Mark scheme: Biological Molecules - Proteins

Question			Answer/Indicative content	Marks	Guidance
1			B	1	
			Total	**1**	
2			C ✓	1 (AO2.1)	**Examiner's Comments** Most candidates were able to correctly spot that C did not have a terminal −COOH group.
			Total	**1**	
3			B ✓	1	
			Total	**1**	
4			**A** ✓	1	**Examiner's Comments** The correct response, A, was selected by many. B was the most common incorrect response. C was also selected by some who recognised the carboxylic acid group on the right hand side of the molecule.
			Total	**1**	
5			C	1 (AO1.1)	
			Total	**1**	
6			D	1 (AO1.1)	
			Total	**1**	
7			A✓	1(AO2.1)	
			Total	**1**	
8			C ✓	1(AO1.1)	
			Total	**1**	
9			D ✓	1 AO 1.2	
			Total	**1**	

10			**C** ✓	1	**Examiner's Comments** This question tested knowledge of molecular structure. Candidates should be aware that carbohydrates and lipids contain only C, H and O. Candidates should also know that insulin is a protein and therefore contains N. ATP being closely related to nucleotides must also contain N as well as P. It appears that many less able candidates became confused by the numbers of letters involved in each row and guessed at the correct response (C).
			Total	**1**	
11			A	1	
			Total	**1**	
12			protein / polypeptide ✓	1	**ALLOW** cysteine **IGNORE** (other named) amino acids
			Total	**1**	
13		i	**Both must be correct for mark** **U** = <u>amino</u> / <u>amine</u> (group) **and** **V** = <u>carboxyl</u> / <u>carboxylic</u> acid (group) ✓ **C**	1	**Additional incorrect answer on either line = 0 marks** **DO NOT ALLOW** imino / amide for **U** **ALLOW** carboxil / spelling that looks and sounds same **DO NOT ALLOW** carbonic / carbonyl for **V** **Examiner's Comments** This recall task was generally well-done but wrong answers included nitrogenous for U.
		ii	**Both must be correct for mark** peptide / amide (bond) **and** <u>condensation</u> (reaction) ✓	1	**Additional incorrect answer on either line = 0 marks** **IGNORE** covalent **DO NOT ALLOW** dipeptide **DO NOT ALLOW** hydrolysis **Examiner's Comments**

					Most candidates were successful in naming the peptide bond and the type of reaction (condensation). Some candidates confused condensation and hydrolysis.
			Total	**2**	
14		i	1. contains non-protein groups ✓ 2. has <u>prosthetic</u> group ✓ 3. (prosthetic group) is , iron / Fe , ion ✓ 4. (prosthetic group) is attached by , covalent bonds / ionic interactions / hydrogen bonds ✓	3 max (AO2.1)	**ALLOW** ions / molecules for groups ALLOW non-polypeptide for non-protein **ALLOW** Fe^{2+} / Fe^{3+} for iron ion **e.g. has non-protein prosthetic group = 2 marks** **<u>Examiner's Comments</u>** Some candidates knew this term and gained two or three marks for this part of the question, others simply described the general structure of a protein, which gained no marks. Many candidates referred to a prosthetic group as inorganic rather than non-protein. There were some misspellings of the word 'prosthetic'. Many candidates refer to 'iron' groups, atoms or molecules, rather than as an ion. **Misconception** A common misconception was the idea that all conjugated proteins have quaternary structure or a haem group.
		ii	1. proteins / contain polypeptide chain(s) ✓ 2. contain , cysteine / sulphur (atoms) ✓ 3. have prosthetic group(s) / are conjugated (proteins) ✓ 4. contain iron ions ✓	2 max (AO2.1)	**Mark as continuous prose** **IGNORE** subunit **IGNORE** ref to structure / amino acids / bonds **ALLOW two** marks for conjugated protein **<u>Examiner's Comments</u>** This part of the question was generally well-answered with many candidates across the ability range gaining both marks for describing similarities between the two molecules. The most common response was

