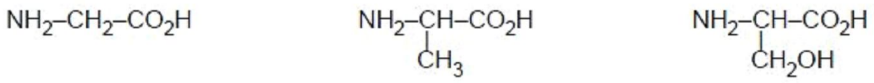
Q1.

6 Much research has been carried out in recent years investigating the exact structure of silk. The silk of a spider's web is at least five times as strong as steel, and twice as elastic as nylon. A silk fibre is composed of many identical protein chains, which are mainly made from the amino acids glycine, alanine and serine, with smaller amounts of four other amino acids.



glycine alanine serine

(a) Amino acids can exist as zwitterions. Draw the zwitterionic structure for glycine.

[1]

(b) Amino acids can act as acids or bases. Write equations to show:

(i) the reaction between alanine and HCl(aq),

.....

(ii) the reaction between serine and NaOH(aq).

.....

[2]

(c) Draw the structural formula of a portion of the silk protein, showing three amino acid residues. Label a peptide bond on your structure.

[3]

(d) What *type* of polymer is silk protein?

.....[1]

(e) The M_r of a silk protein molecule is about 600,000. Assuming it is made from equal amounts of the above three amino acids, calculate the average number of amino acid residues in the protein chain. [M_r (glycine) = 75; M_r (alanine) = 89; M_r (serine) = 105]

number of residues = ... [3]

[Total: 10]

Q2.

7 **(a)** **(i)** In a protein, amino acids are joined together by a process called *condensation polymerisation*. *Addition polymerisation* is used in some synthetic polymers, such as poly(propene).

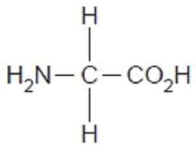
State **two** important differences between *condensation polymerisation* and *addition polymerisation*.

.....

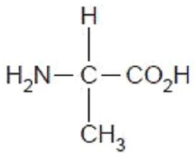
.....

.....

(ii) Using the amino acids glycine and alanine shown, draw the displayed formula of the dipeptide ala-gly, clearly labelling the peptide link.



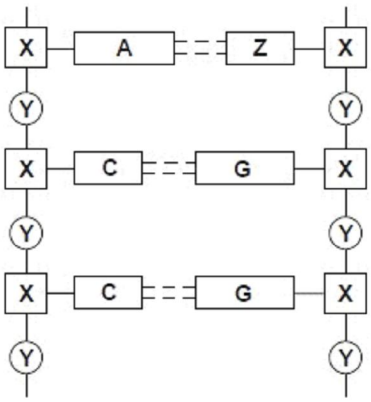
glycine



alanine

[4]

(b) The diagram below shows a section of DNA.
Identify the blocks labelled **X**, **Y** and **Z**.



X ..... **Y** ..... **Z** .....

[3]

(c) The table below shows the 3-base codes used by RNA.

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

(i) What amino acid sequence would the following base code produce?
(You may use abbreviations in your answer.)

-AUGUCUAGAGACGGGUAA-

.....

.....

(ii) What would be the effect on the amino acid sequence if a mutation caused the base G at position 13 in the sequence to be replaced by U?

.....

.....

[3]

(d) **(i)** Name a disease which results from a genetic defect.

.....

(ii) Explain how the genetic defect can bring about your named disease.

.....

.....

.....

[3]

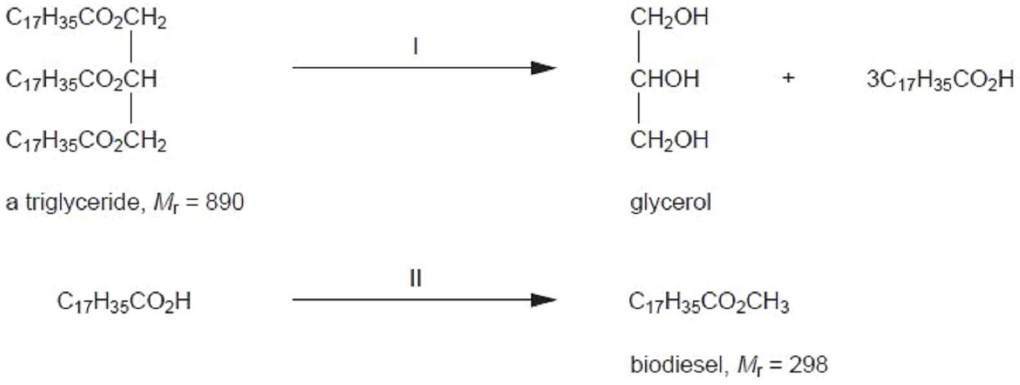
[Total: 13]

Q3.

Use

4 Recently much interest has been shown in the production of the fuel *biodiesel* from algae. Up to 55% of the mass of the dried algae is composed of lipids, the majority of which are triglycerides.

To convert triglycerides into biodiesel, the following processes are carried out.



(a) Name the functional group present in triglycerides.

.....

[1]

(b) Suggest reactants and conditions for

reaction I,

.....

reaction II.

.....

[4]

(c) Suggest the structural formula of the compound formed when glycerol is reacted with

(i) an excess of HBr(aq),

.....

(ii) an excess of hot acidified $K_2Cr_2O_7$(aq).

.....

[2]

(d) Calculate the mass of biodiesel that can be produced from 1000 kg of dried algae, assuming that 50% of the algal mass is triglycerides.

mass = ... kg [2]

(e) **(i)** Construct an equation for the complete combustion of biodiesel.

.....

(ii) Use your equation to calculate the mass of CO_2 produced when 10 kg of biodiesel is burned.

.....

.....

[3]

(f) The production of biodiesel is at present an expensive process.

Suggest a reason why the development of biodiesel as an alternative to fossil fuels is important.

.....

..... [1]

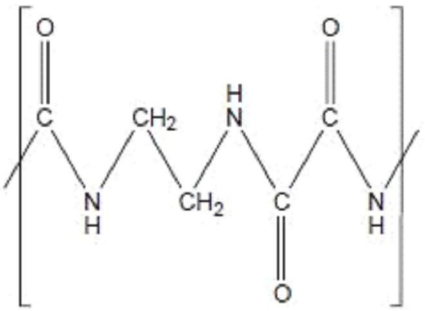
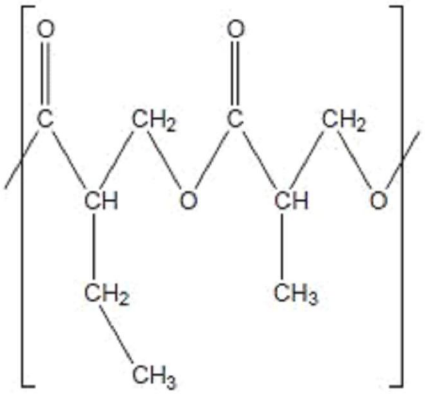
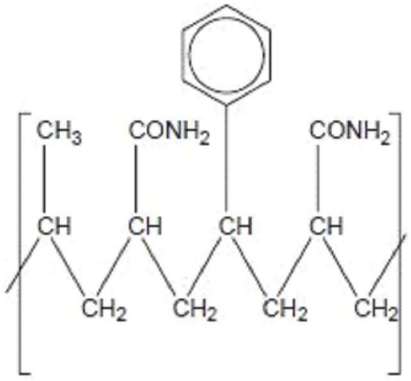
[Total: 13]

Q4.

