of biotin stops specific (metabolic) reaction ✓ example of reaction e.g. could prevent weevils synthesising proteins ✓ weevils can't synthesise biotin ✓	2 max(AO 2.1)													
			Total	3													
2		i	DNA has phosphate (groups) in the backbone ✓ phosphate (group) is charged ✓ <i>idea that</i> forces of attraction occurs between opposite charges on phosphate and arginine ✓	2 max(AO 2.1)	ALLOW has sugar-phosphate backbone												
		ii	enables sperm nucleus to be small ✓ greater protection of DNA molecules ✓	1 max(AO 2.1)	ALLOW enables the head of the sperm to be small												
			Total	3													
3			D	1(AO2.1)													
			Total	1													
4			<table><tr><th>Description</th><th>Haemoglobin</th><th>Myoglobin</th></tr><tr><td>Can bind with up to four oxygen molecules</td><td>✓</td><td></td></tr><tr><td>Has highest affinity for oxygen</td><td></td><td>✓</td></tr><tr><td>Located inside skeletal muscle</td><td></td><td>✓</td></tr></table>	Description	Haemoglobin	Myoglobin	Can bind with up to four oxygen molecules	✓		Has highest affinity for oxygen		✓	Located inside skeletal muscle		✓	2(AO1.1)	3 correct = 2 marks 2 correct = 1 mark 1 correct = 0 mark
Description	Haemoglobin	Myoglobin															
Can bind with up to four oxygen molecules	✓																
Has highest affinity for oxygen		✓															
Located inside skeletal muscle		✓															
			Total	2													

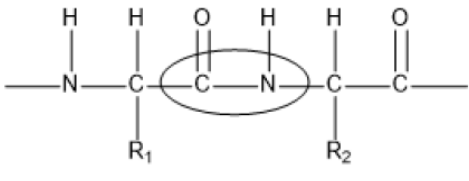
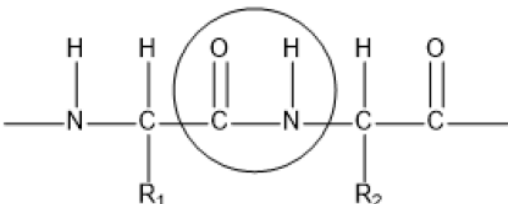
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
5	a	i	use a colorimeter to measure concentration of product ✓ (description of) use of standard curve to convert absorbance to concentration ✓ measure rate of appearance of product / description of plotting graph and use of tangent ✓ repeat at different concentrations of substrate ✓ keep all other , conditions / named condition , constant ✓	max 3(AO2.7)(AO2.7)(AO2.7)(AO2.7)(AO2.7)	
		ii	(so that) enzyme concentration is not a limiting factor ✓	1(AO2.7)	
		iii	FIRST CHECK ON ANSWER LINE If answer = 1.55 mol dm^{-3} award 2 marks $V_{\text{max}} = 9.8$, so $\frac{1}{2} V_{\text{max}} = 4.9$ value for K_M in the range $1.50 - 1.60$ ✓ (correct units =) mmol dm^{-3} ✓	2(AO2.8)(AO2.8)	
		iv	(because the) curve never reaches V_{max} ✓ (because it is) difficult / impossible , to reach high enough [S] ✓ (so) V_{max} / maximum rate , will never be achieved ✓	max 2(AO3.2)(AO3.2)(AO3.2)	ALLOW idea of asymptotic curve ALLOW limited substrate solubility
	b	i	slope = 0.55 ✓	1(AO2.6)	ALLOW answer in range $0.50 - 0.60$

