Q1 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.

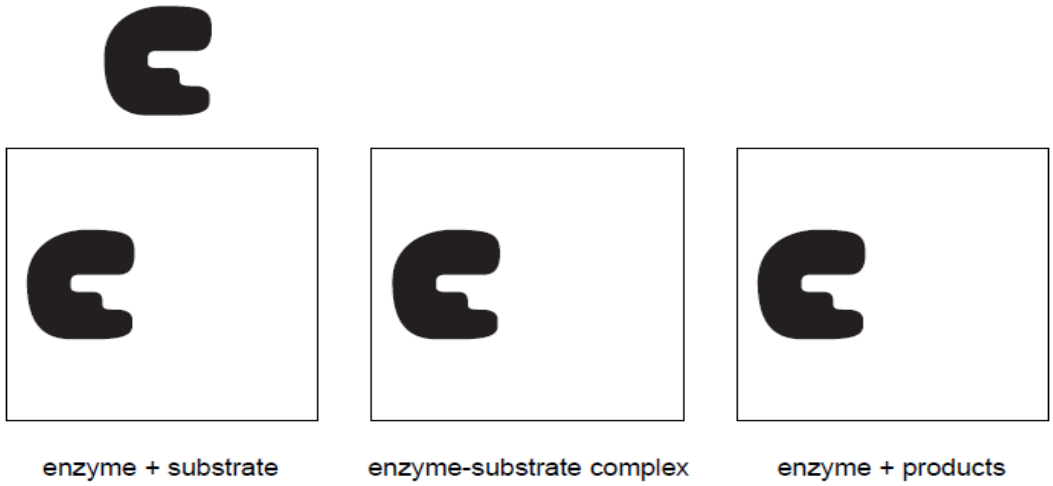
(a) Inorganic catalysts often work better on heating, but enzymes rarely work at temperatures much above 45°C. Explain why this is the case.

.....

.....

..... [2]

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



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

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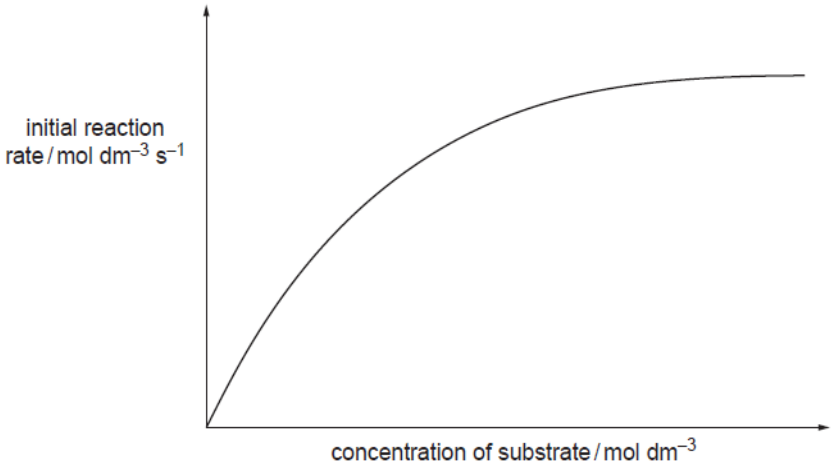
..... [2]

(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.

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.....

(June 2011 P41 Q7)

Q2 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.

.....

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

I .....

.....

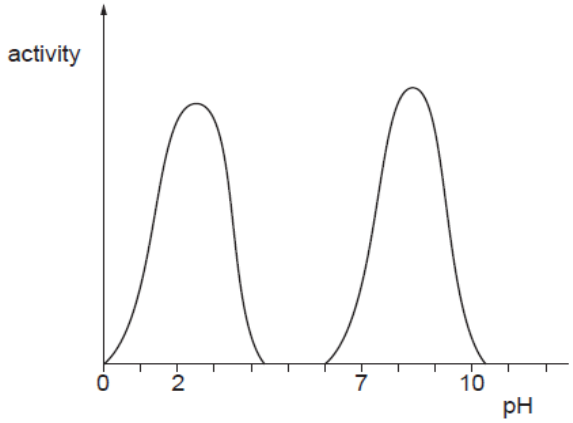
.....

