Amino Acids

A Level

Part A General structure

An amino acid is an organic molecule, containing a central ______ atom bound to a hydrogen atom and to three other chemical groups: ______ group (NH_2), ______ group ($COOH$), and ______ group/side-chain - which is the part that differs in structure among different amino acids.

There are ______ standard amino acids that are coded for by the universal genetic code. Of these standard amino acids, humans can only synthesise 11, and so we have to get the other 9 from our diet. These 9 amino acids are sometimes called ______ amino acids.

Items:

a carboxyl | a nitrate | an amino | an alcohol | oxygen | an R | essential | 20 | carbon | 100 | dispensable

Part B Amino acid or not?

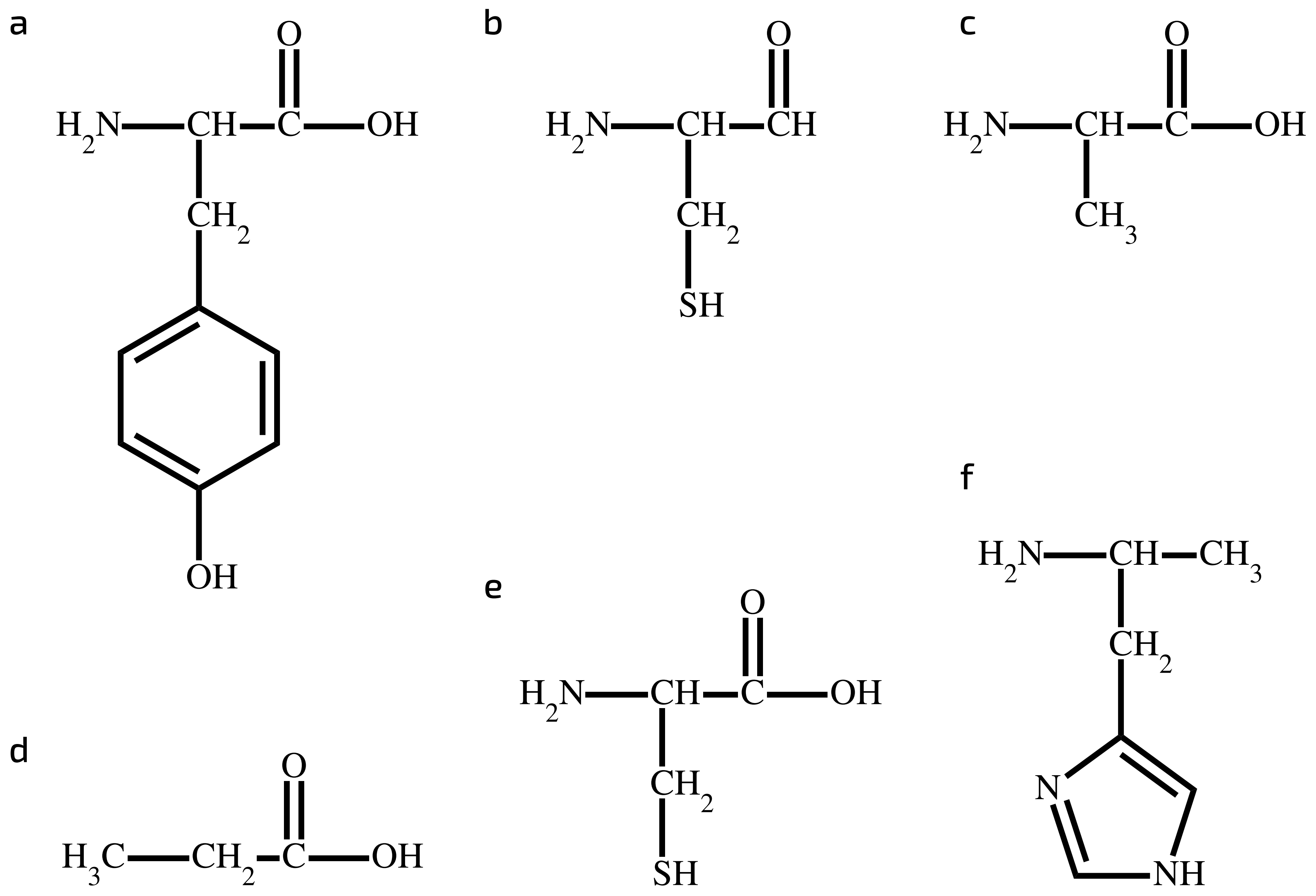
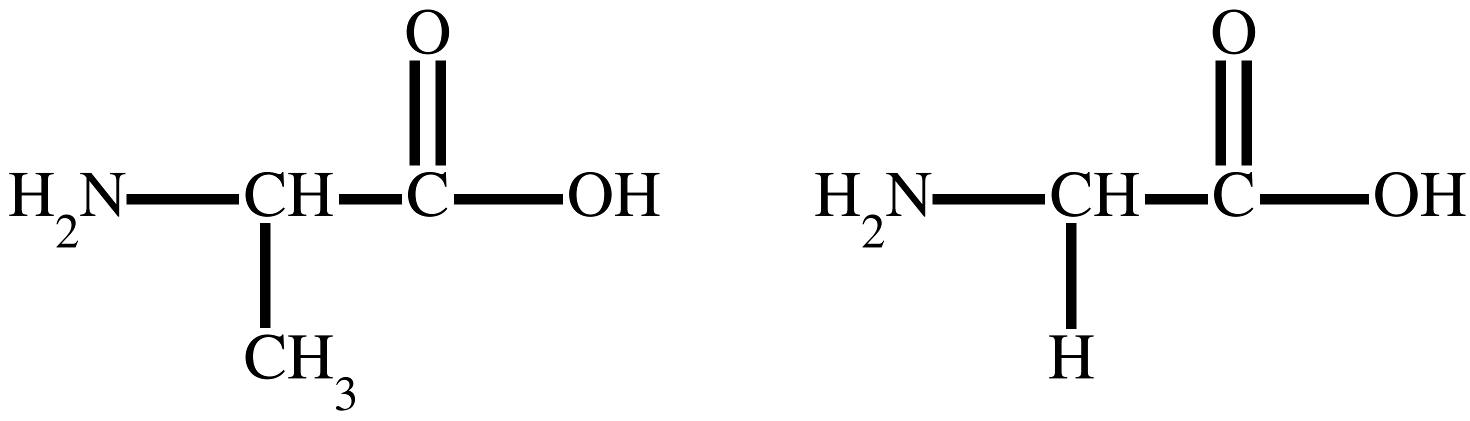


