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6 Enzymes are protein molecules that are highly efficient in catalysing specific chemical reactions in living organisms.

(a) To work in tissues, enzyme molecules generally need to be water-soluble. What does this tell you about the nature of the side-chains on the exterior of the molecules?

.....

.....[1]

(b) Enzymes function by a substrate molecule interacting with a particular part of the enzyme known as the 'active site'. The substrate is converted into products that are then released, to be replaced by another substrate molecule.

(i) Describe briefly the primary, secondary and tertiary structures of an enzyme.

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(ii) The activity of an enzyme depends upon the tertiary structure of the protein molecule. Explain how the tertiary structure produces an effective active site.

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(iii) Give **two** conditions that can **reduce** the activity of an enzyme, explaining the reason in each case.

I .....

.....

.....

II .....

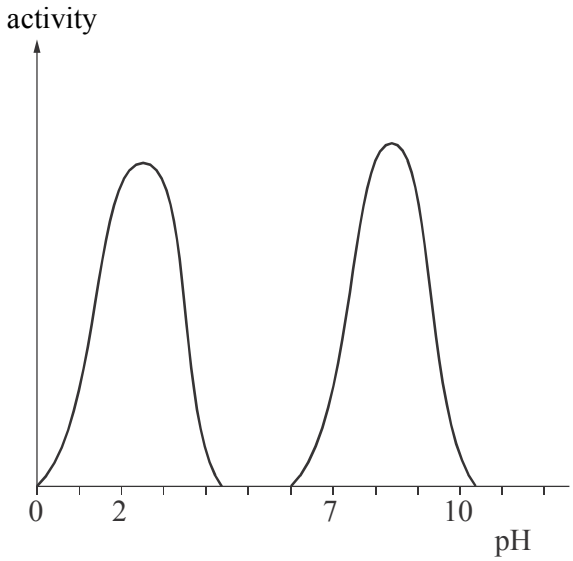
.....

..... [6]

(c) An individual enzyme operates best at a specific pH. Different enzymes operate best under conditions of different pH. Three enzymes involved in the digestion of food are amylase, pepsin and trypsin.

- Amylase, found in saliva, hydrolyses starch to a mixture of glucose and maltose under approximately neutral conditions.
- Pepsin hydrolyses proteins to peptides in the acid conditions of the stomach.
- Trypsin continues the hydrolysis of peptides to amino acids in the mildly alkaline conditions of the small intestine.

The graph below shows the activity of two of the three enzymes mentioned above.



(i) Label each peak shown with the name of the enzyme responsible, either amylase, pepsin or trypsin.

(ii) On the axes above, sketch the graph that the third enzyme would produce, and label it with the name of that enzyme.

[3]

[Total: 10]

7 Enzymes are a special group of protein molecules present in large amounts in living organisms. Enzymes behave as catalysts but, unlike inorganic catalysts, they generally catalyse only one particular reaction.

(a) Inorganic catalysts often work better on heating, but enzymes rarely work at temperatures much above 45°C. Explain why this is the case.

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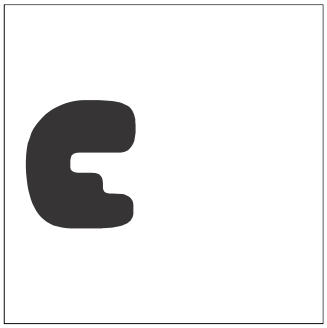
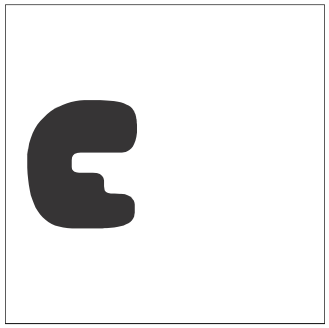
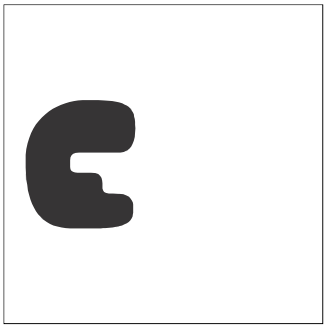
..... [2]

(b) Using the shape below to represent an enzyme, sketch how an enzyme is specific to the breakdown of a particular substrate molecule







enzyme + substrate enzyme-substrate complex enzyme + products

[3]

(c) Describe the effects of a competitive, and of a non-competitive inhibitor on the interaction between enzyme and substrate.

