Helicate

HELICATE · AS AND A-LEVEL BIOLOGY · TOPIC BANK

3.1.4 Proteins

Topic question bank

Version 1 · 1 October 2026

Name

Date

QUESTIONS	TOTAL MARKS	TIME	YOUR SCORE
13	74	No time limit	/ 74

Contents

Subtopic	Questions	Marks
Amino acids, peptide bonds and the biuret test Specification 3.1.4.1	01–03	17
Protein structure and function Specification 3.1.4.1	04–05	11
Enzyme action and specificity Specification 3.1.4.2	06–08	12
Factors affecting the rate of enzyme-controlled reactions Specification 3.1.4.2	09–11	20
Required practical 1: rate of an enzyme-controlled reaction Specification 3.1.4.2 (RP1)	12–13	14
Total		**74**

Instructions

- Answer the questions in the spaces provided. Show all your working.
- The marks for each question are shown in brackets. Use them to judge how much detail to give.
- Work through a subtopic at a time, then mark your answers with the matching mark scheme.

Original questions by Helicate for AQA AS and A-level Biology (7401/7402), specification section 3.1.4. Not affiliated with or endorsed by AQA.

Do not write outside the box

Amino acids, peptide bonds and the biuret test 3.1.4.1

0 1 . 1 In the box, draw the general structure of an amino acid.
Label the amine group and the carboxyl group.

[2 marks]

0 1 . 2 The molecular formula of glycine is $C_2H_5NO_2$. The molecular formula of alanine is $C_3H_7NO_2$.
One glycine and one alanine join to form a dipeptide. What is the molecular formula of this dipeptide?
Tick (✓) one box.

[1 mark]

$C_5H_{12}N_2O_4$ ☐

$C_5H_{10}N_2O_3$ ☐

$C_5H_8N_2O_2$ ☐

$C_5H_{10}N_2O_4$ ☐

3

Turn over for the next question

Do not write outside the box

A species of fungus produces a tripeptide, **T**. A student completely hydrolysed a sample of **T** and then used paper chromatography to identify the amino acids it contained. She:

- put a spot of the hydrolysed sample and a spot of each of five standard amino acid solutions on a pencil line (the origin) near the bottom of a sheet of chromatography paper
- stood the paper in a solvent until the solvent had risen most of the way up the paper
- dried the paper and sprayed it with a stain that makes amino acids visible as coloured spots.

Table 1 shows the R_f value of each standard amino acid in this solvent.

Table 1

Amino acid	**Lysine**	**Threonine**	**Proline**	**Methionine**	**Phenylalanine**
R_f value	0.14	0.35	0.43	0.55	0.68

R_f = distance moved by amino acid ÷ distance moved by solvent front

The student forgot to mark the position of the solvent front before the paper dried. On the dried paper:

- the methionine standard was 7.7 cm from the origin
- the hydrolysed sample of **T** gave three spots, 2.0 cm, 6.0 cm and 9.5 cm from the origin.

0 2 . 1 Identify the **three** amino acids in tripeptide **T**.
Show your working.

[3 marks]

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Amino acids .....

Question 2 continues on the next page

Do not write outside the box

The student then partially hydrolysed another sample of **T**. Only one peptide bond was broken in each molecule. Two different dipeptides were produced:

- one dipeptide contained lysine and proline
- the other dipeptide contained proline and phenylalanine.

A further test showed that, in tripeptide **T**, the amine group attached to the central carbon atom of phenylalanine is **not** part of a peptide bond.

0 2 . 2 Deduce the order of the amino acids in tripeptide **T**. Explain your answer.

[3 marks]

Order .....

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0 2 . 3 Two different amino acids can have the same R_f value in one solvent.
Suggest how the student could check that her identification of the amino acids is correct.