Figure 1: The molecular structures of six organic molecules (a-f).

Which of the organic molecules in Figure 1 are amino acids? Select all that apply.

- [ ] a
- [ ] b
- [ ] c
- [ ] d
- [ ] e
- [ ] f
- [ ] none of them

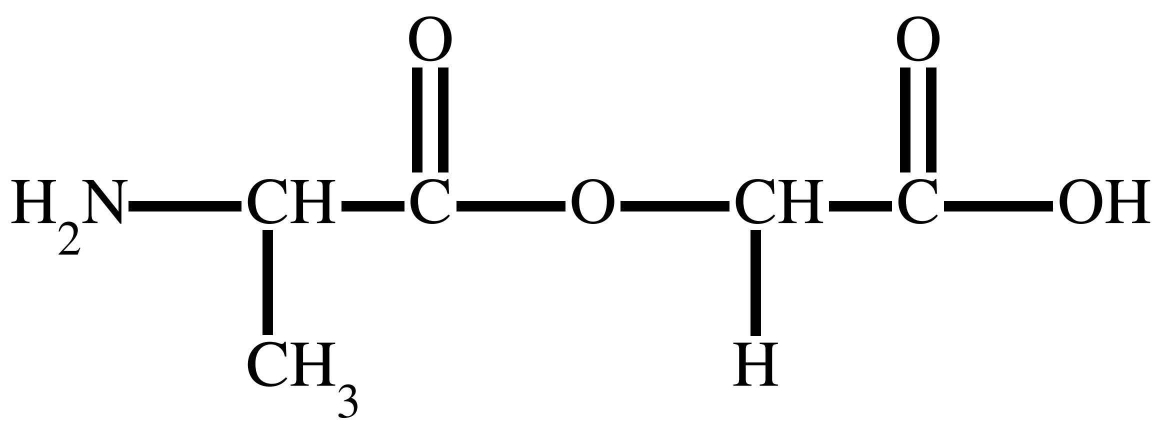
Part C Dipeptide identification



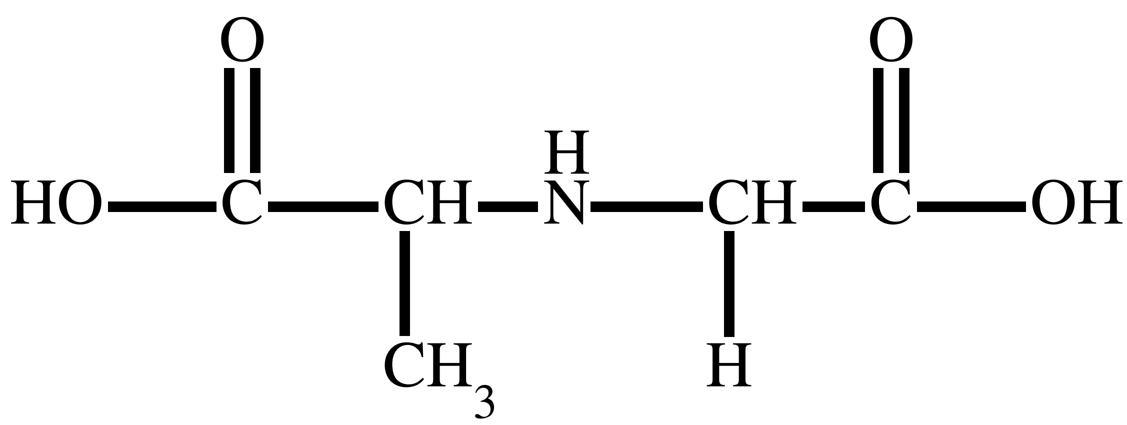
alanine glycine

Figure 2: The molecular structures of two amino acids: alanine and glycine.

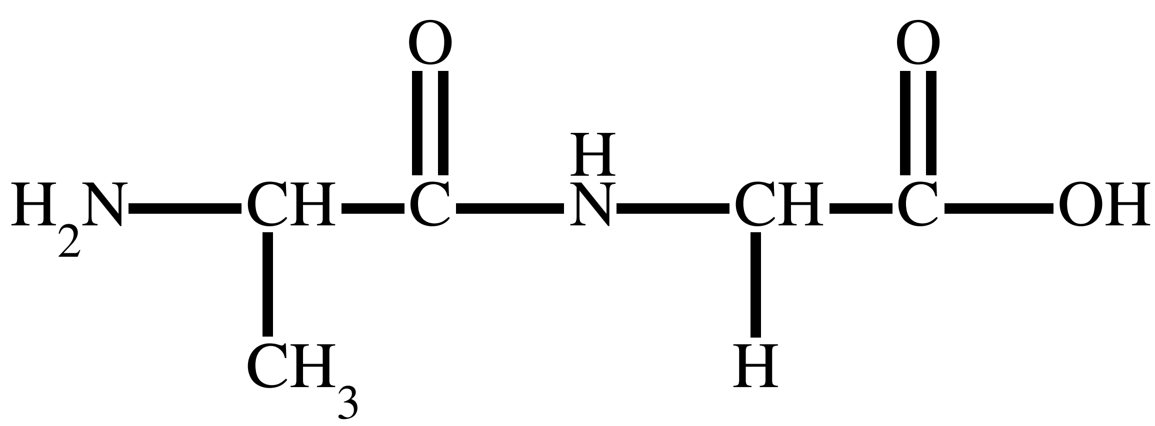
Figure 2 shows the molecular structures of two amino acids: alanine and glycine. Which molecule below represents the dipeptide that would be formed from these amino acids?