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance												
		ii	slope = K_M/V_{max} ✓	1(AO2.6)	ALLOW ECF from candidate's value for slope. ALLOW candidate's numerical value for slope.												
		iii	FIRST CHECK ON ANSWER LINE If answer = 2.75 award 2 marks $K_M = \text{slope} \times V_{max}$ ✓ correct value for K_M (units not required) ✓	2(AO2.6) (AO2.6)	ALLOW ECF from candidate's value for slope.												
			Total	12													
6			A	1 AO2.5													
			Total	1													
7			A	1 AO2.5													
			Total	1													
8			B	1 AO2.4													
			Total	1													
9			<table><thead><tr><th>Feature</th><th>Description</th></tr></thead><tbody><tr><td>The active site of MMP contains a Zn^{2+} ion that is required for substrate binding.</td><td>Primary structure</td></tr><tr><td></td><td>Secondary structure</td></tr><tr><td>The enzyme contains a β-pleated sheet and three α-helices.</td><td>Tertiary structure</td></tr><tr><td></td><td>Competitive inhibition</td></tr><tr><td>The amino acid histidine occurs in three places in the sequence making up the active site of all MMPs.</td><td>Cofactor</td></tr></tbody></table>	Feature	Description	The active site of MMP contains a Zn^{2+} ion that is required for substrate binding.	Primary structure		Secondary structure	The enzyme contains a β -pleated sheet and three α -helices.	Tertiary structure		Competitive inhibition	The amino acid histidine occurs in three places in the sequence making up the active site of all MMPs.	Cofactor	3 AO2.1	1 mark for each correct joining line Examiner's Comments All candidates answered this question, with the most common, correct answer being the recognition of secondary structure. A lot of candidates stated tertiary structure for the third feature, clearly focusing on the term 'active site' and not reading the feature as a whole.
Feature	Description																
The active site of MMP contains a Zn^{2+} ion that is required for substrate binding.	Primary structure																
	Secondary structure																
The enzyme contains a β -pleated sheet and three α -helices.	Tertiary structure																
	Competitive inhibition																
The amino acid histidine occurs in three places in the sequence making up the active site of all MMPs.	Cofactor																
			Total	0													

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
10	a	i		1 AO2.1	ALLOW  <u>Examiner's Comments</u> Most candidates circled the correct bond area. Many candidates focused their circle to the relevant bond only which is excellent practice, although circles encompassing the relevant functional groups and their bonds, was acceptable.
		ii	condensation ✓	1 AO1.1	Mark the first answer. If an additional answer is given that is incorrect, then = 0 marks IGNORE polymerisation
	b	i	1to <u>hydrolyse</u>, peptide bonds / protein / peptide ✓ 2to avoid contamination (with amino acids from skin) ✓	2 AO2.3	IGNORE reference to microorganisms <u>Examiner's Comments</u> Candidates answered part 2 well and recognised the need to not contaminate the paper. A few candidates referred to not interfering with the solute* and solvent. Part 1 proved to be more difficult for candidates to phrase and few used the correct terminology.  This type of incorrect word association* can be minimised by key words constantly listed with particular techniques or annotated diagrams repeatedly drawn.
		ii	$R_f = \frac{(45)}{(88)} = 0.51$ ✓ Correct identification = methionine ✓	2 AO2.4 AO3.1	ALLOW answer in range 0.50 – 0.52 (2 d.p.) ALLOW ECF from incorrect R_f value