[1 mark]

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7

Turn over for the next question

Do not write outside the box

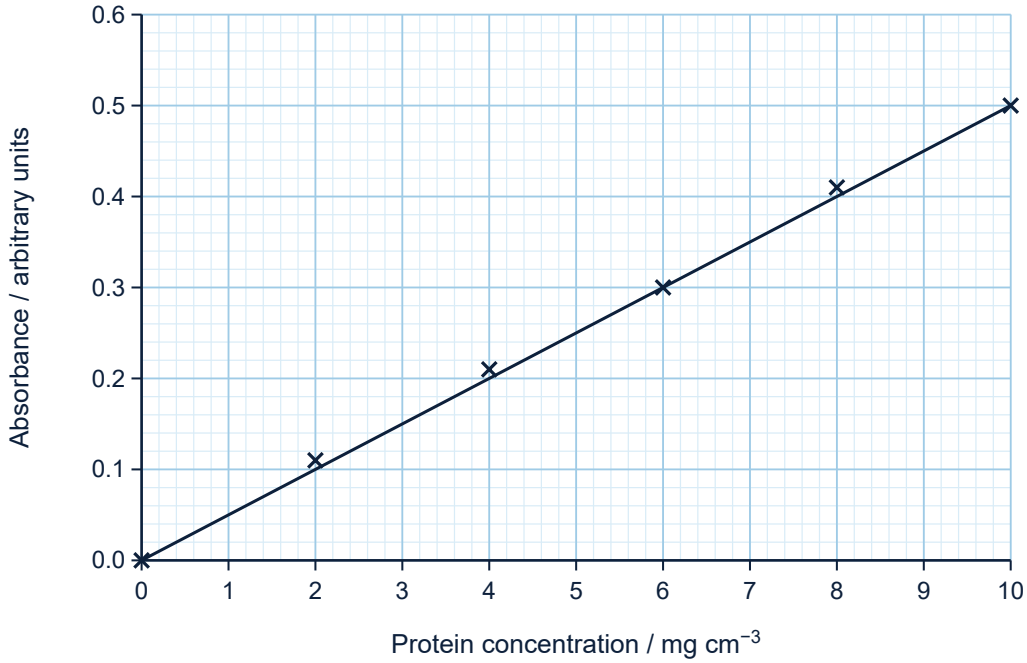
A student used the biuret test and a colorimeter to estimate the concentration of protein in a soya drink.

She:

- made standard solutions of a protein at concentrations from 0 to 10 mg cm^{-3}
- mixed 2 cm^3 of each standard solution with 2 cm^3 of biuret reagent, left the mixture for 15 minutes, then measured its absorbance
- diluted the soya drink by mixing 1 cm^3 of the drink with 4 cm^3 of distilled water
- treated 2 cm^3 of the diluted drink in the same way as the standard solutions.

Figure 1 shows her results for the standard solutions, with a line of best fit.

Figure 1



Question 3 continues on the next page

Do not write outside the box

0 3 . 1 Without a colorimeter, the biuret test can be used to show whether a solution contains protein.
Describe how the student would do this test on a sample of the soya drink, and give the result if protein is present.

[2 marks]

0 3 . 2 The diluted soya drink gave an absorbance of 0.33.
Use Figure 1 to calculate the concentration of protein in the undiluted soya drink.
Give your answer in g per 100 cm^3.

[2 marks]

Answer _____ **g per 100 cm^3**

0 3 . 3 Suggest why the student diluted the soya drink before measuring its absorbance.

[1 mark]

Question 3 continues on the next page

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Do not write outside the box

0 3 . 4 The student then tested an oat drink in the same way. The oat drink contains tiny particles that make it cloudy.
Explain how this could affect the protein concentration she calculated for the oat drink, **and** suggest how she could prevent this.

[2 marks]

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7

Turn over for the next question

Do not write outside the box

Protein structure and function 3.1.4.1

Protein K carries hormone T in the blood plasma of a mammal. Each molecule of protein K is made of two identical polypeptides.

Scientists treated samples of protein K separately with three reagents. Each reagent breaks only one type of bond. For each sample they recorded:

- whether the two polypeptides separated
- how much hormone T the protein could bind, as a percentage of the binding by untreated protein K.

Table 2 shows their results.

Table 2

Treatment of protein K	Did the two polypeptides separate?	Binding of hormone T as a percentage of untreated protein K
None (untreated)	No	100
Reagent 1: breaks disulfide bridges	No	96
Reagent 2: breaks ionic bonds	Yes	85
Reagent 3: breaks hydrogen bonds	Yes	4

0 4 . 1 Use Table 2 to identify **one** type of bond that holds the two polypeptides of protein K together, and **one** type of bond that does **not**. Explain your answers.