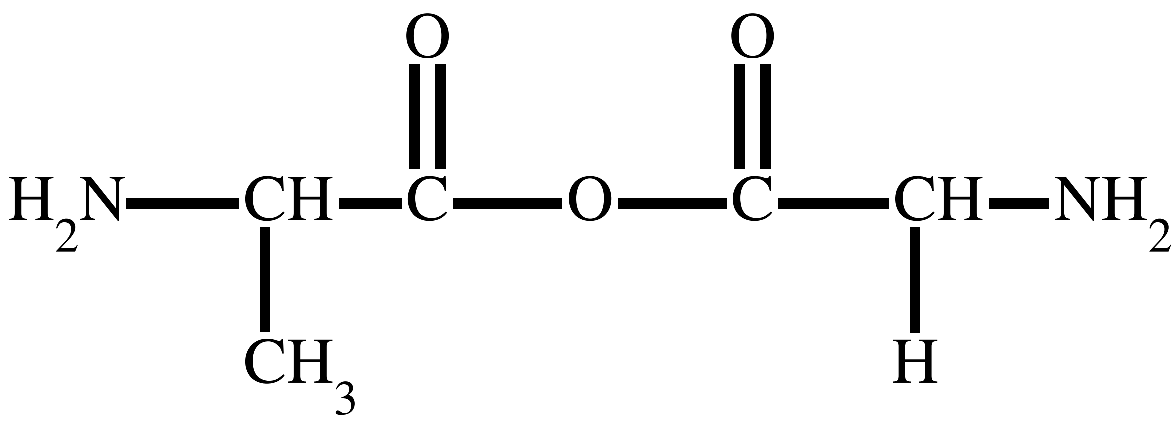
Molecule A



Molecule B



Molecule C



Molecule D

- A
- B
- C
- D

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Protein Primary Structure

A Level

P P P

Part A The building blocks

Proteins are polymers made up of [ ] called [ ]. Proteins range in size from just a few amino acids to tens of thousands of amino acids, but most are between 50 and $2\,000$ amino acids.

A chain of two amino acids is called a [ ]. A chain of many amino acids is called a [ ].

The sequence of amino acids is called the [ ] of the protein.

Items:

glucose | secondary structure | polypeptide | quaternary structure | monosaccharides | amino acids | dipeptide | monomers | primary structure | diamide | tertiary structure | polyamine

Part B Formation and breakdown

Amino acids join together by the process of [ ]. During this process, the [ ] group (NH_2) of one amino acid reacts with the [ ] group ($COOH$) of another amino acid to form a [ ] bond and [ ].

Proteins are broken down into amino acids by the process of [ ]. During this process, [ ] is used to break apart the [ ] bond.

Items:

amino | hydrolysis | condensation | carboxyl | CO_2 | ester | H_2O | peptide | nitrate

Part C Polypeptide possibilities

There are 20 different standard amino acids that are used to build proteins. How many primary structures could be produced for a protein that is 50 amino acids long? Give your answer to 2 significant figures.

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Levels of Protein Structure

A Level

Part A Levels overview

Match the terms to the definitions.

[ ]: the association of several polypeptides with each other and (in some cases) with non-protein groups e.g. haemoglobin is made of four polypeptides and four haem groups (iron-containing organic molecules). Not all proteins have this level of structure, as some are only made of one polypeptide.

[ ]: the folding of the polypeptide due to hydrogen bonds between the H of one amino acid's NH group (within the peptide bond) and the O of another amino acid's CO group (within the peptide bond). Depending on the amino acid sequence, these hydrogen bonds can cause the polypeptide chain to form a tight coil (α-helix) or a long, snaking chain (β-sheet).

[ ]: the sequence of amino acids in the polypeptide (e.g. methionine-alanine-glycine-tyrosine).

[ ]: the folding of the polypeptide due to interactions between R side-chains of different amino acids (which are able to interact due to coiling/zig-zagging caused by hydrogen bonds). These interactions include ionic bonds (between carboxyl and amino groups within the R side-chains), disulfide bridges (between the S of one amino acid and the S of another), and hydrophilic/hydrophobic interactions (i.e. the polypeptide will fold such that hydrophilic R side-chains are on the outside, and hydrophobic R side-chains are on the inside).

Items:

Primary structure **Secondary structure** **Tertiary structure** **Quaternary structure**

Part B Primary structure

Which of these describes the primary structure of a protein? Select all that apply.

- [ ] the association between multiple protein-subunits and non-protein groups to form a single, large protein
- [ ] the snaking of a polypeptide chain to form a β-sheet
- [ ] the coiling of a polypeptide chain to form an α-helix
- [ ] the sequence of amino acids in a polypeptide chain e.g. methionine-glycine-alanine-glycine-lysine-alanine-leucine
- [ ] the 3D folding of a polypeptide chain due to hydrogen bonds, disulfide bridges, ionic bonds, and hydrophobic/hydrophilic interactions

Part C Secondary structure

Which of these describes the secondary structure of a protein? Select all that apply.