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
			Total	0	
11			A	1	
			Total	1	
12			A	1	
			Total	1	
13			enzymes ✓ thromboplastin ✓ fibrinogen ✓ fibrous ✓	4	ALLOW 'insoluble' OR 'filamentous' for 'fibrous' <u>Examiner's Comments</u> This was well answered with 'fibrinogen' and 'fibrous' the most common, correct answers.
			Total	4	
14		i	packed, red (blood) cells / erythrocytes ✓	1	ALLOW red (blood) cell / erythrocyte, concentrate <u>Examiner's Comments</u> (c)(i) was a straightforward recall question but many candidates did not refer to concentrated or packed red blood cells.
		ii	B ✓ B AND O ✓	2	ALLOW ECF <u>Examiner's Comments</u> Blood group O was often identified as a donor in (c)(ii) but identifying the blood group of the patient was more demanding.
			Total	3	
15			C ✓	1	<u>Examiner's Comments</u> This was straightforward recall and the majority of candidates chose the correct response.
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
16			B ✓	1	Examiner's Comments A surprising number of candidates could not identify the region of bond formation in a secondary structure of a protein.
			Total	1	
17			A ✓	1	Examiner's Comments This question contained a lot of information for candidates to process and proved to be quite challenging to candidates.
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
18	a	i	Any two from: graduated (teat) pipette ✓ volumetric pipette ✓ 1 cm ³ / 2 cm ³ , syringe ✓	max 1	DO NOT ALLOW unspecified size of syringe or one of greater volume DO NOT ALLOW 10 cm ³ (or smaller) measuring cylinder
		ii	(chymosin is a) mammalian enzyme ✓ (so) active / works best , at 37°C ✓ 37°C / optimum temperature , is in the middle (of the range chosen) ✓	max 2	IGNORE ruminant
	b		<i>Suggestion:</i> pH should be , controlled / the same ✓ <i>Reason:</i> ensures pH is constant therefore does not , affect enzyme activity / alter enzyme structure ✓ <i>Suggestion:</i> same concentration of , enzyme / chymosin ✓ <i>Reason:</i> increase in enzyme concentration will , speed up the reaction / clotting process ✓ <i>Suggestion:</i> same type of milk used ✓ <i>Reason:</i> different types of milk may have different concentration of , protein / substrate ✓ <i>Suggestion:</i> same concentration of , milk / substrate , used ✓ <i>Reason:</i> increase in concentration will , speed up the reaction / clotting process ✓	4	Correct reason MUST be linked to the suggestion ALLOW chymosin works at low pH found in stomach ALLOW ORA ALLOW ORA
	c	i	<i>idea that</i> the reaction could still continue if not enough inhibitor is used ✓ <i>idea that</i> too much inhibitor could affect the quality of the final product ✓ <i>idea of</i> increased cost to commercial cheese producers if more inhibitor is used than needed to stop the reaction ✓	2 max	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	*Summary of instructions to markers: <i>Read through the whole answer. (Be prepared to recognise and credit unexpected approaches where they show relevance.)</i> <i>Using a 'best-fit' approach based on the science content of the answer, first decide which of the level descriptors, Level 1, Level 2 or Level 3, best describes the overall quality of the answer.</i> <i>Then, award the higher or lower mark within the level, according to the Communication Statement (shown in <i>italics</i>):</i> • <i>award the higher mark where the Communication Statement has been met.</i> • <i>award the lower mark where aspects of the Communication Statement have been missed.</i> • <i>The science content determines the level.</i> • <i>The Communication Statement determines the mark within a level.</i>		
		ii	Level 3 (5-6 marks) Comprehensive details of the apparatus and method used to produce reliable data. Most variables are identified and the method states how these are controlled. <i>There is a well-developed line of reasoning which is clear and logically structured and uses scientific terminology at an appropriate level. All the information presented is relevant and forms a continuous narrative.</i> Level 2 (3-4 marks) The apparatus and a method to provide reliable results are given although some details may be missing. Some variables are identified and the method references how variables are controlled. <i>There is a line of reasoning presented with some structure and use of appropriate</i>	6	Indicative scientific points could include: Apparatus & method • test tubes • apparatus for volume measurement (e.g. pipettes, syringes, small (<50 cm³) measuring cylinders) • distilled water • details of quantitative preparation of dilution series of inhibitor to include volumes and final concentration • water bath • stop clock / timer • method of determining end point Variables • independent variable = concentration of inhibitor • dependent variable = time until solution