[2 marks]

Holds them together .....

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Does not .....

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Question 4 continues on the next page

Do not write outside the box

0 4 . 2 Reagent 2 and reagent 3 both separated the polypeptides, but they had very different effects on the binding of hormone T.
Explain this difference.

[3 marks]

0 4 . 3 A student concluded that protein K does not contain any disulfide bridges.
Explain why this conclusion may **not** be valid.

[1 mark]

6

0 5 . 1 Which row correctly describes the tertiary structure of a protein?
Tick (✓) one box.

[1 mark]

Description	Bonds that maintain this structure	
The sequence of amino acids in a polypeptide	Peptide bonds	☐
The coiling or folding of a polypeptide chain	Hydrogen bonds only	☐
The further folding of a polypeptide into a specific overall shape	Hydrogen bonds, ionic bonds and disulfide bridges	☐
Two or more polypeptides joined together	Peptide bonds only	☐

Question 5 continues on the next page

Do not write outside the box

Receptor R is a protein in the cell-surface membrane of some cells. It binds a signalling molecule, F.

- In normal receptor R, the amino acids at position 58 and position 112 are both cysteine. Cysteine has an R group that contains a sulfur atom.
- In one person, the cysteine at position 112 is replaced by serine. The R group of serine has an oxygen atom in place of the sulfur atom.
- Cells with this changed receptor do not respond to F.

0 5 . 2 Explain why cells with the changed receptor do not respond to F.

[4 marks]

5

Turn over for the next question

Do not write outside the box

Enzyme action and specificity 3.1.4.2

0 6 . 1 Enzymes catalyse reactions inside cells (intracellular reactions) and outside cells (extracellular reactions).
Which reaction is catalysed by an extracellular enzyme?
Tick (✓) one box.

[1 mark]

- Hydrolysis of ATP by ATP hydrolase in a muscle cell ☐
- Joining of DNA nucleotides by DNA polymerase during DNA replication ☐
- Hydrolysis of starch by amylase in saliva in the mouth ☐
- Condensation of glucose molecules to form glycogen in a liver cell ☐

0 6 . 2 Describe the induced-fit model of enzyme action. Use it to explain how an enzyme lowers the activation energy of the reaction it catalyses.

[3 marks]

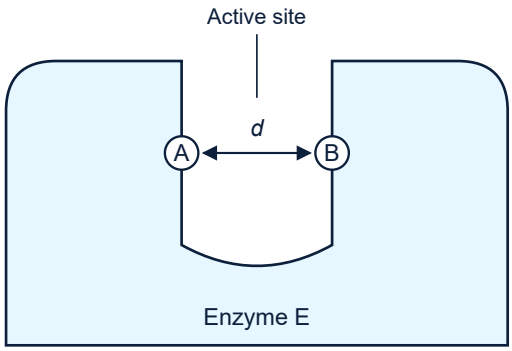
4

Turn over for the next question

Do not write outside the box

Scientists measured the distance across the active site of enzyme E, between two amino acids, **A** and **B**, on opposite sides of the active site. Figure 2 shows the distance measured, *d*.

Figure 2



A and **B** are amino acids in the enzyme.

They measured *d* when the active site was empty, when the substrate was bound and when molecule M was bound. Molecule M has a similar shape to the substrate, but it is slightly smaller. M binds to the active site, but it is not converted into a product. Table 3 shows their results.

Table 3

Molecule in the active site	Distance *d* / nm
None	1.6
Substrate	1.1
Molecule M	1.5

0 7 . 1 The lock-and-key model was an earlier model of enzyme action.
Explain how the results in Table 3 support the induced-fit model rather than the lock-and-key model.

[2 marks]

Question 7 continues on the next page

Do not write outside the box

0 7 . 2 Use Table 3 and the induced-fit model to suggest why molecule M is **not** converted into a product.