II .....

.....

.....
(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.

(June 2011 P42 Q6)

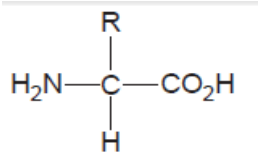
Q3 Proteins exist in an enormous variety of sizes and structures in living organisms. They have a wide range of functions which are dependent upon their structures. The structure and properties of an individual protein are a result of the primary structure – the sequence of amino acids that form the protein.
(a) Proteins are described as condensation polymers.
(i) Write a balanced equation for the condensation reaction between two glycine molecules, H2NCH2CO2H.

(ii) Draw the skeletal formula for the organic product.

(b) X-ray analysis has shown that in many proteins there are regions with a regular arrangement within the polypeptide chain. This is called the secondary structure and exists in two main forms.
(i) State the two forms of secondary structure found in proteins.

.....
(ii) Draw a diagram to illustrate **one** form of secondary structure.

(c) There are around 20 different common amino acids found in humans most of which have the same general structure.

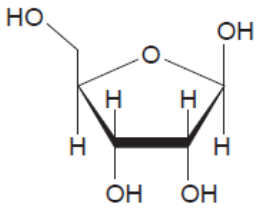


The nature of the group R affects which bonds are formed as the secondary structure of the protein is further folded to give the tertiary structure.
Complete the table indicating the type of **tertiary** bonding that each pair of the amino acid residues is likely to produce.

residue 1	residue 2	type of tertiary bonding
–HNCH($CH_2CH_2CH_2CH_2NH_2$)CO–	–HNCH($CH_2CH_2CO_2H$)CO–	
–HNCH(CH_3)CO–	–HNCH(CH_3)CO–	
–HNCH(CH_2SH)CO–	–HNCH(CH_2SH)CO–	
–HNCH(CH_2OH)CO–	–HNCH(CH_2CO_2H)CO–	

(Nov 2011 P41 Q6)

Q4 The formation of proteins is a key process in the growth and repair of tissues in living organisms.
(a) (i) Study the structures of the three molecules below. One of the molecules could be a building block for a protein while the other two could be building blocks for other biological polymers.



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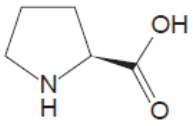
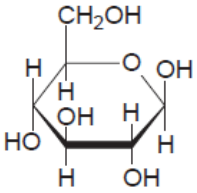


K



L

Which of the three could be a building block for a protein? Explain your answer.

.....

.....
(ii) For which biological polymer could **one** of the other molecules form a building block?

molecule ..... **polymer** .....
(b) Protein molecules have four levels of structure as the long molecules fold and take shape.
(i) The primary structure is the sequence of amino acids in the protein chain. What type of bonding exists between the amino acids in this chain?

.....

(ii) What type of bonding can exist in **all** of the other types of structure?

.....

(iii) Name one type of bonding that does **not** occur in the primary or secondary structure of the protein.

.....

(c) Many proteins play an important role in catalysing chemical reactions in living organisms.
(i) What name is given to these catalysts?

.....

(ii) Give **two** changes in conditions under which these catalysts may be inactivated, explaining the chemical reason for this in each case.

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(Nov 2011 P43 Q6)

Q5 In key reactions responsible for growth and repair in the human body, amino acids react together to form polymers known as proteins.
(a) (i) What *type of reaction* is this polymerisation?

.....

(ii) From stocks of glycine and alanine, it is possible to make the dipeptide gly-ala.
Using the same three-letter abbreviations for the amino acids, give the structures of all other possible dipeptides that can be made from these stocks of amino acids. [3]

(b) (i) DNA consists of a double helix formed by two strands held together by hydrogen bonds between base pairs.
Sketch a section of DNA showing **two** base pairs, using blocks for the various components. You should label all of the components.

(ii) Suggest what the effect on DNA replication would be if the hydrogen bonds between the strands were replaced by stronger bonds, e.g. covalent bonds.

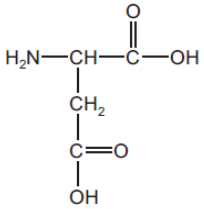
.....