					that both were proteins or contained polypeptides.
		iii	1. haemoglobin , is a larger molecule / has greater molecular mass / has more amino acids ✓ 2. haemoglobin has , quaternary structure / more than one polypeptide chain ✓ 3. haemoglobin has , more than one / four , prosthetic groups / iron ions ✓ 4. haemoglobin contains haem (groups) ✓	2 max (AO2.1)	**Mark as continuous prose** **ALLOW ORA** for rubredoxin **ALLOW** longer polypeptide chain(s) **IGNORE** subunit **ALLOW** rubredoxin , does not have quaternary structure / only has one polypeptide chain **ALLOW** haemoglobin has , four / two alpha and two beta , polypeptide chains **DO NOT ALLOW** haemoglobin has , one / two / three , polypeptide chains **ALLOW** rubredoxin only has one prosthetic group **ALLOW ORA** for rubredoxin **ALLOW** haemoglobin doesn't contain sulphur in its , prosthetic group / haem **Examiner's Comments** As with the similarities in Q20(a)(iii), many candidates could gain marks for the differences between the two molecules. Many correct responses stated that haemoglobin had more than one polypeptide chain and more than one prosthetic group or iron ions.
			Total	**7**	
15	a		**Level 3 (5–6 marks)** Describes differences and similarities of llama and camel haemoglobin at all four levels of protein structure with correct reference to bonding. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Describes differences and similarities of llama and camel haemoglobin in some levels of protein structure with some	6	**Indicative scientific points include:** • difference in primary structure • different amino acid / polypeptide sequence • one amino acid changed. • amino acid change could cause change to secondary structure • initial coiling or folding of polypeptide chain • α-helix • β-pleated sheet

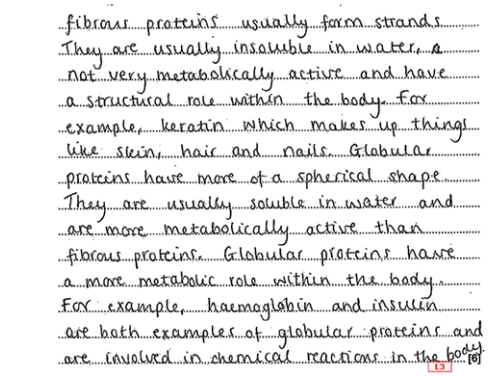
			reference to bonding. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–2 marks)** Describes a difference or similarity of llama and camel haemoglobin at a level of protein structure. *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** No response or no response worthy of credit.		• hydrogen bonding. • amino acid change could cause change to tertiary structure • further coiling of secondary structure • ionic bonding • disulphide bonds • hydrophilic / hydrophobic bonds • 3D shape. • amino acid change has not changed quaternary structure • alpha and beta subunits still able to form haemoglobin in both camel and llama.
	b	i	2.8 (kPa)	1	**ALLOW** answer in the range of 2.8–3.0 kPa
		ii	(llama) haemoglobin needs higher affinity for oxygen (1) (so) can pick up oxygen at lower partial pressure (of oxygen) (1)	2	
	c		insoluble (1) strong / AW (1) unreactive / AW (1)	3	 **IGNORE** flexible.
			Total	**12**	
16		i	Secondary quaternary primary tertiary	**2**	All 4 correct ✓ ✓ 2 or 3 correct ✓ **Examiner's Comments** On the whole this question was well answered by the majority of candidates, with most candidates gaining at least one mark and a high proportion gaining both marks. However confusion over tertiary and quaternary structure was evident. Most candidates realised that the α-helix was part of the secondary structure but some candidates failed to realise that when 2

					different polypeptides chains are involved then the level of structure is quaternary.
		ii	other foods have , same / similar , antigen ✓ *idea that* the antigen is a short sequence of amino acids (so may be common to more than one polypeptide) ✓ variable region / binding site, (of antibody) is not specific (to gliadin antigens) ✓ antibody binds to ,T lymphocyte / mast cell ✓ mast cell releases histamine (causes inflammation) ✓	**2 max**	**DO NOT ACCEPT** active site **ACCEPT** binding site is complementary to, more than one molecule / substances other than gliadins **IGNORE** Antibody can bind to, range of structures / foods **ACCEPT** attaches to **Examiner's Comments** Candidates may have been taught that antibodies are specific to one antigen and as a result they found this question challenging. Whilst there were some good responses, many did not understand the link between cross-reactivity of anti-gliadin antibodies and the same / similar antigens on other foods. A few candidates realised that the antigen must be present on other proteins / foods but failed to mention the term "antigen" so gained no credit; often replacing the term antigen with the term receptor. Some candidates realised that the antibodies produced must not be specific to the gliadin antigen but did not use the terms variable region / binding site in their answers so again scored no marks. Very few candidates achieved mark points 2, 4 and 5 for mentioning that the antigen is a short sequence of amino acids or that antibodies bind to mast cells / T lymphocytes and that mast cells release histamine.
			Total	**4**	
17		i	**1** gene / DNA, copied /	2 max	**Read all and mark as prose** **ALLOW** used as a template to create / AW, for 'copied to'