[2 marks]

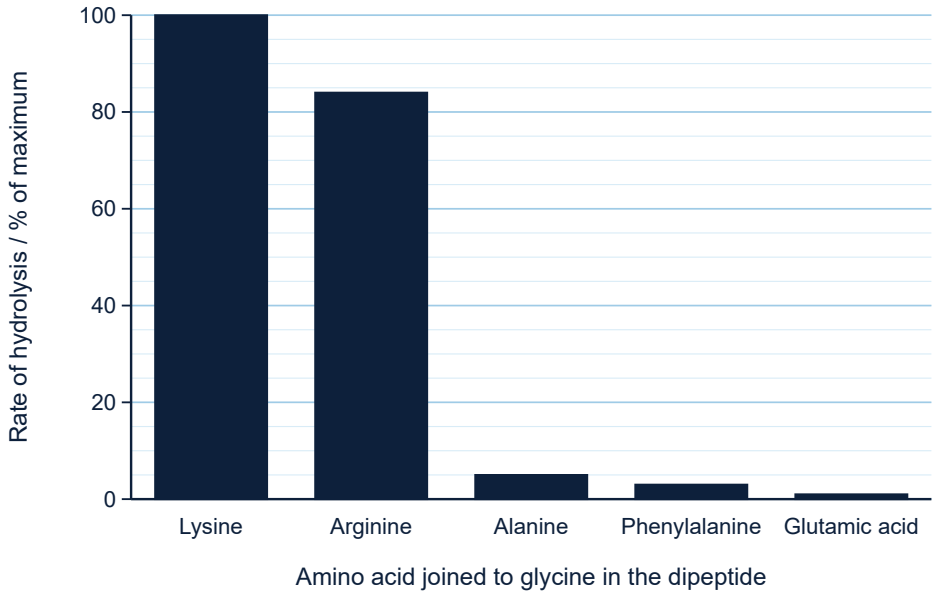
4

Turn over for the next question

Do not write outside the box

Protease P hydrolyses peptide bonds. Scientists measured the rate at which protease P hydrolysed five different dipeptides. Each dipeptide was made of glycine joined to one other amino acid. Figure 3 shows their results.

Figure 3



- Lysine and arginine have positively charged R groups.
- Alanine and phenylalanine have R groups with no charge.
- Glutamic acid has a negatively charged R group.
- The active site of protease P contains an amino acid with a negatively charged R group.

0 8 . 1 Use this information to explain the results in Figure 3.

[3 marks]

Question 8 continues on the next page

Do not write outside the box

0 8 . 2 Suggest why protease P hydrolysed the dipeptide containing arginine more slowly than the dipeptide containing lysine.

[1 mark]