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
			<i>scientific language. The information presented is mostly relevant.</i> Level 1 (1–2 marks) The apparatus and an outline method are suggested but information may be missing to provide reliable results. There is limited reference to variables and how they are controlled. <i>The information is communicated with only a little structure. Communication is hampered by the inappropriate use of technical terms.</i> 0 marks No response or no response worthy of credit		is transparent - correct units included (mol dm^{-3}, s) - control variables e.g. temperature, volumes Repeatability - repeats for dilutions of inhibitor - reference to quantitative processing of data e.g. calculation of means Risk Assessment - potential chemical hazards & control (enzyme / chymosin) - potential electrical hazards & control (water bath) <i>Communication statement guidance</i> The method can be written as bullet or numbered points and should follow a logical sequence. For some, this will be a method with different sections e.g. apparatus, method, variables while for others it will be more similar to the method given in the question. Both are acceptable. To form a continuous narrative, all sentences or bullet/numbered points should make sense and it should be possible to read from beginning to end without having to refer to footnotes or omissions.
	d	i	<u>non-competitive</u> (inhibition) AND (inhibitor) binds / attaches , at , another / allosteric / 2nd, site OR changes shape of the enzyme / allosteric effect OR (causes) distortion to shape of active site ✓	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance										
		ii	curve / line , starts at the same point AND is the same shape as sketch graph AND curve / line , levels out / plateaus , at a lower rate of reaction than sketch graph ✓	1	ALLOW ECF from (i) if identified as competitive inhibitor										
			Total	17											
19		i	interrupts triplet code / causes frame-shift / production of premature stop codon ✓ (DNA) triplets code for different amino acids ✓ primary structure of protein changed ✓ protein cannot interact with other, proteins / named component ✓	max 2											
		ii	gene (encoding Factor VIII), on X chromosome / X-linked / sex-linked ✓ males lack second X chromosome ✓	2	ORA ORA										
		iii	male gametes <table><tr><td></td><td>X^h</td><td>Y</td></tr><tr><td rowspan="2">female gametes</td><td>X^H</td><td>$X^H X^h$</td><td>$X^H Y$</td></tr><tr><td>X^h</td><td>$X^h X^h$</td><td>$X^h Y$</td></tr></table> probability = 0.5 ✓✓		X^h	Y	female gametes	X^H	$X^H X^h$	$X^H Y$	X^h	$X^h X^h$	$X^h Y$	3	ALLOW H/h not superscripted on X ALLOW 50% or ½
	X^h	Y													
female gametes	X^H	$X^H X^h$	$X^H Y$												
	X^h	$X^h X^h$	$X^h Y$												
			Total	7											
20			C ✓	1											
			Total	1											
21			D ✓	1											
			Total	1											
22			C ✓	1											
			Total	1											

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
23		i	600 ✓✓	2	For incorrect reading(s) from the graph but a correct calculation allow 1 max
		ii	<i>idea that</i> (over trial period), cognitive function improved / was higher than baseline for all three drugs tested OR <i>idea that</i> no significant difference between the three drugs OR <i>idea that</i> improvement not sustained / dropping back to baseline ✓ figures given in support ✓	2	
		iii	(the curve would) plateau / AW, below the curve in Fig. 4.2 ✓	1	
			Total	5	