			transcribed, to (m)RNA ✓ **2** (*idea that* RNA goes to / translation is at) ribosome(s) / RER ✓ **3** DNA, is too large to / cannot / is not able to, leave nucleus / cross nuclear envelope / fit through nuclear pores ✓		**ALLOW** RNA, copies / takes a copy of, gene / DNA **DO NOT ALLOW** replicated for 'copied' **ALLOW ORA** 'RNA, is small enough to / can / is able to' or just 'RNA leaves nucleus' **ALLOW** nuclear membrane for 'nuclear envelope' **DO NOT ALLOW** leave the cell for 'leave nucleus' **Examiner's Comments** As a recall question this was done well, particularly with respect to the sizes of molecules being able or unable to leave the nucleus via nuclear pores, and ribosome being the site of translation. Some candidates confused translation with transcription. **Misconception** Some candidates misuse language in describing transcription. Correct: • DNA is transcribed into mRNA. *(Note passive tense)* • mRNA is a transcript of the DNA. • mRNA is a copy of the DNA. Incorrect: • mRNA transcribes the DNA. *(Active tense)* • mRNA copies the DNA. *(RNA polymerase does this)*. • DNA is converted into mRNA.
		ii	90 252 **or** 90 255 **or** 90 258 ✓ ✓	2	**Correct final answer gets 2 marks**, even if no working is shown. Wrong final answer (which may include a 90 252 stage in the working) = **ALLOW 1 mark for seeing any of these:**

					327 × 92 × 3 **OR** 30 084 **OR** 981 **Examiner's Comments** Most candidates multiplied the number of amino acids in pepsin (327) by the number of times bigger that titin is compared to pepsin (92). These candidates gained 1 mark for arriving at the figure 30 084. Only a minority of candidates understood that the question information was about the number of amino acids in a polypeptide while the question was asking for the number of bases in the equivalent DNA. Some of those who realised the distinction divided by the number of bases that code for one amino acid in error. The correct process was multiplying by 3 due to the logic that every amino acid in a polypeptide is coded for by 3 bases on DNA. Candidates who followed a different route could calculate the number of bases in DNA coding for pepsin and then multiply by 92, or could add 3 or 6 bases to their final answer for a stop and/or start codon.
		iii	For answers marked by levels of response: Read through the whole answer from start to finish, concentrating on features that make it a stronger or weaker answer using the indicative scientific content as guidance. The indicative scientific content indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance. Using a 'best-fit' approach based on the science content of the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, best describes the overall quality of the answer using the guidelines described in the level descriptors in the mark	6 max	*Communication may be via bullet points, a table of comparisons, labelled diagrams or prose.* Indicative scientific points may include the following: FIBROUS PROTEINS **Properties:** • insoluble • elongated / long / rods / filaments / ropes / strands • strong / tough • flexible IGNORE size refs / compact / coiled / bond types / hard Functions: Look for the general category or for a named protein or glycoprotein example with

			scheme. Once the level is located, award the higher or lower mark. **The higher mark** should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in italics) have been met. **The lower mark** should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in italics) are missing. **In summary:** • **The science content determines the level.** • **The communication statement determines the mark within a level.** **Level 3 (5–6 marks)** A detailed comparison of the properties **and** functions of fibrous **and** globular proteins. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** A comparison of the properties **and/or** functions of fibrous **and** globular proteins. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1−2 marks)** A limited comparison of the properties		supporting detail. Related categories and examples are paired or grouped together: • for structure • collagen in, bone / cartilage / connective tissue / tendons / ligaments / skin / blood vessels • fibrin + role described • for protection • keratin in, skin / hair / nails • to give, elasticity / elastic properties • elastin in, (named) blood vessels / alveoli / cartilage • for, contraction / mechanical movement • actin / myosin, in muscle • microtubules in, cilia / flagella / spindle / cytoskeleton GLOBULAR PROTEINS Properties: • soluble • spherical / ball-shaped • have, 3D / tertiary / 3o, shape / structure • specific / complementary (to another molecule) • ref. conjugated / contain prosthetic group • temperature / pH, sensitive • hydrophilic on outside IGNORE size refs, compact, round, bond types Functions: Look for the general functional category name or description, or a named protein or glycoprotein example with some supporting detail. • enzymes / metabolic role / to catalyse reaction(s) / to lower activation energy • named enzyme + its specific role described • hormones / receptors / for cell signalling • named hormone / insulin + role described