4

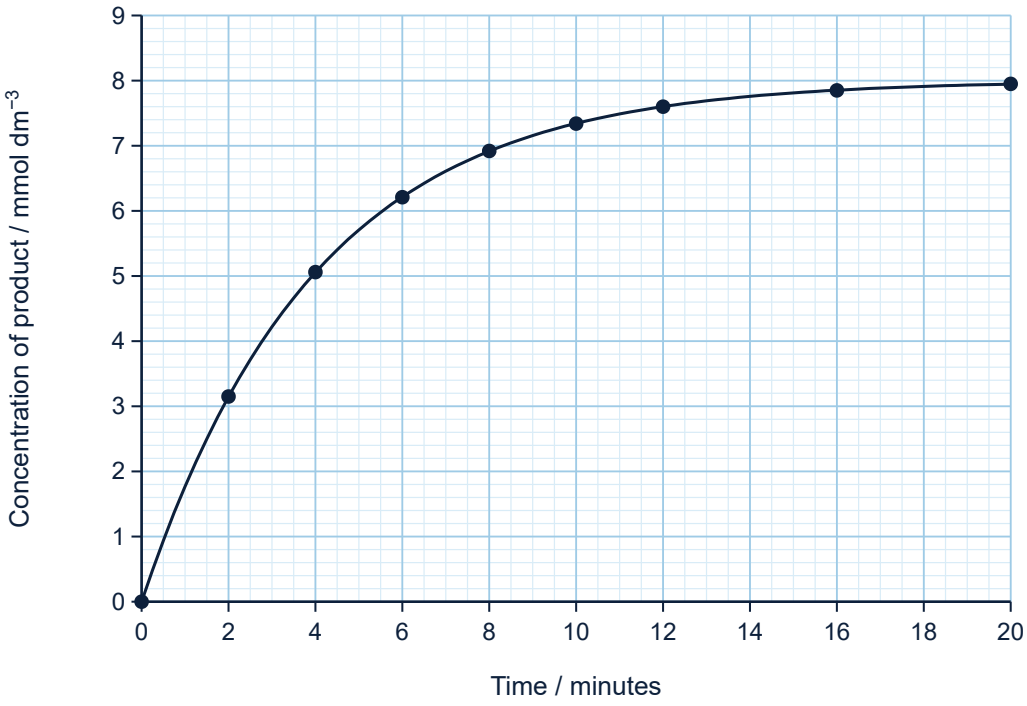
Turn over for the next question

Do not write outside the box

Factors affecting the rate of enzyme-controlled reactions 3.1.4.2

Enzyme N converts a colourless substrate into a coloured product. A scientist mixed enzyme N with its substrate and measured the concentration of the product at intervals. The concentration of enzyme N was kept constant. Figure 4 shows the results.

Figure 4



0 9 . 1 Draw a tangent on Figure 4 to find the initial rate of this reaction.

[2 marks]

Answer ..... **mmol dm^{-3} min^{-1}**

Question 9 continues on the next page

Do not write outside the box

0 9 . 2 Explain why the rate of the reaction decreases as the reaction continues.

[2 marks]

0 9 . 3 The scientist repeated the investigation with double the concentration of enzyme N. All other conditions were the same.
Which row describes the results she would expect, compared with Figure 4?
Tick (✓) one box.

[1 mark]

Initial rate of reaction	Concentration of product when the curve levels off	
About the same	About twice as high	☐
About twice as high	About the same	☐
About twice as high	About twice as high	☐
About half as high	About the same	☐

5

Turn over for the next question

Do not write outside the box

Enzyme J is found in a parasitic worm. Scientists investigated how drug D affects the initial rate of the reaction catalysed by enzyme J. They used a low and a high substrate concentration. Table 4 shows their results.

Table 4

Concentration of drug D / μmol dm^{-3}	Initial rate of reaction / μmol min^{-1}	
	Substrate concentration 2 mmol dm^{-3}	Substrate concentration 20 mmol dm^{-3}
0	25.0	45.5
5	16.7	41.7
10	12.5	38.5
20	8.3	33.3
40	5.0	26.3

10.1 Calculate the percentage decrease in the initial rate caused by 20 μmol dm^{-3} of drug D at each substrate concentration.
Give each answer to **two** significant figures.

[2 marks]

2 mmol dm^{-3} ..... %

20 mmol dm^{-3} ..... %

Question 10 continues on the next page

Do not write outside the box

1 0 . 2 The scientists concluded that drug D is a competitive inhibitor of enzyme J.
Explain how the data in Table 4 support this conclusion.

[3 marks]

1 0 . 3 Drug E also inhibits enzyme J. Increasing the substrate concentration does **not** reduce the percentage decrease in rate caused by drug E.
Explain how drug E reduces the rate of reaction, and why increasing the substrate concentration does not reduce its effect.

[3 marks]