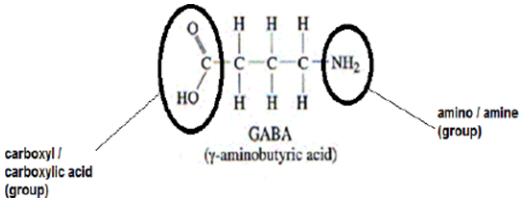
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
24	a	i	<i>volumes</i> <i>idea of</i> using the appropriate measuring instrument (e.g. 1 cm ³ syringe for urease / 5 cm ³ for urine / microsyringe instead of 'drops' for indicator) ✓ <i>times</i> <i>idea of</i> a stop watch / timer and a comparison to determine final colour ✓	2	ALLOW alternative relevant answers ALLOW suggestion that reaction is monitored in a colorimeter and the same absorbance value used each time for the end point
		ii	use same concentration of urease (throughout) ✓ place tubes in a water bath ✓	2	ALLOW alternative relevant answers DO NOT ALLOW 'add a buffer' or 'control pH' as a change in pH is the dependent variable
	b	i	mean = 58.6 ✓ standard deviation = 5.8 ✓✓	3	ALLOW ECF for incorrect calculation of mean 2 max if either answer is given to more than 3 significant figures
		ii	Sample B (no mark) <i>justification</i> <i>idea of</i> more substrate molecules available ✓ more enzyme-substrate complexes form in a given time ✓ rate of the reaction increases ✓	max 2	ALLOW ammonia produced at a faster rate
			Total	9	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
25	a	i	<i>evidence</i> - only one gene (locus) (paragraph 8) ✓ <i>idea that</i> one gene codes for one polypeptide ✓	2	
		ii	<i>protein</i> - haemoglobin ✓ <i>similarity</i> - <i>idea of</i> same prosthetic group / haem attached to each sub-unit ✓ <i>difference</i> - <i>idea that</i> there are two different sub-units in haemoglobin / 2 alpha and 2 beta sub-units ✓	3	IGNORE reference to same number of sub-units ALLOW 'haemoglobin is not a homotetramer' or 'haemoglobin is a heterodimer' IGNORE 'haemoglobin is a heterotetramer'
	b		(track) D ✓ <i>explanation</i> - up to 2 marks detergent destroys (secondary, tertiary and) quaternary structure ✓ (4) subunits smaller so migrate lower down gel ✓ all subunits are, same / a similar size / 492 amino acids ✓	max 3	If incorrect track identified then award up to two marks
			Total	8	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
26			complete carboxyl group circled and labelled AND complete amine group circled and labelled; OR Both groups circled AND carboxyl, amino on dotted lines in that order;	1	 Examiner's Comments A few candidates circled the relevant parts of the molecule but failed to add names. Other candidates inserted the names in the dotted lines. This was credited if the correct parts were circled and if the order corresponded to the order on the diagram. Some candidates circled incorrect areas on the diagrams. Others circled correctly but used incorrect names. Some responses seen included naming the NH₂ group as 'nitrogen', 'nitrate' or 'nitrogenous base'. Other candidates referred to it as the 'R' group.
			Total	1	

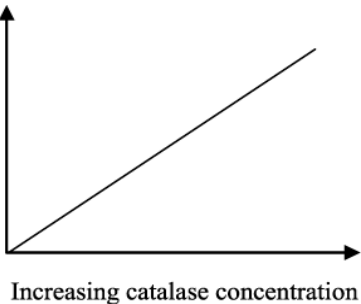
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27		i	amino acid(s);	1	Mark the first answer. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer = 0 marks ALLOW iron IGNORE mineral unqualified (as given in question)
		ii	(Vitamin) B3 / nicotinamide;	1	Mark the first answer. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer = 0 marks
		iii	antioxidant(s) / vitamin C;	1	Mark the first answer. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer = 0 marks
		iv	(Vitamin) B9 / folate / folic acid;	1	Mark the first answer. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer = 0 marks
			Total	4	

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28		i	lactic acid; electron transport chain, inhibited / damaged OR no / less aerobic respiration; anaerobic respiration product is lactate;	3	
		ii	<i>Idea that</i> methanol and ethanol are similar shapes; <i>Idea that</i> ethanol binds to active site of, enzyme / alcohol dehydrogenase; <i>idea that</i> less methanol converted to toxic product;	2 max	ACCEPT methanol has a similar structure to ethanol Mp2 ACCEPT ethanol acts as a competitive inhibitor OR ethanol forms an enzyme substrate complex
		iii	physiological / physical (dependency) (<i>no mark</i>) AND <i>idea that</i> more active/efficient enzyme / alcohol broken down, faster / AW;	1	DO NOT CREDIT 'psychological' even if the explanation of tolerance is correct. CREDIT reverse argument – less active / efficient enzyme / alcohol broken down, more slowly / AW Examiner's Comments In part (i) although lactic acid was given as an answer, many candidates ignored the instruction to use the figure and failed to spot the damage to the electron transport chain. Part (ii) discriminated well with good candidates using their knowledge of complementary shape and active sites. However, weaker candidates confused which compound would have the active site and what compounds would bind and it was not uncommon to see references to methanol having an active site. Many correctly identified the form of dependency in part (iii) but then gave a general description rather than linking it back to the alleles and the effect on alcohol dehydrogenase activity.
			Total	6	