.....[4]

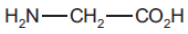
(c) Some diseases, such as sickle-cell anaemia, are caused by mutation resulting in a change in the triplet code.
(i) Explain why some changes in the triplet code do **not** result in a change in the primary structure of a protein.

.....

.....
(ii) Suggest what change in the tertiary structure of a protein would result from a mutation that replaced aspartic acid with glycine.



aspartic acid



glycine

.....

.....
(iii) Sometimes a mutation can result in the *deletion* of a single base in DNA (or RNA). Explain why this is likely to have more serious consequences for the protein than the *replacement* of one base by another.

.....

.....

(June 2012 P41 Q6)

Q6 (a) The table shows the structures of four amino acids found in proteins in the human body. Complete the table by indicating the type of tertiary interaction each side-chain is most likely to have when its amino acid is present in a protein chain.

amino acid	structure	type of interaction
alanine	$H_2NCH(CH_3)CO_2H$	
cysteine	$H_2NCH(CH_2SH)CO_2H$	
lysine	$H_2NCH((CH_2)_4NH_2)CO_2H$	
serine	$H_2NCH(CH_2OH)CO_2H$	

(b) Metal ions play an important role in the biochemistry of the human body. For each of the following metal ions, outline one of the places in the body it can be found and its main role there.
iron .....

.....

.....

potassium .....

.....

.....

zinc .....

.....

.....

(c) Many chemical reactions at a cellular level require energy in order to take place. This energy is largely provided by the breakdown of one particular compound.
(i) Write an equation showing the breakdown of this compound.

.....

(ii) What type of chemical reaction is this?

.....[2]

(d) Cystic fibrosis is a genetic disease caused by a mutation in the DNA sequence resulting in the production of a faulty version of an important protein which acts as an ion pump in the cell membrane. This pump controls the flow of ions into and out of cells.
People with the faulty protein show two major symptoms.
● water is retained in cells in the lungs resulting in the formation of a thick, sticky mucous outside the cells;
● their sweat is very salty.
Based on the information given for people with cystic fibrosis,
(i) suggest which ions are involved in the ion flow,

.....

.....

(ii) suggest and explain what type of bonding might result in thick or sticky mucous.

.....

.....[2]
(June 2012 P42 Q6)

Q7 Proteins are complex molecules made up from long chains that are folded to give a three-dimensional structure.
(a) Study the table which describes aspects of bonding in proteins. For each description of a bonding type, indicate whether it contributes to the primary, secondary or tertiary structure of a protein.

bonding type	structure involved
disulfide bonds between parts of the chain	
hydrogen bonds in a β-pleated sheet	
ionic bonds between parts of the chain	
peptide links between amino acids	

(b) Explain, with the use of diagrams as appropriate, the difference between competitive and non-competitive inhibition of enzymes.

.....

.....

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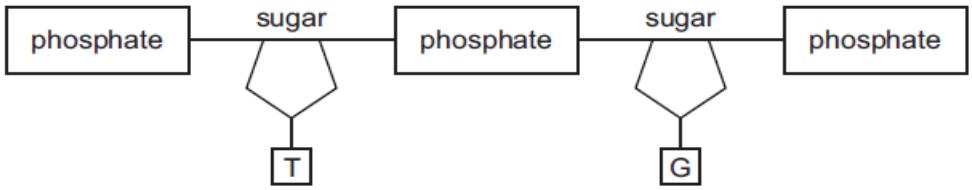
..... [4]

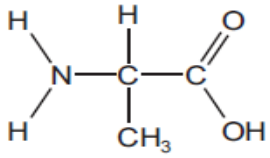
(c) The diagram shows one strand of DNA. Draw a matching strand showing clearly, with labels, the bonds holding the two strands together. Name the bases in **your** strand, indicating clearly which base bonds to each base in the strand shown.



names of bases .....

(Nov 2012 P42 Q6)

Q8 The proteins in the human body are complex polymers made up of around 20 different amino acids. Alanine is a typical amino acid.



alanine

(a) Glycine, H2NCH2CO2H, is the simplest amino acid and differs from each of the other 2-amino acids in a significant way. What is this difference?