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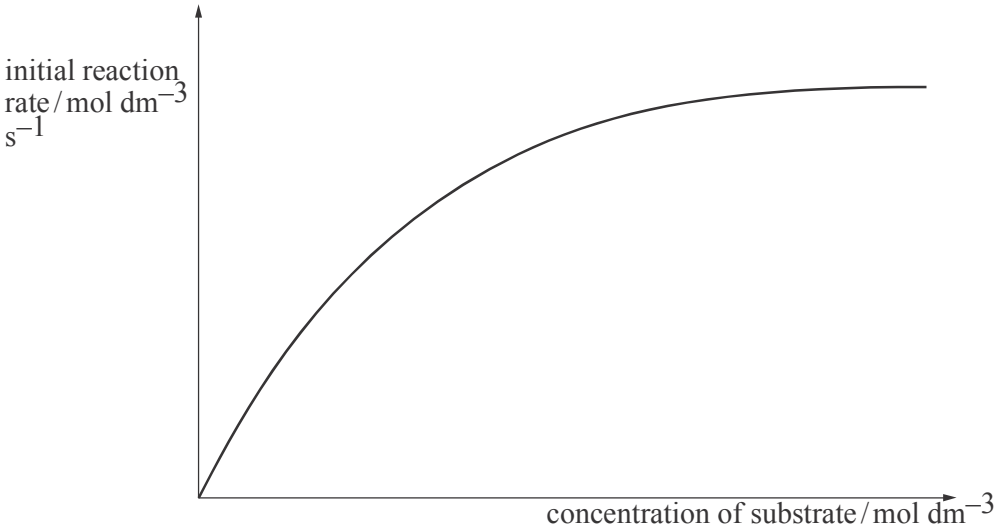
.....[2]

(d) **(i)** The diagram shown illustrates an enzyme-catalysed reaction. On the diagram sketch the graph that would be obtained if the same reaction was carried out in the presence of a **non-competitive** inhibitor.



(ii) Explain why a **non-competitive** inhibitor has this effect on the reaction.

.....

.....

[Total: 10]

Answers:

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6 (a) They are polar/ionic or can hydrogen-bond or are hydrophilic.

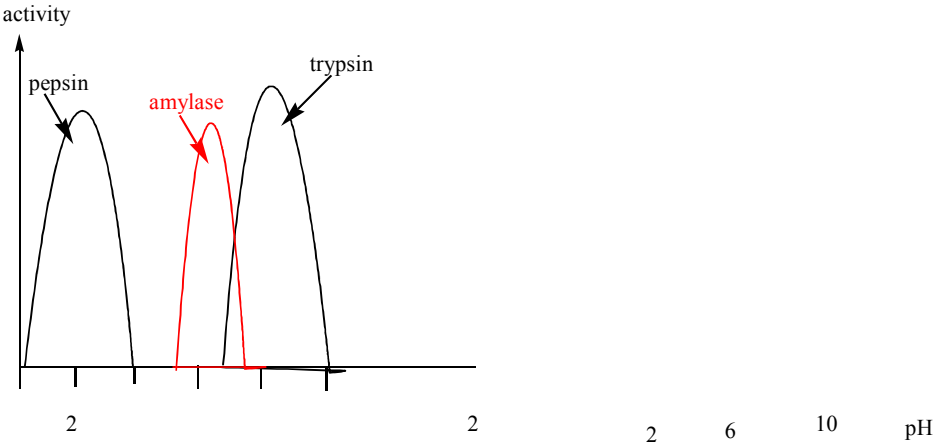
(b) (i) Primary structure is the sequence/order of amino acids
Secondary structure is the H-bonding between C=O & N-H or peptide
Tertiary structure gives the (overall) 3D structure/shape/folding/globularity
(not 'coiling' on its own)
or mention of at least one method of forming the 3° structure, e.g.;
hydrogen bonding between R-groups/side chains; –S-S- bridges;
van der Waal's forces; ionic interactions.