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29	a		 Initial rate of reaction Increasing catalase concentration	1	
	b		<i>Award 1 mark for an advantage of either tissue and 1 mark for a disadvantage of either tissue to a maximum of 2 marks.</i> <i>Advantages of using liver</i> idea of more enzyme per gram OR easier to grind / blend (1) <i>Advantages of using celery</i> cheaper OR slower activity may give more accurate results (1) <i>Disadvantages of using liver</i> religious objections depending on animal source OR messy to prepare / AW (1) <i>Disadvantages of using celery</i> may be out of season OR different parts of the plant have different activity levels (1)	3	In the absence of a justified decision regarding tissue choice award a maximum of 2 marks DO NOT award double marks for statements simply reversed for the other tissue

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	c		Student gives reasoned argument / justification for final choice (1) concentration of, hydrogen peroxide / H₂O₂, (AU) in first column AND volume of water displaced (cm³) to the right of the IV, with each concentration of hydrogen peroxide recorded in separate row AND all cells surrounded by straight ruled lines (1) all data for 2AU recorded correctly AND all data for 4AU recorded correctly (1) both mean values calculated correctly AND recorded to, the same / one more decimal place, than raw data (1)	3	<i>Table should resemble:</i> <table><tr><th>Concentration of hydrogen peroxide (AU)</th><th colspan="4">Volume of water displaced (cm³)</th></tr><tr><th></th><th>1</th><th>2</th><th>3</th><th>Mean</th></tr><tr><td>2</td><td></td><td></td><td></td><td></td></tr><tr><td>4</td><td></td><td></td><td></td><td></td></tr></table> OR <table><tr><th>Concentration of hydrogen peroxide (AU)</th><th>Initial level of meniscus (cm³)</th><th>End level of meniscus (cm³)</th><th>Volume of water displaced (cm³)</th><th>Mean volume of water displaced (cm³)</th></tr><tr><td>2</td><td></td><td></td><td></td><td></td></tr><tr><td>4</td><td></td><td></td><td></td><td></td></tr></table> Figures to be checked on a printed paper at standardisation.	Concentration of hydrogen peroxide (AU)	Volume of water displaced (cm ³)					1	2	3	Mean	2					4					Concentration of hydrogen peroxide (AU)	Initial level of meniscus (cm ³)	End level of meniscus (cm ³)	Volume of water displaced (cm ³)	Mean volume of water displaced (cm ³)	2					4				
Concentration of hydrogen peroxide (AU)	Volume of water displaced (cm ³)																																							
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2																																								
4																																								
	d	i	<i>variance for leg muscle</i> 29.16 AND <i>variance for wing muscle</i> 136.89 (1)	1	Look for answer written outside of the table																																			
		ii	<i>t value</i> 3.558 (1)(1)(1)	3	DO NOT ALLOW if negative sign is given If incorrect t value is given, marks can be given for intermediate stages as follows: <i>one mark for modulus calculation</i> 14.5 <i>one mark for denominator calculation prior to square rooting</i> 16.605 AWARD ecf from either / both previous calculations																																			