7 Each of the following structures is an 8-atom segment of the chain of a commercial polymer.

For each structure,

- decide whether it is part of a condensation or an addition polymer, and
- draw the structural formulae of the monomer(s) from which the polymer is made.

polymer	addition or condensation?	formulae of monomers
		
		
		

[8]

[Total: 8]

Q5.

8 **(a)** State and show, using suitable diagrams, the types of bonding that occur in the primary, secondary and tertiary structures of a protein.

primary

secondary

tertiary

[6]

(b) Analysis of a polypeptide **A** showed that the amino-(N-)terminal end is methionine (met) and that the carboxyl-(C-)terminal end is lysine (lys).

Enzymic hydrolysis of the polypeptide produced the following tripeptides, with the amino acid residue on the left having the free amino group.

met-ala-gly gly-arg-val ala-gly-arg arg-val-lys ala-gly-ala gly-ala-gly

Work out the sequence of amino acids in **A**, using the 3-letter abbreviations. Use each tripeptide once only.

[2]

(c) Give **two** examples of how interchanging the positions of two amino acids could affect the bonding in, and hence the overall structure of, the protein.

.....

.....

.....

.....

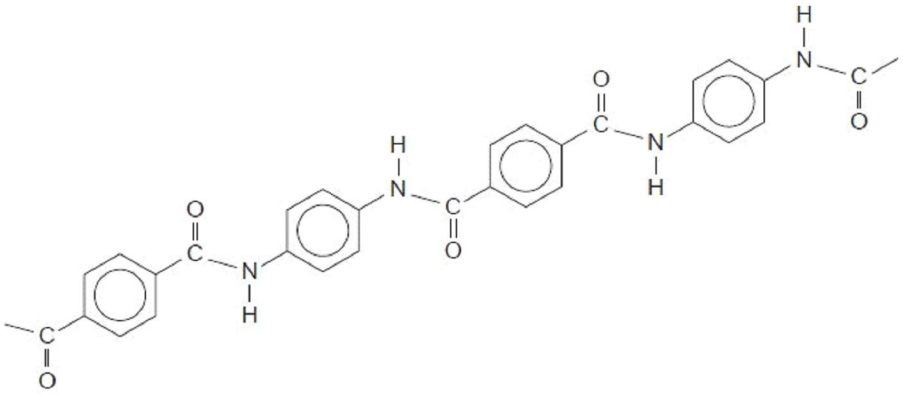
..... [4]

[Total: 12]

Q6.

9 **(a)** Spider silk is a natural polymer which has an exceptional strength for its weight. *Kevlar* is a man-made polymer designed to have similar properties. It has a wide variety of uses from sporting equipment to bullet-proof vests.

For Examiner's Use



Kevlar

(i) In *Kevlar*, the polymer strands line up to form strong sheets with bonds between the strands.

On the diagram above, draw part of a second polymer chain showing how bonds could be formed between the chains.

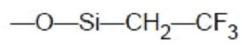
(ii) Suggest what type of bonds these are.

.....

(iii) Draw **two** possible monomer molecules for making the polymer *Kevlar*.

[5]

(b) The transport of oil by sea has resulted in a number of oil spills in recent years. As well as a waste of a valuable resource, these have caused major environmental problems. Traditional sorbent materials absorb water and sink. Researchers have developed new sorbent materials to help collect the spilled oil. The sorbent consists of a material called 'hydrophobic aerogels'. This is a network of silicon(IV) oxide with some of the silicon atoms attached to fluorine-containing groups.



The introduction of these fluorine-containing groups allows the oil to be absorbed but not the water. Tests show that these materials can absorb more than 200 times their mass of oil without sinking.

(i) Suggest what the word **hydrophobic** means.

.....

(ii) Suggest why the fluorine-containing groups allow oil to pass through but not water molecules.

.....

.....

.....

.....

(iii) Suggest another important fluorine-containing polymer that repels water-containing materials.

.....

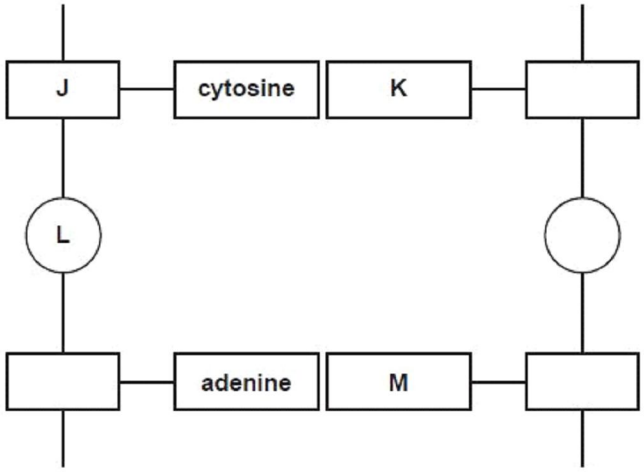
[4]

[Total: 9]

Q7.

8 The molecule that contains the genetic information for an individual organism is called deoxyribonucleic acid, DNA.

(a) The diagram shows part of a DNA molecule. Study the diagram and identify the blocks labelled **J**, **K**, **L** and **M** as accurately as you can.



block letter	identity
J	
K	
L	
M	

[3]

(b) The DNA molecule is formed from two polymer strands.
What stops these strands from separating from each other?

.....

.....[2]

(c) List **three** differences between the structures of DNA and RNA.

For Examiner's Use

1. .....

.....

.....

2. .....

.....

.....

3. .....

.....

.....

[3]

(d) Outline the different **roles** of mRNA and tRNA in the processes of transcription and translation.

mRNA .....

.....

.....

tRNA .....

.....

.....

[2]

[Total: 10]

Q8.

6 Human hair and silk both consist of proteins. Proteins are described as having three major levels of structure: primary, secondary and tertiary.

(a) Outline what is meant by the terms *primary structure* and *tertiary structure* of a protein.

primary structure .....

.....

.....

tertiary structure .....

.....

.....

[2]

(b) In hair, the secondary structure consists of α-helices which are cross-linked by disulfide bonds. The amino acid responsible for this cross-linking is cysteine, $H_2NCH(CH_2SH)CO_2H$.

(i) Show by means of a diagram how the disulfide cross-links are formed.

(ii) What type of reaction is this?

.....

(iii) State **three** other interactions that stabilise the tertiary structure of proteins.

For Examiner's Use

.....

.....

.....

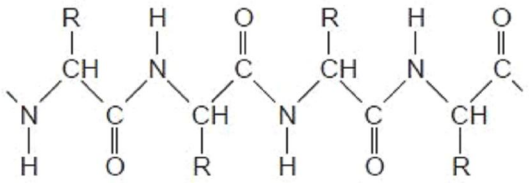
[4]

(c) The β-pleated sheet is a different form of secondary structure found in proteins, such as those in silk.

(i) What type of bonding is responsible for stabilising the β-pleated sheet in silk?

.....

(ii) On the diagram below, draw a second polypeptide strand and show how bonds would be formed that stabilise this β-pleated sheet.