(ii) The 3° structure provides a complementary shape to that of the substrate
or it provides the right/specifically shaped cavity for the substrate.
or provides nearby groups to aid the reactions of the substrate

(iii) Two conditions out of the following:
(a) Increased temperature
(b) Decreased temperature
(c) Change in pH
(d) Addition of heavy metals (or specified, e.g. Hg/Ag)
(e) Addition of inhibitors (competitive or non-competitive)

Suitable reasons:
(i) 3D structure changes shape/is deformed/is broken or R-R interactions (or a specific example, e.g. H-bonding) are broken
(ii) inhibitor occupies active site.
(iii) either fewer substrate molecules with E > E_a or fewer successful collisions.

(c) (i)



left hand peak labeled as pepsin
right hand peak labeled as trypsin

(ii) Peak between pH 6 and pH 8 and correct name (amylase)

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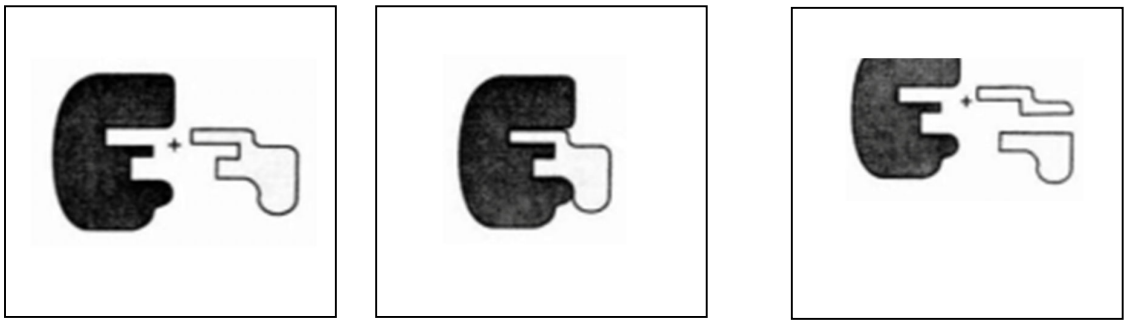
7 (a) The tertiary/3-dimensional structure/shape is held together by hydrogen/ionic/van der Waals bonds.
These break (relatively) easily/are weak/break at/above 45 °C.

(b) (or similar diagrams)



Enzyme + substrate | Enzyme-substrate complex | Enzyme + products

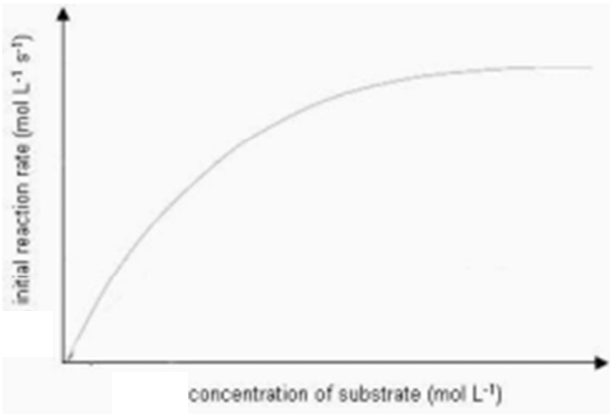
(c) a competitive inhibitor combines with the enzyme's active site (so preventing the substrate from binding)

non-competitive inhibitor bonds with the enzyme away from the active site/at an allosteric site

this changes the shape of the active site

Also allow competitive inhibition can be overcome by increasing [substrate] or non-competitive inhibition cannot be removed by increasing [substrate] for the 3rd mark

(d) (i)



Line must be of similar shape to original but level out below original line

(ii) Inhibitor reduces the number of enzymes with 'working' active sites.