- [ ] the snaking of a polypeptide chain to form a β-sheet
- [ ] the sequence of amino acids in a polypeptide chain e.g. methionine-glycine-alanine-glycine-lysine-alanine-leucine
- [ ] the 3D folding of a polypeptide chain due to hydrogen bonds, disulfide bridges, ionic bonds, and hydrophobic/hydrophilic interactions
- [ ] the coiling of a polypeptide chain to form an α-helix
- [ ] the association between multiple protein-subunits and non-protein groups to form a single, large protein

Part D Tertiary structure

Which of these describes the tertiary structure of a protein? Select all that apply.

- [ ] the sequence of amino acids in a polypeptide chain e.g. methionine-glycine-alanine-glycine-lysine-alanine-leucine
- [ ] the coiling of a polypeptide chain to form an α-helix
- [ ] the association between multiple protein-subunits and non-protein groups to form a single, large protein
- [ ] the snaking of a polypeptide chain to form a β-sheet
- [ ] the 3D folding of a polypeptide chain due to hydrogen bonds, disulfide bridges, ionic bonds, and hydrophobic/hydrophilic interactions

Part E Quaternary structure

Which of these describes the quaternary structure of a protein? Select all that apply.

- [ ] the coiling of a polypeptide chain to form an α-helix
- [ ] the snaking of a polypeptide chain to form a β-sheet
- [ ] the association between multiple protein-subunits and non-protein groups to form a single, large protein
- [ ] the 3D folding of a polypeptide chain due to hydrogen bonds, disulfide bridges, ionic bonds, and hydrophobic/hydrophilic interactions
- [ ] the sequence of amino acids in a polypeptide chain e.g. methionine-glycine-alanine-glycine-lysine-alanine-leucine

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Types of Proteins

A Level

P P P

Part A Definitions

Most proteins can be categorized as either fibrous or globular, based on their structures.

Fill in the table below, comparing fibrous and globular proteins.

	Fibrous	Globular
Primary structure		
Tertiary/quaternary structure		
Solubility in water		
Function(s)		

Items:

repetitive sequence **insoluble** **non-repetitive sequence** **simple: long & linear** **structural** **chemical interactions** **soluble** **complex: highly folded**

Part B Fibrous proteins

Which of the following are examples of fibrous proteins? Select all that apply.

- [ ] insulin (the hormone that causes cells to increase their uptake of glucose and convert it to glycogen and/or triglycerides)
- [ ] elastin (the protein that gives elasticity to blood vessel walls)
- [ ] keratin (a type of protein found in hair, nails, and skin)
- [ ] α-amylase (the enzyme that breaks down starch into disaccharides and trisaccharides)
- [ ] collagen (a major component of tendons, ligaments, bones, and skin)
- [ ] haemoglobin (the protein that transports oxygen through the bloodstream)

Part C Globular proteins

Which of the following are examples of globular proteins? Select all that apply.

- [ ] insulin (the hormone that causes cells to increase their uptake of glucose and convert it to glycogen and/or triglycerides)
- [ ] collagen (a major component of tendons, ligaments, bones, and skin)
- [ ] haemoglobin (the protein that transports oxygen through the bloodstream)
- [ ] elastin (the protein that gives elasticity to blood vessel walls)
- [ ] keratin (a type of protein found in hair, nails, and skin)
- [ ] α-amylase (the enzyme that breaks down starch into disaccharides and trisaccharides)

Part D Conjugated proteins

Conjugated proteins are [ ] proteins that have a non-protein component, which is called a [ ].

[ ] is a conjugated protein, as it is made of four polypeptides - each bound to a haem group (an organic molecule containing [ ]).

Examples of other non-protein components include carbohydrates and lipids.

Items:

Haemoglobin **prosthetic group** **an Fe^{2+} ion** **fibrous** **globular** **a Ca^{2+} ion** **Insulin** **Collagen**

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Protein Practicals

A Level

P P P

Part A Testing for proteins

What is the name of the test used to determine if proteins are present in a solution?

Fill in the blanks to explain how this test works.

The protein solution is added to ______ (e.g. sodium hydroxide solution), and dilute copper(II) sulfate solution is added to this. The solution will change colour from ______ to ______, due to a reaction between the copper(II) ions and the ______.