[3]

(d) The cysteine-containing protein in hair is called α-keratin. A similar sequence of amino acids can produce β-keratin proteins found in the scales, claws and shells of reptiles such as tortoises. In β-keratin the secondary structure of the protein is in the form of a β-pleated sheet.

Suggest what makes the β-pleated sheet in β-keratin so much less flexible than the β-pleated sheet in silk.

.....

.....

.....[1]

[Total: 10]

Q9.

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.

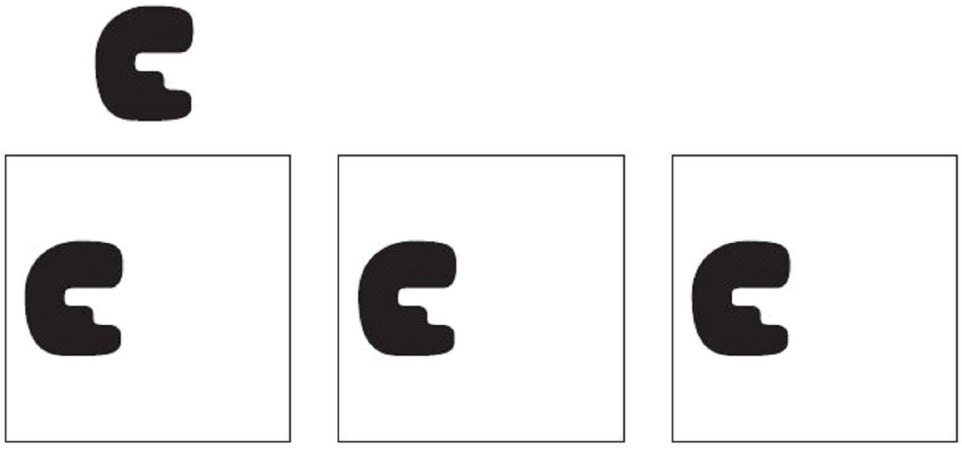
(a) Inorganic catalysts often work better on heating, but enzymes rarely work at temperatures much above 45°C. Explain why this is the case.

.....

.....

.....[2]

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



[3]

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

For Examiner's Use

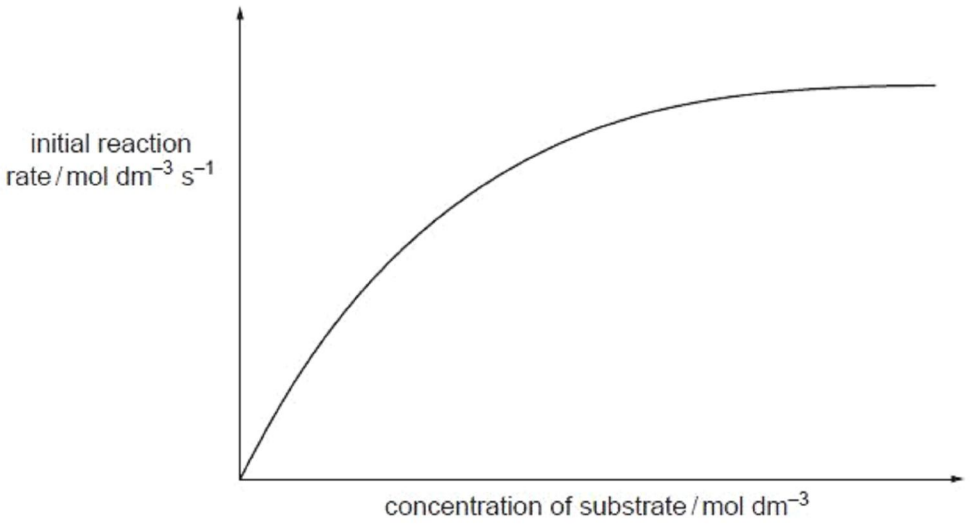
.....

.....

.....

.....[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.

.....

.....

[3]

[Total: 10]

Q10.

9 In today's world, many traditional materials have been replaced by different sorts of polymers. This includes rigid polymers such as those used in car bodies to replace steel and flexible polymers like those used in textiles to replace cotton or wool.

For Examiner's Use

(a) (i) To form a polymer, what is the **minimum** number of functional groups that the monomer must possess?

.....

(ii) Illustrate your answer to **(i)** with the structure of a possible monomer.

[2]

(b) State **two** differences between addition and condensation polymerisation.

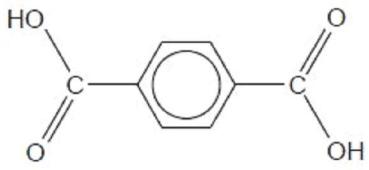
(i) .....

.....

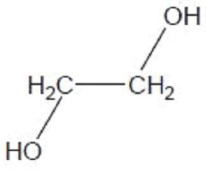
(ii) .....

.....[2]

(c) The polymer formed from the co-polymerisation of the two monomers shown is known as *Terylene*.



benzene-1, 4-dicarboxylic acid



ethane-1-2-diol

(i) The two monomers react by condensation polymerisation. What other molecule is formed in this reaction?

.....

(ii) Draw the structure of **one** repeat unit of *Terylene*.

For Examiner's Use

(iii) What is the name given to polymers containing the same functional group as *Terylene*?

..... [4]

(d) The monomers ethene and but-1-ene can also co-polymerise to form a polyalkene, but this does not produce a regular alternating structure like *Terylene*. Explain why this is the case, drawing diagrams if you wish.

.....

.....

.....

.....

[2]

[Total: 10]

Q11.

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.

.....

.....

.....

.....

.....

.....

(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 .....

.....

.....

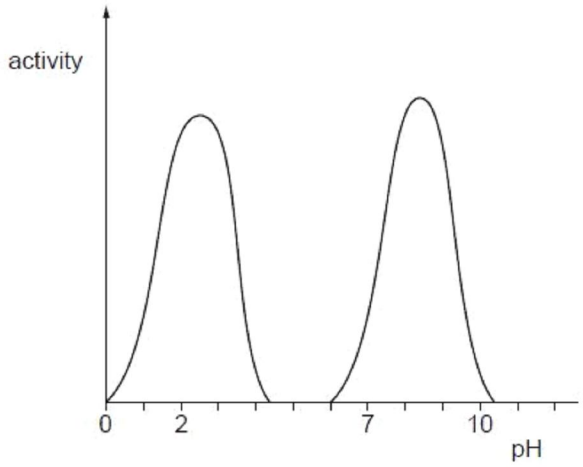
[6]

(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.

For Examiner's Use

- 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]

Q12.

6 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]

For Examiner's Use

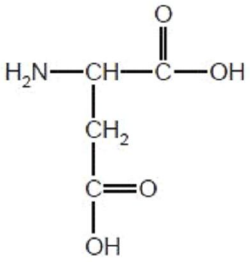
(c) Some diseases, such as sickle-cell anaemia, are caused by mutation resulting in a change in the triplet code.

(i) Explain why some changes in the triplet code do **not** result in a change in the primary structure of a protein.

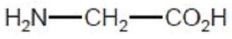
.....

.....

(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.

.....

.....

[3]

[Total: 10]

Q13.

8 Some of the most commonly used polymers are formed by the polymerisation of ethene, C_2H_4. The presence of side-chains affects the bulk properties of an addition polymer. Unbranched polymers pack closer together than polymers with several side-chains.