..... [1]

(b) Protein molecules coil and fold, producing molecules with complex three-dimensional shapes. This is referred to as the secondary and tertiary structures of a protein.

(i) State **one** form of **secondary** structure and give the type of bonding responsible.

structure .....

bonding .....

(ii) Give **two** examples of bonding causing the **tertiary** structure, and give the amino acid responsible in each case.

bonding ..... amino acid .....

bonding ..... amino acid .....[6]

(c) Suggest why globular proteins, such as enzymes, contain relatively small amounts of glycine and alanine when compared to the amounts of some other amino acids. You may wish to refer to their structures given above.

.....

..... [1]

(d) DNA consists of a double helix with each strand having a sugar-phosphate 'backbone' with one of four bases – adenine (A), cytosine (C), guanine (G) and thymine (T) – attached to the sugar.

(i) The two strands of the double helix are held together by hydrogen bonds between pairs of bases. What are the pairs of bases?

.....

.....

In protein synthesis, sections of the DNA are copied by mRNA and this, in turn, is read by the ribosome in order to assemble the amino acids for the new protein chain. Each group of three bases codes for one amino acid, with some amino acids having several codes.
The codes are summarised below.

UUU	phe	UCU	ser	UAU	tyr	UGU	cys
UUC	phe	UCC	ser	UAC	tyr	UGC	cys
UUA	leu	UCA	ser	UAA	stop	UGA	stop
UUG	leu	UCG	ser	UAG	stop	UGG	trp
CUU	leu	CCU	pro	CAU	his	CGU	arg
CUC	leu	CCC	pro	CAC	his	CGC	arg
CUA	leu	CCA	pro	CAA	gln	CGA	arg
CUG	leu	CCG	pro	CAG	gln	CGG	arg
AUU	ile	ACU	thr	AAU	asn	AGU	ser
AUC	ile	ACC	thr	AAC	asn	AGC	ser
AUA	ile	ACA	thr	AAA	lys	AGA	arg
AUG	met/ start	ACG	thr	AAG	lys	AGG	arg
GUU	val	GCU	ala	GAU	asp	GGU	gly
GUC	val	GCC	ala	GAC	asp	GGC	gly
GUA	val	GCA	ala	GAA	glu	GGA	gly
GUG	val	GCG	ala	GAG	glu	GGG	gly

(ii) The coding for all protein chains starts with the AUG, and ends with one of three 'stop' codes shown in the table. What amino acid sequence would the following series of bases produce?

-AUGGGUAGCCUCGCAUCGUAA-

.....

(iii) What would be the effect on the amino acid sequence, of a mutation that changed the base at position 10 in the series of bases above from C to G?

.....

(Nov 2012 P43 Q6)

Q9 There are two important polymerisations that occur within living organisms – protein synthesis and the formation of DNA.

(a) Complete the table placing a tick in the correct column to indicate in which process each substance could be used.

substance	protein synthesis	formation of DNA
adenine		
alanine		
aspartate		
phosphate		

(b) Proteins and DNA form different helical structures. Briefly describe the bonding that maintains the shape of each of these helical structures.

protein .....

.....

.....

DNA .....

.....

.....

(c) Describe the differences in bonding in the *primary* and *tertiary* structures of proteins. Your answer should include reference both to the nature of the bonding and the types of amino acid causing it.

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.....

(June 2013 P41 Q6)

Q10 There are two important polymerisations that occur within living organisms – protein synthesis and the formation of DNA.

(a) Complete the table by placing a tick in the correct column to indicate in which process each substance could be used.

substance	protein synthesis	formation of DNA
cysteine		
cytosine		
glutamine		
guanine		

(b) DNA consists of a double helical structure.

(i) Describe the bonding between the two strands in DNA and state which part of each strand is joined by it.

.....

.....

(ii) How does the strength of this bonding relate to the mechanism of the replication of DNA?

.....

.....[4]

(c) Some diseases are caused by changes in the structure of proteins. Explain the genetic basis of these changes.