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		iii	Any 3 from: t_{critical} is 2.101 at 5% probability level (1) the (calculated) value is greater than the critical value at the 5% ($p = 0.05$) significance level (1) the (calculated) value is also greater than the critical value at the 1% ($p = 0.01$) significance level (1) (therefore the student can) reject the null hypothesis (1) the difference in enzyme activity is not due to random chance (1)	3	
		iv	precision of the leg muscle is greater (than the data for the wing muscle) AND as the SD for the wing muscle is higher than that of the SD for the leg muscle (1)	1	ALLOW use comparative use of figures
		v	<i>(chicken leg muscle)</i> <i>idea that</i> higher catalase activity so more, aerobic respiration / oxidative phosphorylation (1)	1	
			Total	16	
30		i	(anti) A AND (anti) B antibodies	1	
		ii	(antibody has) two, binding sites / variable regions (1) <i>idea that</i> sites bind to antigens on different blood cells (1)	2	ALLOW an explanation from a diagram
			Total	3	
31		i	(area on) beta subunit (1) <i>Explanation</i> <i>idea that</i> this has different 3D or tertiary structure to hCG OR <i>idea that</i> this has a unique 3D or tertiary structure (1)	2	
		ii	Y AND Z (1)	1	Both letters required for one mark
			Total	3	

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32			error = coenzyme, correction = prosthetic group error = tertiary, correction = quaternary	2	ALLOW 'cofactor' for 'prosthetic group' ALLOW '3°' for 'tertiary' and '4°' for 'quaternary'
			Total	2	
33		i	A: any 2 from: (di)sulfide, bonds / bridges (1) covalent bonds (1) between cysteine amino acids / S-S atoms / S-H groups (1) B: alpha helix (1) hydrogen bonding / interactions, between –NH (group) of one amino acid and –CO (group) of another (1)	4	disulfide bonds are covalent = 2 marks DO NOT ALLOW disulfate IGNORE ref to carbohydrate chains
		ii	any 3 from: transported to Golgi (apparatus / body / complex) (1) glycosylated / sugar / carbohydrate added using glycosylase / enzymes (1) packaged into / formation of (secretory) vesicles (1) fusion of vesicles with, plasma / cell surface, membrane (1)	3	
			Total	7	
34			D	1	
			Total	1	
35			A	1	
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
36		i	Any 2 from: <i>idea that</i> nitrogen monoxide must be, lipid soluble / hydrophobic (explanation) it diffuses / AW, through the cell surface membrane binds to, receptor / AW, inside the cell <i>idea that</i> second messenger is cyclic GMP rather than cyclic AMP	2	
		ii	Any 3 from: Viagra acts as a competitive inhibitor (of PDE-5) <i>idea that</i> cyclic GMP, is not broken down / lasts longer (in cells) <i>idea that</i> blood vessels dilate, more / for longer <i>idea that</i> erection maintained for longer	3	ALLOW 'Viagra forms an enzyme inhibitor complex' OR description 'prevents the formation of ESC'
			Total	5	

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Question			Answer/Indicative content	Marks	Guidance
37		i	troponin, binds to / AW, tropomyosin myosin binding site is blocked (by tropomyosin) / <i>idea that</i> myosin is prevented from binding to actin	2	
		ii	comparison of median values in support of a statement / comparison of interquartile range values in support of a statement <i>plus any two from the following marks up to a maximum of 3</i> <i>idea that</i> (very) high concentrations are only seen where a heart attack is confirmed / heart attack subject have significantly higher median values than other groups <i>idea that</i> bottom of interquartile range for confirmed heart attacks is significantly higher than other groups / top of interquartile range of other groups is significantly below bottom of range for group with heart attack <i>idea that</i> unlikely to get 'false positives' or 'false negatives' <i>idea that</i> sample sizes are very different in the three groups and could affect the validity of the data	3	DO NOT ALLOW a simple description of the concentrations for each group – look for a clear statement that the high levels are specific to a heart attack or that they are significantly higher for this group.
			Total	5	