Poly(ethene) exists in two different forms LDPE (low density poly(ethene)) which has lots of side-chains, and HDPE (high density poly(ethene)) in which there are fewer and shorter side-chains.

(a) Explain with the aid of sketches why the presence of side-chains causes a difference in density in poly(ethene).

.....

.....

..... [2]

(b) By reference to the type of bonding between the poly(ethene) chains, explain why LDPE has a lower melting point that HDPE.

.....

.....

..... [2]

(c) Polymerisation can take place by two different methods depending on the monomers involved. The two methods are addition and condensation.
Give **two** differences between the methods.

1. .....

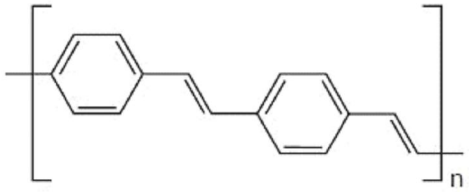
.....

2. .....

.....
[2]

For Examiner Use

(d) There has been a great deal of commercial interest in the development of polymers that can conduct electricity and/or emit light. A length of one such polymer is shown.



(i) Suggest how this polymer conducts electricity.

.....

(ii) Suggest the molecular geometry required for this molecule to conduct.

Explain your answer.

.....

.....

(iii) What is the empirical formula of this polymer?

.....

[4]

[Total: 10]

Q14.

6 **(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	$H_2NCH(CH_2OH)CO_2H$	

[3]

(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 .....

.....

.....

[3]

(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]

[Total: 10]

Q15.

6 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		

[3]

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

protein .....

.....

.....

DNA .....

.....

.....

[4]

(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.

.....

.....

.....

.....

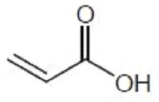
.....

[3]

[Total: 10]

Q16.

8 In recent years there has been a lot of interest in polymers in the form of gels that absorb aqueous materials. One of the largest uses of these polymers is in disposable nappies (diapers). The gel which is used in this case is a polymer of propenoic acid.



propenoic acid

(a) (i) Draw a section of the polymer of propenoic acid showing **two** repeat units.

(ii) By what type of chemical reaction is this polymer formed?

.....

(iii) By what type of bonding is water held on the polymer?

.....

[3]

(b) For some disposable nappies (diapers), the monomer is a mixture of propenoic acid and sodium propenoate. The properties of the polymer are influenced by the proportion of sodium salt in the monomer mixture.

(i) Suggest and explain how the difference in the structure of this polymer compared to one formed only from propenoic acid might affect the water absorbing properties of the polymer.

.....

.....

.....

(ii) Suggest a property the polymer should have in order to be used in disposable products.

.....

[3]

(c) A variation on the gel used for disposable nappies (diapers) containing more sodium propenoate has been used to treat soils contaminated by heavy metals such as lead (Pb^{2+}) and cadmium (Cd^{2+}). Suggest why the gel is effective.

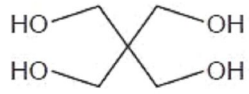
.....

.....

.....

[2]

(d) Another variation on this type of polymer is used in hair gels. In these, the polymer chains are cross-linked by a compound known as pentaerythritol.



pentaerythritol

(i) By what type of chemical reaction are the cross-links in this polymer formed?

.....

(ii) It is important that the gel should be easily washed out of hair. What is it about the structure of the polymer that allows this to happen?

.....

[2]

[Total: 10]

Q17.

6 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		

[3]

(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.

.....

.....

.....

.....

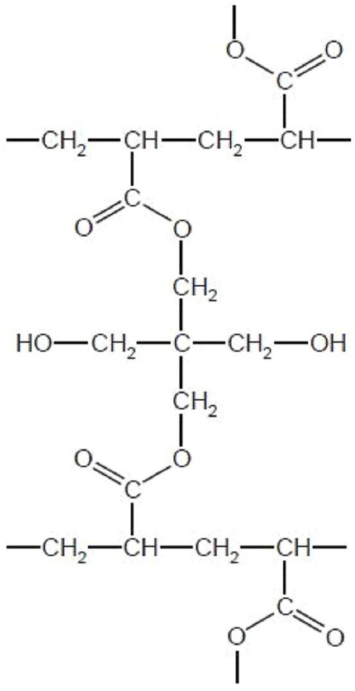
[3]

[Total: 10]

Q18.

8 In recent years there has been considerable interest in a range of polymers known as 'hydrogels'. These polymers are hydrophilic and can absorb large quantities of water.

(a) The diagram shows part of the structure of a hydrogel.



The hydrogel is formed from chains of one polymer which are cross-linked using another molecule.

(i) Draw the structure of the monomer used in the polymer chains.

(ii) State the type of polymerisation used to form these chains.

.....

.....

(iii) Draw the structure of the molecule used to cross-link the polymer chains.

(iv) During the cross-linking, a small molecule is formed as a by-product. Identify this molecule.

.....

[5]

(b) Once a hydrogel has absorbed water, it can be dried and re-used many times. Explain why this is possible, referring to the structure on the opposite page.

.....

.....

.....

[2]

(c) Not every available side chain in the polymer is cross-linked, and the amount of cross-linking affects the properties of the hydrogel.

(i) The amount of cross-linking has little effect on the ability of the gel to absorb water. Suggest why this is the case.

.....

.....

.....

(ii) Suggest **one** property of the hydrogel that will change if more cross-linking takes place. Explain how the increased cross-linking brings about this change.

.....

.....

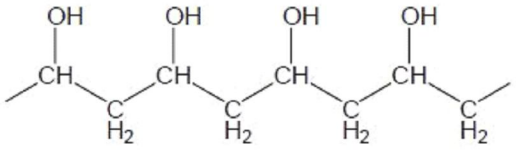
.....

[3]

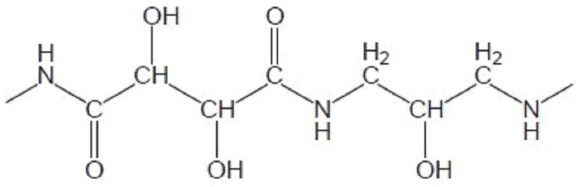
[Total: 10]

Q19.

5 Hydrophilic polymers find important uses in the manufacture of contact lenses and wound dressings. Their chemical structures allow them to bond with water molecules, which keeps them soft and flexible. Sections of two hydrophilic polymers are shown below.



H



J

(a) What type of polymerisation has produced

(i) polymer **H**? .....

(ii) polymer **J**? .....

[2]

(b) What type of attractions might occur between these polymers and molecules of water?

..... [1]

(c) Chains of polymer **H** can be 'cross-linked', i.e. joined together, by reaction with a small bifunctional molecule.

(i) Which one of the following molecules would be most suitable for such cross-linking?

(place a tick in one box only)

$HOCH_2CH_2OH$	☐
$H_2NCH_2CH_2NH_2$	☐
$HOCH_2CH_2CO_2H$	☐
$HO_2CCH_2CH_2CO_2H$	☐
$H_2NCH_2CH_2CO_2H$	☐

(ii) What type of bond would be formed during the cross-linking?

.....

[2]

(d) **(i)** Suggest the reagents and conditions needed to hydrolyse polymer **J** into its monomers.