Items:

carboxyl groups | an alkaline solution | an acidic solution | blue | red | peptide bonds | R side-chains | purple

Part B Thin-layer chromatography

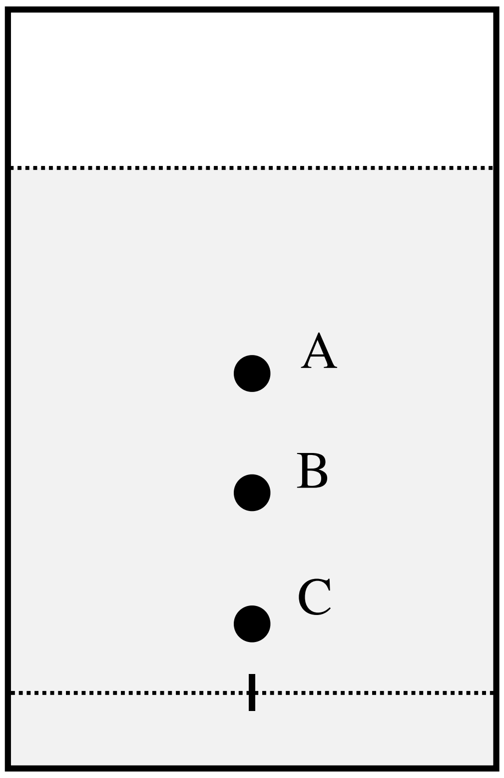

Figure 1: A thin-layer chromatography (TLC) plate was prepared for one solution ("Solution X"), which contained three amino acids. After 10 minutes, the plate was removed and sprayed with ninhydrin spray to visualise the amino acids (labelled A-C). The solvent front (top dotted line) had moved a distance of $18\,\mathrm{cm}$ from the starting position (bottom dotted line). "A" moved $10.98\,\mathrm{cm}$. "B" moved $6.84\,\mathrm{cm}$. "C" moved $2.34\,\mathrm{cm}$. The retention factor (R_f) values for some amino acids are given in the table below.

Amino acid	R_f value
alanine	0.38
arginine	0.20
cysteine	0.40
glutamine	0.13
methionine	0.55
phenylalanine	0.68
serine	0.27
threonine	0.35
valine	0.61

Which amino acids are present in solution X?

- [ ] alanine
- [ ] arginine
- [ ] cysteine
- [ ] glutamine

- [ ] methionine
- [ ] phenylalanine
- [ ] serine
- [ ] threonine
- [ ] valine

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Enzymes

A Level

P P P

Part A Enzyme overview

Enzymes are [ ] proteins that function as [ ] in biological reactions. Enzymes are essential for life because they [ ] the activation energy of fundamental reactions i.e. they allow these reactions to happen much [ ]. The complex tertiary/quaternary structure of enzymes ensures that enzymes are highly [ ] in terms of the reactions they catalyse.

Items:

globular | faster | lower | general | substrates | catalysts | specific | increase | slower | fibrous

Part B Enzyme reactions

An enzyme catalyses a reaction by binding to the [ ] to form an [ ]. The part of the enzyme that binds is called the [ ]. After the reaction is complete, the [ ] releases the [ ]. The enzyme is then free to catalyse another reaction.

Items:

product(s) | enzyme-substrate complex | enzyme-product complex | substrate(s) | active site

Part C Models of enzyme action

_____: the _____ of the enzyme perfectly matches the shape of the _____, which ensures complete specificity.

_____: the _____ of the enzyme changes shape in response to the _____ binding, and only matches the shape after this initial binding.

Items:

Induced-fit model **substrate** **product** **active site** **cofactor** **Lock-and-key model**

Part D Limiting factors

Which of the following are limiting factors in all enzyme-controlled reactions? Select all that apply.

- [ ] pH
- [ ] concentration of product
- [ ] concentration of substrate
- [ ] temperature
- [ ] concentration of enzyme

Part E Enzyme examples

Enzyme	Reactant(s)	Product(s)
Amylases		
Proteases		
Lipases		
Catalase		

Items:

proteins | starch | fats | fatty acids & glycerol | hydrogen peroxide | maltose | peptides/amino acids | water & oxygen

Part F Stopping an enzyme from working

What is the name given to a non-substrate molecule that binds to the active site of an enzyme, and thus prevents the substrate from binding?

What is the name given to a non-substrate molecule that binds to part of the enzyme that is **not** the active site, but in doing so causes the shape of the active site to change, such that the substrate can no longer bind?