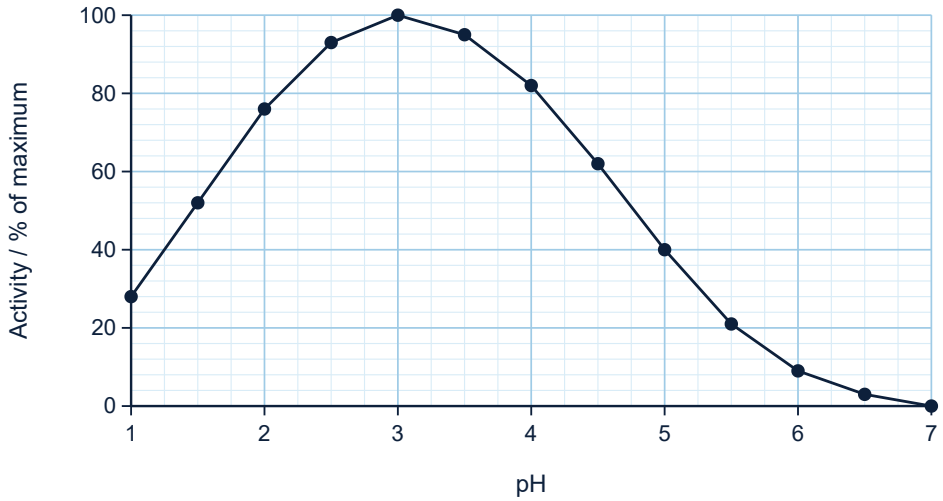
8

Turn over for the next question

Do not write outside the box

Pitcher plants trap insects in a pitcher of fluid. The plant secretes a protease into the fluid, which digests the proteins in the insects. Figure 5 shows the effect of pH on the activity of this protease.

Figure 5



1 1 . 1 Use Figure 5 and your knowledge of protein structure to explain the effect of pH on the activity of this protease between pH 3 and pH 7.

[5 marks]

Question 11 continues on the next page

Do not write outside the box

1 1 . 2 In one pitcher, the plant stopped secreting acid for several days, and the pH of the fluid rose from 3.0 to 4.5.
Use the formula $pH = -\log_{10} [H^+]$ to calculate how many times greater the hydrogen ion concentration was at pH 3.0 than at pH 4.5. Give your answer to **two** significant figures.

[2 marks]

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.....

.....

Answer ..... **times**

7

Turn over for the next question

Do not write outside the box

Required practical 1: rate of an enzyme-controlled reaction 3.1.4.2 (RP1)

Amylase hydrolyses starch. Iodine solution is orange-brown, but turns blue-black when starch is present.

A student investigated how temperature affects the time taken for amylase to hydrolyse all the starch in a starch solution. At each temperature she:

- warmed a tube containing 5 cm^3 of starch solution and a tube containing 1 cm^3 of amylase solution in a water bath for 10 minutes
- poured the amylase solution into the starch solution and started a stop clock
- every 30 seconds, placed one drop of the mixture into a separate drop of iodine solution on a spotting tile
- recorded the first time at which the iodine solution stayed orange-brown.

Table 5 shows her results.

Table 5

Temperature / °C	Time until iodine solution stayed orange-brown / s			Mean time / s
	Repeat 1	Repeat 2	Repeat 3	
20	420	390	450	420
30	240	210	240	230
40	150	120	150	140
50	180	210	180	190
60	Still blue-black after 600 s			–

12.1 Give **two** variables, other than the volumes of the starch and amylase solutions, that the student should have controlled.

[2 marks]

1 .....

2 .....

Question 12 continues on the next page

Do not write outside the box

12.2 The true time for all the starch to be hydrolysed could be up to 30 seconds shorter than the time the student recorded.
Calculate the percentage uncertainty in the mean time at 40 °C.

[2 marks]

Answer ..... **%**

12.3 Suggest how the student could reduce this uncertainty, using the same method.

[1 mark]

12.4 The student wanted to plot a graph of the rate of reaction against temperature.
Which is the most appropriate way to present these data?
Tick (✓) one box.

[1 mark]

- A bar chart, because temperature is a categoric variable ☐
- A line graph with temperature on the *x*-axis, because temperature is a continuous variable ☐
- A line graph with temperature on the *y*-axis, because the rate of reaction depends on temperature ☐
- A histogram, because the data show the frequency of each rate ☐

Question 12 continues on the next page

Do not write outside the box

1 2 . 5 The student concluded that the optimum temperature for this amylase is 40 °C. Evaluate this conclusion.

[2 marks]

8

Turn over for the next question

Do not write outside the box

1 3 Copper ions inhibit amylase. The student was given a stock solution of copper sulfate.
Describe how she could use the spotting-tile method to investigate the effect of copper ion concentration on the rate of starch hydrolysis by amylase. Include how she would make sure that her results are valid.

[6 marks]

6

END OF QUESTIONS

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