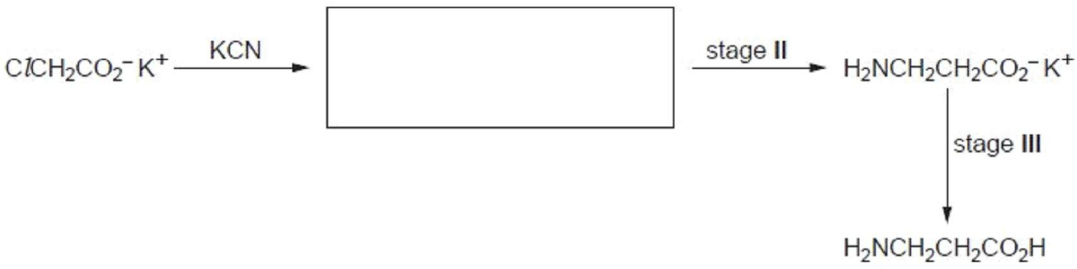
.....

(ii) Draw the structural formulae of the two products of this hydrolysis reaction.

.....

[3]

(e) The last compound in the list in **(c)(i)** above is 3-aminopropanoic acid. This can be made from potassium chloroethanoate by the following 3-stage route.



(i) In the box above write the structure of the intermediate in this route.

(ii) Suggest reagents and conditions for

stage **II** .....

stage **III** .....

[3]

[Total: 11]

Q20.

8 **(a)** DNA carries the genetic code in living organisms and consists of a double helix.

(i) Describe what is meant by a *double helix*.

.....

.....

(ii) How are the strands of the double helix held together?

.....

.....

[2]

(b) In replicating the genetic code two RNA molecules, mRNA and tRNA, are used to perform functions called *transcription* and *translation*.
Describe the role of the RNA molecules in these two functions.

transcription .....

.....

.....

translation .....

.....

.....[4]

(c) When an egg is boiled, the protein changes from a viscous liquid to a solid.

(i) Suggest what causes this change as the protein is heated.

.....

.....

(ii) Why is there no change to the primary structure of the protein under these conditions?

.....

.....

[2]

(d) Describe in outline how energy is provided in animal cells.

.....

.....

.....

.....

.....

.....[3]

[Total: 11]

Q21.

4 **(a)** The viscosity of engine oil can be improved by the addition of certain medium chain-length polymers.

A portion of the chain of one such polymer is shown below.

$$-CH_2CH(CH_2CH_2CH_3)CH_2CH(CH_2CH_2CH_3)CH_2-$$

On average, the molecules of the medium-chain polymer contain 40 carbon atoms.

(i) Suggest the structure of the monomer.

.....

(ii) How many monomer units are incorporated into the average molecule of the polymer?

.....

[2]

(b) Used car engine oil can be recycled for use as a fuel by the processes of distillation and cracking.

(i) Assuming a typical molecule of engine oil has the formula $C_{40}H_{82}$, suggest an equation for a cracking reaction that could produce diesel fuel with the formula $C_{16}H_{34}$ and other hydrocarbons only.

.....

(ii) What conditions are needed for this cracking reaction?

.....

(iii) Considering only the bonds broken and the bonds formed during the reaction, use the *Data Booklet* to calculate the enthalpy change for the reaction you wrote in **(b)(i)**.

.....

.....

.....

(iv) Comment on how the conditions you described in **(b)(ii)** relate to the enthalpy change you calculated in **(b)(iii)**.

.....

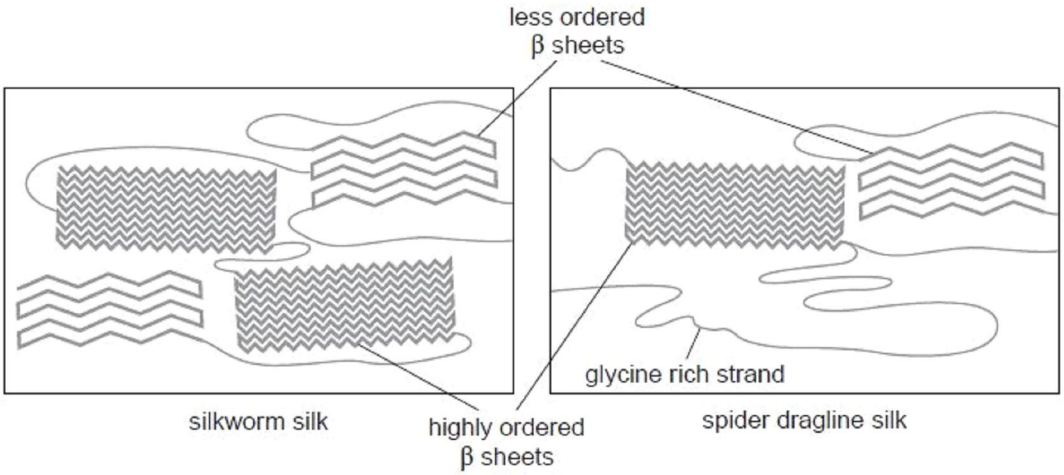
.....

[4]

[Total: 6]

Q22.

10 **(a)** Silk from silkworms, used as a fabric shows a different secondary structure to that produced by spiders.



(i) What sort of bonding would you expect to occur between adjacent parts of the protein chains in each form of silk?

silkworm .....

spider .....

(ii) Suggest **two** differences in properties that these forms of silk could have. Explain your answer.

.....

.....

.....

.....

(iii) Spider dragline silk contains large amounts of the amino acid glycine. How does this affect the properties of the silk?

.....

.....

[5]

(b) Both forms of silk are condensation polymers.

(i) Explain what is meant by a condensation polymer.

.....

.....

(ii) Another type of polymer is called an addition polymer. Name an example of an addition polymer.

.....

(iii) Suggest why condensation polymers such as proteins show a wider range of properties than addition polymers.

.....

.....

.....

.....

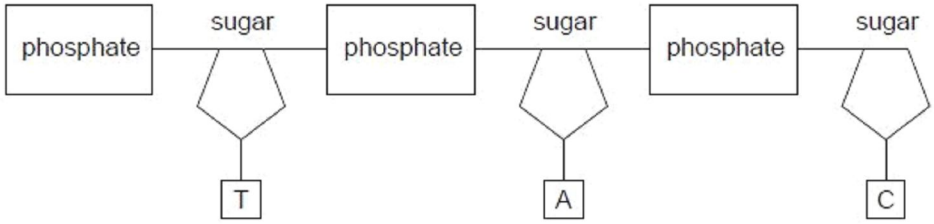
.....

[5]

[Total: 10]

Q23.

6 **(a)** The diagram shows part of one strand of DNA. Draw the complementary strand, labelling the bonds formed to the original strand, and labelling the components of the strand you draw.



[3]

(b) Briefly describe the roles of each of the following in protein synthesis.

(i) tRNA .....

.....

.....

(ii) the ribosome .....

.....

.....

[4]

(c) Some diseases, such as sickle cell anaemia, are caused by a single mutation in the DNA for a particular gene. This causes the haemoglobin produced to change the shape of red blood cells, reducing their efficiency in carrying oxygen.

(i) What is meant by a *mutation*?

.....