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Enzyme Reactions

A Level

C C C

Part A Product formation over time

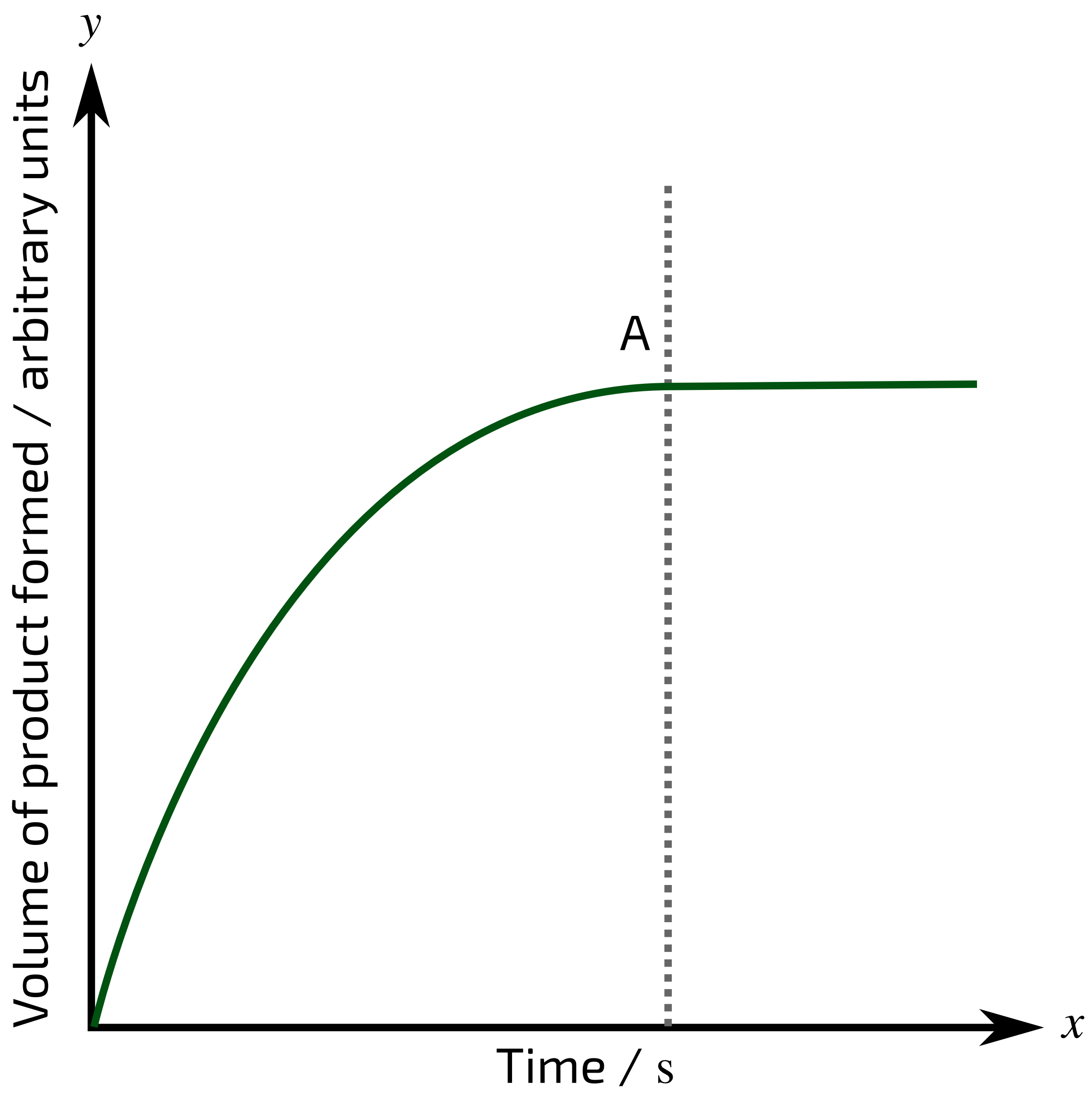

Figure 1: The volume of product formed over time for an enzyme-controlled reaction. Temperature and pH were kept constant throughout the reaction.

Which of the following could explain why no more product is being formed after point A in Figure 1? Select all that apply.