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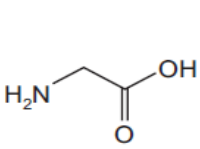
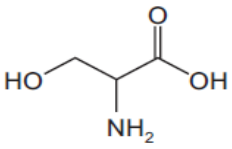
(June 2013 P42 Q6)

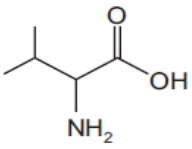
Q11 **(a)** Protein molecules are formed by the polymerisation of amino acids in the body. The structures of three amino acids are given.



glycine (*gly*)



serine (*ser*)



valine (*val*)

(i) How many different tripeptides can be made using **one** molecule of **each** of the amino acids shown?

.....

(ii) Draw the tripeptide *ser-gly-val*, showing the peptide bonds in displayed form.

(iii) Within the tripeptide, which amino acid provides a hydrophobic side chain?

.....

(iv) Polypeptide chains can form bonds giving proteins their *secondary* and *tertiary* structures. Using the tripeptide in **(ii)**, state **two** types of bonding that can be formed and the groups in the tripeptide that are involved in this bonding.

bond ..... groups .....

bond ..... groups .....

(b) Enzymes are particular types of proteins that catalyse chemical reactions. The efficiency of enzymes can be reduced by the presence of other molecules known as inhibitors. Explain how both *competitive* and *non-competitive* inhibitors prevent enzymes from working efficiently.

(i) competitive inhibitors .....

.....

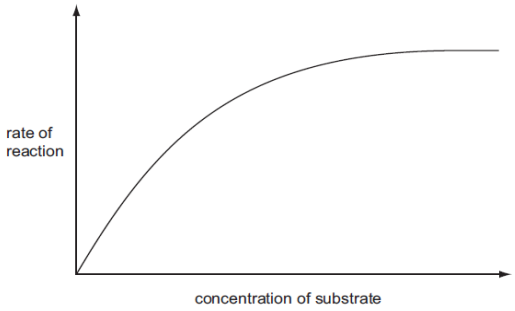
.....

(ii) non-competitive inhibitors .....

.....

.....

(iii) The graph shows the rate of an enzyme-catalysed reaction against the substrate concentration in the absence of an inhibitor. On the same axes, sketch a graph showing the rate of this reaction if a *non-competitive inhibitor* was present

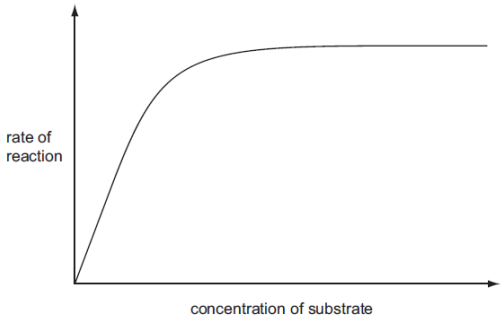


(Nov 2013 P42 Q6)

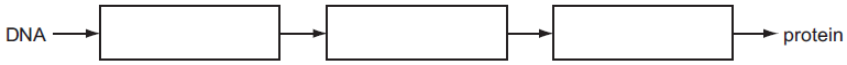
Q12 **(a)** Enzymes are particular types of proteins that catalyse chemical reactions. The efficiency of enzymes can be reduced by the presence of other substances known as inhibitors.
(i) State **one** example of a substance that can act as a *non-competitive* inhibitor in enzyme reactions.

.....
(ii) For the inhibitor you have identified, explain why it is a non-competitive inhibitor.

.....
(iii) The graph shows the rate of an enzyme-catalysed reaction against the substrate concentration in the absence of an inhibitor. On the same axes, sketch a graph showing the rate of this reaction if a *competitive inhibitor* was present.



(b) DNA is responsible for encoding the amino acid sequence to produce proteins. Ribosome, tRNA and mRNA are all involved in the process of protein synthesis.
(i) Write ribosome, tRNA and mRNA in the boxes below to show the correct sequence in which they are involved.



(ii) Sequences of three bases code for specific amino acids. The code UGA however does not usually code for an amino acid. Suggest its use.

.....
(c) Much of the energy used in biochemical reactions is provided by the hydrolysis of the molecule ATP.
(i) What are the breakdown products of the hydrolysis of ATP?

.....
(ii) Give **two** uses for the energy released by ATP hydrolysis in cells.

1. .....

2. .....

(Nov 2013 P43 Q7)