(ii) Explain why such a mutation could alter the bonding in haemoglobin.

.....

.....

.....

.....

[4]

[Total: 11]

Q24.

7 **(a)** Explain, using diagrams where appropriate, the types of interaction responsible for the primary, secondary and tertiary structure of a protein.

primary structure

.....

.....

.....

secondary structure

.....

.....

.....

tertiary structure

.....

.....

.....[6]

Q25.

7 Whilst small amounts of some metal ions are vital in the human body, others can be highly toxic.

(a) Hg^{2+} ions are toxic for a number of reasons. Hg^{2+} ions can react with the R–S–S–R group, which is found in proteins.

$$R–S–S–R + 2Hg^{2+} + H_2 \longrightarrow 2\,R–S–Hg^{+} + 2H^{+} \qquad \text{reaction 1}$$

(i) What is the name of the R–S–S–R group in proteins?

.....

(ii) Which level of protein structure will be affected by reaction 1?

.....

.....

(iii) Why will this affect the activity of an enzyme?

.....

.....

[3]

(b) Ag^{+} ions can combine with free –COOH groups in the side chains of the amino acid residues in proteins to form partially covalent silver carboxylates.

$$RCOOH + Ag^{+} \longrightarrow RCOOAg + H^{+} \qquad \text{reaction 2}$$

(i) What type of behaviour is the –COOH group showing in reaction 2?

.....

.....

(ii) What types of R group interactions will be affected by reaction 2? Explain your answer.

.....

.....

.....

.....

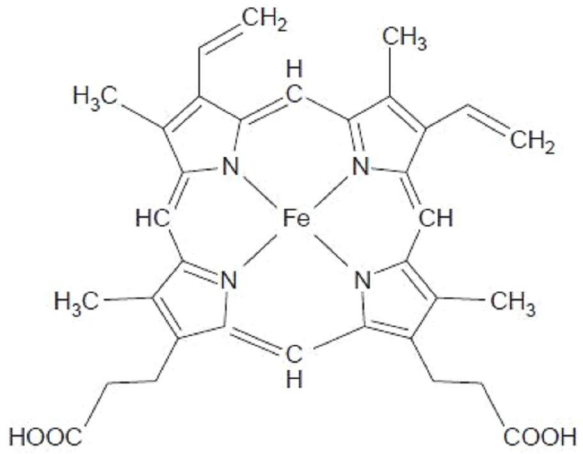
.....

[4]

(c) By contrast, iron is an extremely important metal used in haemoglobin to transport oxygen molecules from the lungs to muscle cells and to carry carbon dioxide in the reverse direction.

For Examiner's Use

One haemoglobin molecule contains four haem groups, each of which contains one iron atom. In the haem group four nitrogen atoms are in the same plane as the iron atom. The oxygen molecule is attached above this plane, and the iron atom is joined to a protein chain below this plane.



haem

(i) How many oxygen **atoms** could one haemoglobin molecule transport?

.....

(ii) By what type of bonding is the oxygen molecule likely to be held to the iron atom in haem?

.....

(iii) What is the geometry of bonding around the iron atom?

.....

[3]

[Total: 10]

Q26.

9 DNA is an extremely important chemical in human cells. It has been described as the 'blueprint of life'.

(a) What **three** types of compound are linked together in DNA?

.....[1]

(b) DNA consists of two strands linked together. Draw a **block diagram** to illustrate this and showing **two** repeat units in the backbones, labelling the components and showing and labelling the bonds between the strands.

[4]

(c) DNA is used to encode for the production of a particular protein. Put the following biochemical structures in the correct sequence from the use of DNA as a template to the formation of the protein by writing their names in the relevant box below.

tRNA

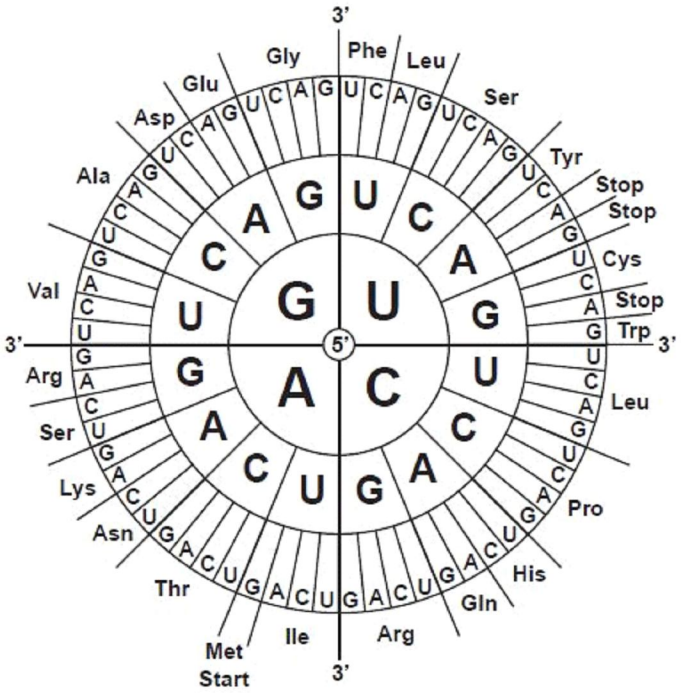
mRNA

ribosomes

DNA ➡ [ ] ➡ [ ] ➡ [ ] ➡ protein [2]

(d) In order to produce proteins, the information stored in the DNA molecules has to be translated to produce an mRNA strand. A sequence of three bases, called a triplet, on the mRNA describes a particular amino acid. These amino acids are then combined together to form proteins. The amino acid specified by each triplet is shown below.

For Examiner's Use



The sequence of three bases in a triplet is read from the middle outwards e.g. UGG specifies Trp.

(i) There are four different bases present in mRNA. How many different triplets are possible using these four bases.

.....

(ii) What peptide fragment would the following sequence code for when read from left to right? (Use 3-letter abbreviations for amino acids.)

5' – A U G A G C C G A C U U G A C G U G – 3'

.....

(iii) What would be the effect of changing the 11th base from U to C?

.....

[4]

[Total: 11]

Q27.

6 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, $H_2NCH_2CO_2H$.

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

[2]

(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.

.....

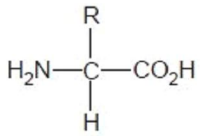
.....

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

[4]

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

For Examiner's Use



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
$-HNCH(CH_2CH_2CH_2CH_2NH_2)CO-$	$-HNCH(CH_2CH_2CO_2H)CO-$	
$-HNCH(CH_3)CO-$	$-HNCH(CH_3)CO-$	
$-HNCH(CH_2SH)CO-$	$-HNCH(CH_2SH)CO-$	
$-HNCH(CH_2OH)CO-$	$-HNCH(CH_2CO_2H)CO-$	

[4]

[Total: 10]

Q28.

8 In today's world we make use of a wide range of different polymers. These polymers are often substitutes for traditional materials, but may have more useful properties.

For Examiner's Use

(a) Complete the table identifying one traditional material that has been replaced by each polymer.

traditional material	modern polymer and its use
	PVC in packaging
	Terylene in fabrics
	polycarbonate bottle

[2]

(b) Throwing away articles made from polymers after use is a major environmental concern for **two** main reasons. Identify **each** of these reasons and suggest a strategy that has been adopted to try to overcome each of these.

reasons : .....