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Question			Answer/Indicative content	Marks	Guidance
38		i	<i>phytoene synthase</i> is, limiting / in low quantities / low activity; little, phytoene / substrate, for <i>phytoene desaturase</i>; little, lycopene/ substrate, for <i>lycopene ? cyclase</i>;	2 max	Examiner's Comments This proved to be a difficult question for two marks. Most students scored one by recognising that <i>phytoene synthase</i> was the limiting factor because it was the enzyme that catalyses the first stage in a metabolic pathway. However the question asked why the other two enzymes were not limiting and only a few candidates were able to answer this.
		ii	different base sequences (in the different genes/ DNA); different amino acid sequences (in the different enzymes); different, tertiary/3D, structures/ shape (in the different enzymes);	2 max	ACCEPT different, triplet /codon/ nucleotide, sequences. ACCEPT different primary structures ACCEPT refs to active site different shape Examiner's Comments The biochemistry required for this answer was surprisingly elusive. Some candidates tried to link their answer with active sites, but most of these failed to mention that it was the shape that was important. Of those candidates who recognised they needed some biochemistry here, most did not use the term 'sequence' when suggesting differences in DNA or protein primary structure. Many proposed different environmental conditions affecting the different plants, which did not gain credit.
			Total	4	

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Question			Answer/Indicative content	Marks	Guidance
39		i	<i>idea that Rhizobium</i> is, involved in nitrogen fixation / not involved in nitrification; (<i>Rhizobium</i>) will not reduce / increases levels of, ammonia / ammonium ions;	1 max	IGNORE refs to plant host / symbiosis / legume / nodules / not aquatic / not free living ACCEPT description e.g. <i>Rhizobium</i> produces, ammonia / ammonium ions from nitrogen gas ACCEPT NH_3 / NH_4^+ Examiner's Comments This question was well answered by most candidates. The fact that <i>Rhizobium</i> was a nitrogen fixer was the commonest correct response. Unsurprisingly there was some confusion between nitrogen fixing/nitrifying and even denitrifying, but this was rare. Some candidates just said that <i>Rhizobium</i> is found in roots and would therefore not survive in water, which did not gain credit.
		ii	use of (micro)organisms to, remove / oxidise, ammonia / ammonium ions; use of (micro)organisms for, commercial process / industrial process;	1 max	ACCEPT NH_3 / NH_4^+ IGNORE 'prevents build- up of ammonia' IGNORE refs to products of nitrification / food production / drug production / for human benefit Examiner's Comments This question was not well answered. Many candidates missed getting the mark by giving a generalised and vague definition of biotechnology, e.g. microbes that are used for human benefits, rather than linking it to commercial or industrial processes. Those candidates who chose to discuss this example of biotechnology rarely gained the mark as they wrote about microorganisms being used to keep fish alive, rather than to remove ammonia.

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Question			Answer/Indicative content	Marks	Guidance
		iii	<i>idea that</i> the desired product is <i>Nitrosomonas (europaea)</i> (cells); enzymes / proteins, are denatured (by incorrect pH); enzymes needed for, (named metabolic) processes in growth; (incorrect pH) disruption of, tertiary / 3D, structure / shape; <i>ref to</i> effect of hydrogen ions on, H / ionic, bonds;	3 max	ACCEPT increases yield of <i>N. europaea</i> IGNORE ref to products of <i>Nitrosomonas europaea</i> DO NOT CREDIT nitrogenase is denatured CREDIT enzymes for, respiration / protein synthesis / cell reproduction / DNA replication IGNORE active site Examiner's Comments The vast majority of candidates did not really understand that the desired product was the <i>Nitrosomonas</i> bacteria, though plenty still gained the point for saying the bacteria would die. Many gained a mark for denaturation of enzymes, though it was obvious they were talking about enzymes associated with nitrification rather than the enzymes used for processes in growth. Quite a few discussed a change in tertiary structure though many talked about the shape of the active site, which wasn't specific enough to gain that mark. When candidates recognised that hydrogen bonds were broken, many didn't gain the mark as they didn't link this with the effect of hydrogen ions.
			Total	5	