- [ ] All of the substrate has been used up in the reaction
- [ ] All of the enzyme has been used up in the reaction
- [ ] The enzyme has become denatured
- [ ] The product is acting as a cofactor
- [ ] The product is acting as a competitive inhibitor

Part B Reaction rate over temperature

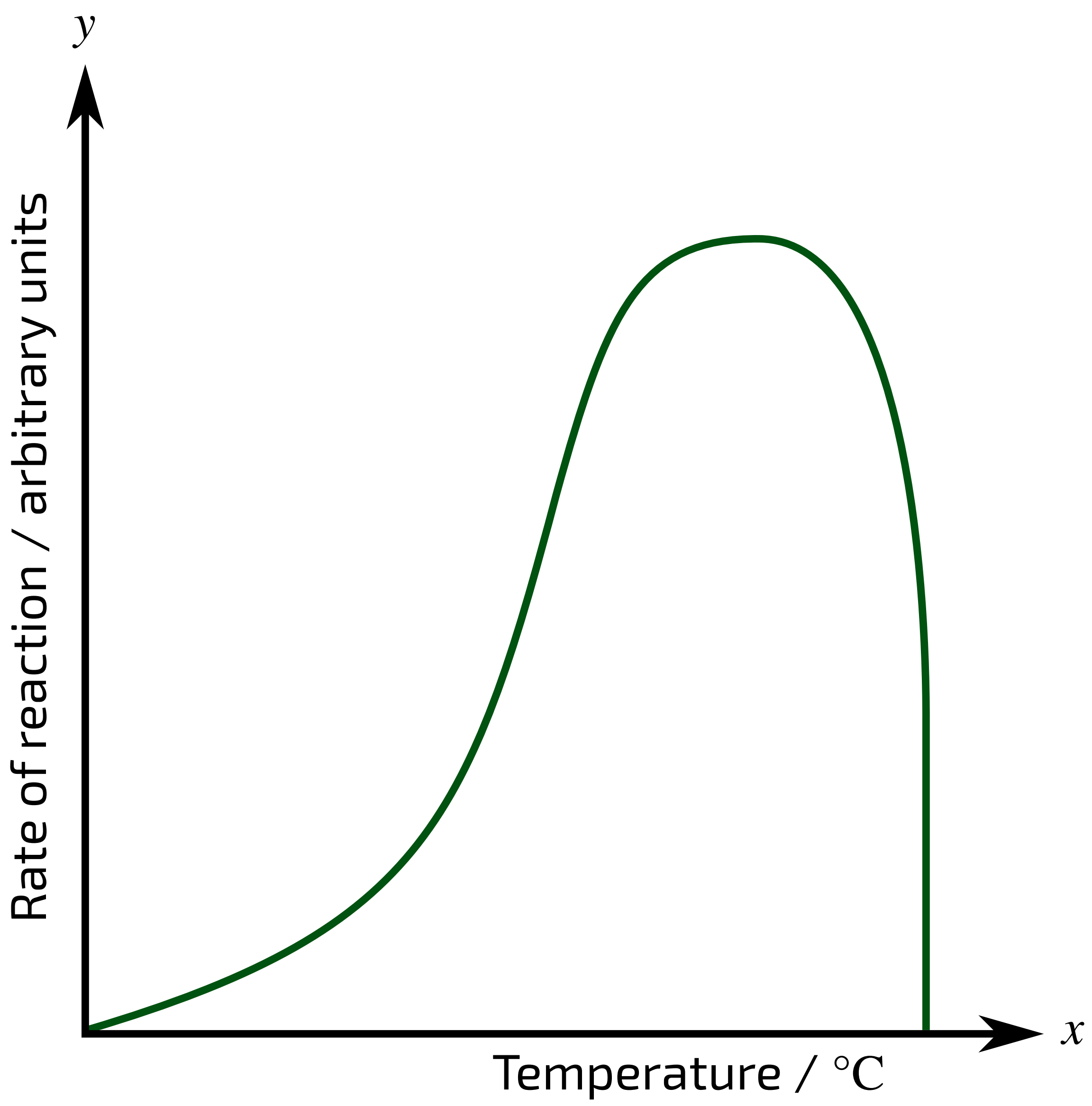

Figure 2: The reaction rate at different temperatures for an enzyme-controlled reaction.

Which of the following correctly describe the relationship shown in Figure 2?

- ◯ The rate of reaction increases over time until all the substrate is used up, after which point the reaction stops.
- ◯ The rate of reaction increases over time until the product begins to act as a competitive-inhibitor, which slows the reaction down.
- ◯ The rate of reaction positively correlates with temperature across the range of temperatures measured.
- ◯ The rate of reaction increases with temperature up to the enzyme's optimal temperature, beyond which the enzyme is denatured and the reaction will not work.

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