.....

.....

strategy 1 : .....

.....

strategy 2 : .....

.....

[3]

(c) One suggestion for the disposal of polymers is to use them as a fuel to provide energy for small-scale power stations or district heating schemes.
Identify one polymer which would be **unsuitable** for this use, explaining the reason behind this.

polymer .....

reason .....

.....

.....

[2]

(d) Polymers can be either thermoplastic or thermosetting.

Name a thermoplastic polymer. .....

State which type of polymerisation produces thermoplastic polymers, explaining your answer in terms of the structure of the polymer.

.....

.....

.....

.....

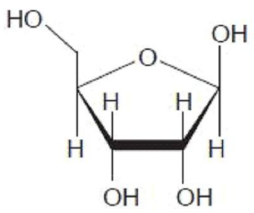
[3]

[Total: 10]

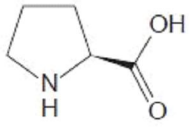
Q29.

6 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.



J



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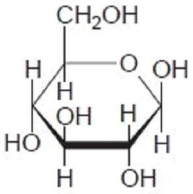


L

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** .....

[2]

(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.

.....

[3]

(c) Many proteins play an important role in catalysing chemical reactions in living organisms.

For Examiner's Use

(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.

.....

.....

.....

.....

.....

.....

[4]

[Total: 9]

Q30.

6 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	

[3]

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

.....

.....

.....

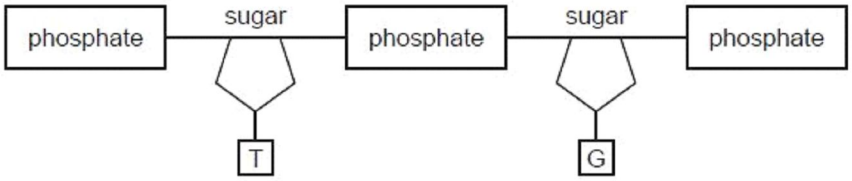
.....

.....

..... [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.

For Examine Use



names of bases .....

[3]

[Total: 10]

Q31.

8 The increasing awareness of the diminishing supply of crude oil has resulted in a number of initiatives to replace oil-based polymers with those derived from natural products. One such polymer, 'polylactide' or PLA, is produced from corn starch and has a range of applications.

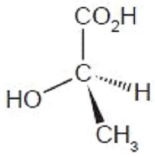
(a) The raw material for the polymer, lactic acid (2-hydroxypropanoic acid), is formed by the fermentation of corn starch using enzymes from bacteria.

(i) Calcium hydroxide is added to the fermentation tanks to prevent the production of lactic acid from slowing down.
Why might high acidity reduce the effectiveness of the enzymes?

.....

.....

(ii) The structure of lactic acid is shown.



What type of reaction takes place in this polymerisation?

.....
[2]

(b) Lactic acid exists in two stereoisomeric forms. Draw the other form in the box.

[1]

F
Exam
U

(c) One of the reasons PLA has attracted so much attention is that it is biodegradeable. This does, however, restrict some potential uses. The simple polymer has a melting point of around 175 °C, but softens between 60-80 °C. However, its thermoplastic properties enable it to have a range of uses in fibres and in food packaging.

(i) Explain why PLA would **not** be a suitable packaging material for foods pickled in vinegar.

.....

.....

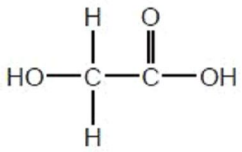
(ii) PLA containers are not used for hot drinks. Suggest why.

.....

.....

[2]

(d) Lactic acid can also be co-polymerised with glycolic acid.



glycolic acid

(i) Draw a section of the co-polymer showing one repeat unit.

(ii) Suggest what type(s) of bonding will occur between chains of this co-polymer, indicating the groups involved.

.....

.....

.....

(iii) Suggest one property in which the co-polymer differs from PLA.

.....

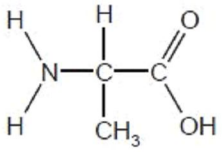
.....

[5]

[Total: 10]

Q32.

6 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, $H_2NCH_2CO_2H$, 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?

.....

[5]

[Total: 13]

Q33.

For Examiner's Use

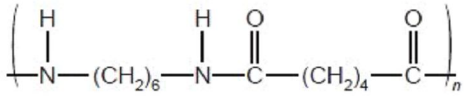
8 The physical properties of polymers depend on the average relative molecular mass of the polymer chains and on the functional groups present in the monomers.

The presence of side-chains in addition polymers can increase the spacing between polymer chains in the bulk substance and hence reduce the overall density.

In condensation polymers it is the *nature* of the side-chain that is often more important since this can lead to cross-linking of the polymer chains forming a three-dimensional structure.

(a) For each of the following polymers, give the structure of the monomer(s) and state the *type of reaction* used to produce the polymer.

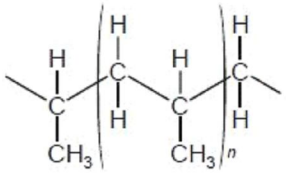
polymer **A**



monomer(s)

type of reaction .....

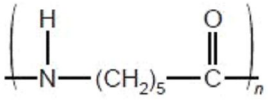
polymer **B**



monomer(s)

type of reaction .....

polymer **C**



monomer(s)

type of reaction .....

[5]

(b) Look at the structures of the three polymers and answer the following questions.

For Examin Use

(i) Suggest why the density of **B** is lower than that of **A**.

.....

.....

(ii) Which polymer will have the weakest forces between chains, and what is the nature of these forces?

.....

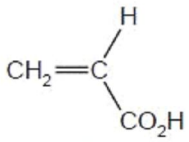
.....

[2]

[Total: 7]

Q34.

5 Super-absorbent polymers have the ability to absorb 200-300 times their own mass of water. They are classified as hydrogels and they are widely used in personal disposable hygiene products such as babies' nappies (diapers).
These polymers are commonly made by the polymerisation of compound **K** mixed with sodium hydroxide in the presence of an initiator.



K

(a) (i) Explain what is meant by the term *polymerisation*.

.....

.....

(ii) What type of polymerisation is involved in the formation of hydrogels?

.....

(iii) Describe the changes in chemical bonding that occur during the polymerisation of **K**.

.....

.....

[3]

(b) *Acrylic acid* is the common name for compound **K**.
Suggest the systematic (chemical) name of **K**.

.....

[1]

(c) **(i)** Draw the structure of at least **two** repeat units of the polymer formed by the above method from acrylic acid, **K**, when mixed with NaOH.

(ii) The C–C–C bond angle in compound **K** changes when the polymer is formed.
State and explain how the C–C–C bond angle differs between a molecule of **K** and the polymer.

angle changes from ..... to .....

explanation .....

.....

[4]

(d) **(i)** Draw a detailed diagram of a portion of the polymer you have drawn in **(c)(i)** to explain how it can absorb a large volume of water.

Ex

(ii) A student added 0.10 g of the polymer to 10 cm^3 of aqueous copper(II) sulfate solution.
Predict, with a reason, what you expect to observe.

.....

.....