			or functions of fibrous **and** globular proteins. *A basic structure and some relevant information is provided, although a clear line of reasoning may not be present. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** No response or no response worthy of credit.		• opsonin / antitoxin / agglutinin + role described • fibrinogen in blood clotting • to transport substances across cell membranes • carrier / channel / pump + role described • to transport substances in blood • haemoglobin + role described e.g. carry oxygen • to, package / organise DNA **Examiner's Comments** Candidates generally had plenty to say and almost all attempted to fulfil the command word compare by making reference to both fibrous and globular proteins. Level 3 answers fully answered the question brief by providing science content covering at least one property of a fibrous protein and one property of a globular protein and at least one function of each type of protein. The word 'property' was confused by some candidates with structure and this resulted in irrelevant material about levels of protein structure and bonding within proteins. Properties may be physical or chemical and relate to aspects like the solubility, strength, flexibility, shape and stability (for example at different temperatures) of molecules. Exemplar 1  fibrous proteins usually form strands. They are usually insoluble in water, a not very metabolically active and have a structural role within the body. For example, keratin which makes up things like skin, hair and nails. Globular proteins have more of a spherical shape. They are usually soluble in water and are more metabolically active than fibrous proteins. Globular proteins have a more metabolic role within the body. For example, haemoglobin and insulin are both examples of globular proteins and are involved in chemical reactions in the body. [6] Exemplar 1 is a level 3 answer that is contained within the line space, answers all aspects of the question and contains an appropriate level of science content. There is a well-developed line of reasoning, a clear

					and logical structure and all the material is relevant and substantiated by fact, so the communication statement for 6 marks is met.
		iv	**EITHER** **1** 9300 / 9700 ✓ **2** deaths year^{-1} or deaths per year or deaths / year ✓ **OR** **3** 9.3 / 9.7 ✓ **4** thousand deaths year $^{-1}$ or thousand deaths per year or thousand deaths / year ✓	2	Correct answer to 2 s.f. **with** correct matching units = **2 marks** **ALLOW** mark for unit even if no or wrong figure given **ALLOW** minus sign with number or 'fewer' with unit **ALLOW** from AIDS / of AIDS in unit **ALLOW** mp 3 so long as the **word thousand** appears afterwards or in the units (even if the unit is wrong in another respect) **DO NOT ALLOW** '*9.3 1000 deaths per year*' for mp3 (but gets mp 4) **Examiner's Comments** Candidates often achieved one of the two marks available but few successfully worked through all the processes involved in arriving at an answer with appropriate units for the rate of decrease over three years. One error was for candidates to calculate not a rate (over time) but a percentage decrease. A breakdown of how to tackle this question is listed in the 'Assessment for Learning' box. This, together with sections from the three tutorial sheets listed under OCR support, could form the basis of a step-by-step worksheet on solving the problem set in this question. Additional questions could be devised using this graph to calculate rates of increase or decrease in the numbers of new diagnoses or those living with an AIDS diagnosis for different time periods. **AfL** 1. Select the dash-dot line for deaths and read to the nearest half-square of the grid where values for 1995 and 1998 intercept the y axis. 2. Check the left-hand y axis label to see that

					these figures represent thousands. 3. Subtract one away from the other to find the difference. 4. Divide this answer by the time between the two values on the x axis, 3 years. 5. Give the answer to two significant figures. 6. Determine the units.  **OCR support** Tutorial sheets and quizzes are available to support the teaching of the skills listed in the specification for Maths for Biology. Three areas cover key skills needed to successfully answer this question: http:/www.ocr.org.uk/qualifications/by-subject/biology-related/maths-for-biology/m3-graphs/ (calculating a rate from a graph with time on the *x* axis) http:/www.ocr.org.uk/qualifications/by-subject/biology-related/maths-for-biology/m0-arithmetic-and-numerical-computation/ (introduction to significant figures) http:/www.ocr.org.uk/qualifications/by-subject/biology-related/maths-for-biology/m0-arithmetic-and-numerical-computation/ (using and choosing units)
		v	*(answers must relate to **data** on graph)* **1** decrease in new diagnoses, from 1992 / already / began before 1995 ✓ **2** peak / plateau, in deaths, from 1994 / already / began before	2 max	**ALLOW** when, saquinavir / drug / medicine, was introduced for '1995' in mps **1**, **2** and **3** **ALLOW** new diagnoses decrease at same time as deaths **ALLOW** from / since / after, 1993 (instead of 1992) **Examiner's Comments** As specified in the question, candidates had to make use of data from the graph in their answer. Ideas from their own knowledge like