[4]

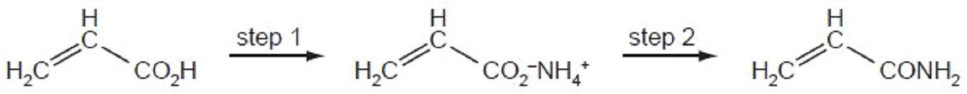
(e) Compound **L**, $CH_2=CHCONH_2$, can also be polymerised to form a super-absorbent polymer.

(i) Name the **two** functional groups in compound **L**.

.....

.....

Compound **K** can be converted into compound **L** by the following two-step route.



K **L**

(ii) Suggest a reagent for step 1.

.....

(iii) What other product is formed in step 2?

.....

(iv) State the reagents and conditions necessary to re-form **K** from **L**.

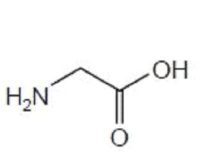
.....

[5]

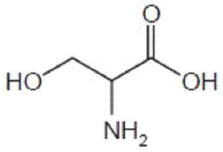
[Total: 17]

Q35.

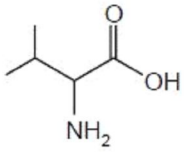
6 **(a)** Protein molecules are formed by the polymerisation of amino acids in the body. The structures of three amino acids are given.



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 .....

[6]

(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.

Fo Exami Us

(i) competitive inhibitors .....

.....

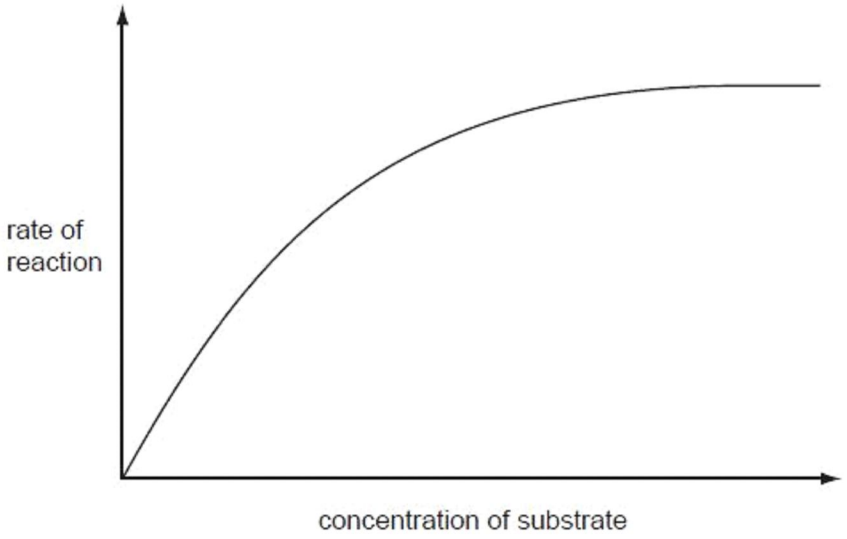
.....

(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.

[4]

[Total: 10]

Q36.

7 **(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.

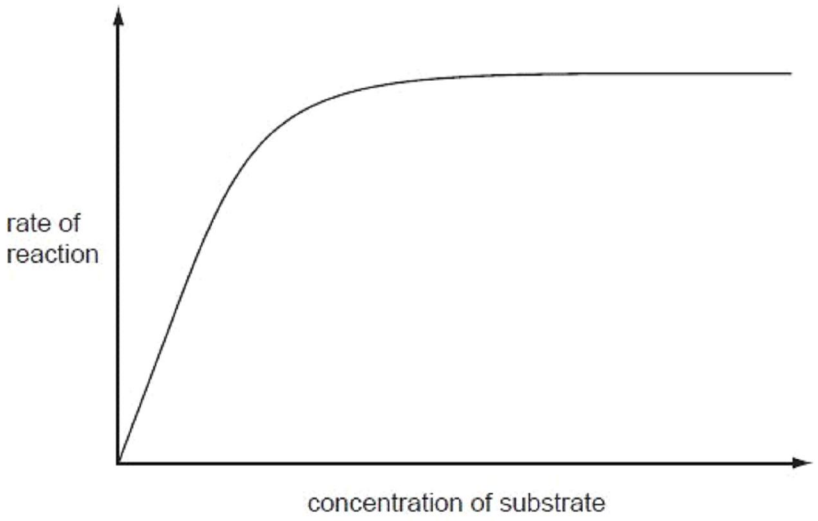
.....

(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.



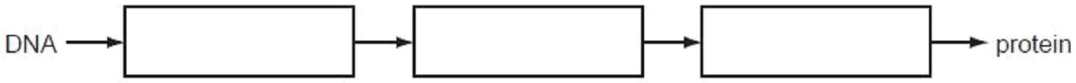
On the same axes, sketch a graph showing the rate of this reaction if a *competitive inhibitor* was present.

[4]

(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.

.....

[3]

(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. .....

[3]

[Total: 10]

Q37.

9 Until 1985, carbon was thought to exist in only two structural forms or *allotropes*. In 1985 another form, buckminsterfullerene, was discovered, in which the carbon exists as spherical molecules.

(a) The other two forms of carbon have very different structures.

(i) Name these two forms.

..... and .....

(ii) Give **three** differences in physical properties between these two forms.

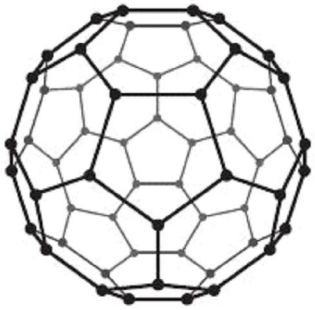
.....

.....

.....

[4]

(b) The diagram shows the structure of buckminsterfullerene.



buckminsterfullerene

The molecule of buckminsterfullerene contains 60 carbon atoms. Suggest a reason why buckminsterfullerene reacts with hydrogen under suitable conditions and give a formula for the product.

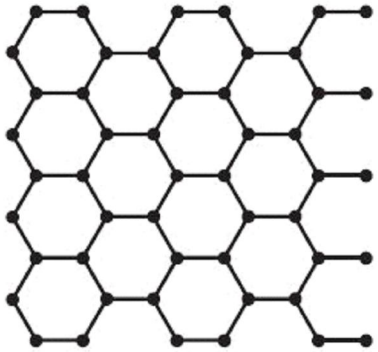
.....

.....

.....

[2]

(c) In 2010, two scientists from the University of Manchester were awarded the Nobel Prize for Physics for their work on graphene, a new structural form of carbon. Graphene is one of the new 'nano-materials' being developed for commercial uses in the next 10 years.



graphene

(i) Graphene is in the form of sheets of carbon one atom thick. Calculate the number of carbon atoms present in a sheet of graphene with a mass of one thousandth of a gram (0.001 g).

The number of hexagons in a large sheet of graphene can be assumed to be one half of the number of carbon atoms. Each hexagon has an area of 690 nm^2.

(ii) Calculate the area of the sheet of graphene in **(i)**.

area of sheet = ... nm^2

(iii) Would you expect samples of graphene and buckminsterfullerene to be electrical conductors? Explain your answers.

graphene .....

.....

buckminsterfullerene .....

.....

[4]

[Total: 10]