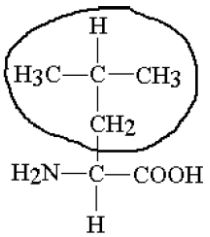
			1995 ✓ **3** no change in / same, (rate of) increase in people living with AIDS, before / after, 1995 ✓		improved education or increased precautions against transmission of HIV did not therefore score. Strong responses did not just look at 1995 to judge whether the introduction of a drug had an effect (pre-supposing that a change would begin from this point), but instead drew conclusions from ongoing trends that pre-dated 1995. These showed that new diagnoses were already falling, deaths had already peaked and the number living with AIDS experienced no change in its rate of increase.
			Total	**14**	
18		i	**1** is long chain (of amino acids) ✓ **2** little / no, tertiary structure ✓ **3** insoluble / has many non-polar amino acids ✓ **4** has, only two different amino acids / only glycine and proline / a small range of amino acids ✓ **5** has a structural function / provides strength (to the artery wall) ✓	3 max (AO2.1)	**ALLOW** long molecule **IGNORE** reference to secondary structure **Note:** 'many' non-polar amino acids must be implied in response **ALLOW** has many, hydrophobic R groups / amino acids **ALLOW** so can withstand pressure of blood
		ii	many, hydrogen bonds (between polypeptides) ✓ many, covalent bonds / crosslinks (between collagen molecules) ✓ polypeptides overlap / polypeptides have staggered ends ✓	1 max (AO2.1)	
			Total	**4**	
19		i	264 / 263.932 / 263.93 / 263.9 (nm^3) ✓ ✓ ✓	3 (AO2.2)	**ALLOW 2 max** for the following if answer is incorrect **1 mark** for $9.04 \times 10^{-4} \times 4500$ **1 mark** for 268 - 4.068

					Examiner's Comments Many candidates coped well with this calculation and gained full marks. There was no requirement to express answers to a number of significant figures, so candidates were credited for a range of answers including those with decimal places. Some candidates made errors in copying the required data from the question and others appeared not to realise that the volume of the sphere had already been calculated for them. There were some errors seen where candidates lacked confidence with using standard form and this is a mathematical skill that possibly still needs practice. **OCR support** The 'Maths for Biology' website offers support on the correct use of standard form: https:/www.ocr.org.uk/subjects/biology/maths-for-biology/arithmetic-and-numerical-computation/
		ii	hydrophobic regions / R groups , on inside (of molecule / protein) **AND** hydrophilic regions / R groups , on outside (of molecule / protein) ✓	1 (AO2.1)	**BOTH required for one mark** **ALLOW** e.g. hydrophobic regions point inwards and hydrophilic regions face outwards **DO NOT ALLOW** hydrophobic tails / hydrophilic heads **Examiner's Comments** The majority of candidates understood the nature of the terms 'hydrophobic' and 'hydrophilic' with regards to molecules. However, many responses included reference to the arrangement of 'heads' and 'tails' in phospholipids rather than the protein molecule, ferritin which could not be credited.
			Total	**4**	
20		i	disulfide ✓	1	
		ii	α-helix ✓	1	**DO NOT ALLOW** a-helix

		iii	quaternary ✓	1	**Examiner's Comments** Knowledge of protein structure was generally good, and most candidates achieved full marks. Marks were lost where candidates had not read the question carefully. In part (a) (i) some candidates wrote 'peptide' as they had not looked at the diagram to see that bond X is not between two adjacent amino acids in the chain. In part (a) (iii) some candidates wrote 'primary' as they had looked at the diagram and could not see the sequence of amino acids.
			Total	**3**	
21		i	***Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.*** ***In summary:*** *Read through the whole answer. (Be prepared to recognise and credit unexpected approaches where they show relevance.)* *Using a 'best-fit' approach based on the science content of the answer, first decide which of the level descriptors,* ***Level 1, Level 2 or Level 3****, best describes the overall quality of the answer.* *Then, award the higher or lower mark within the level, according to the* ***Communication Statement*** *(shown in italics):* o *award the higher mark where the Communication Statement has been met.* o *award the lower mark where aspects of the Communication Statement have been missed.* • ***The science content determines the level.*** • ***The Communication Statement determines the mark***	**6**	**Indicative scientific points may include:** **Genetic code (G)** • DNA base sequence codes for amino acid sequence • reference to mRNA base sequence • triplet code / 3 bases = 1 amino acid • degenerate code • substitution could result in same amino acid **Transcription (C)** • transcription then translation • complementary base pairing • synthesis of mRNA strand • role of RNA polymerase **Translation (L)** • mRNA binds to ribosome • tRNA binds to mRNA • tRNA brings specific amino acid • mRNA translated into polypeptide **Effect of y allele (M)** • substitution / frame-shif • different base sequence of DNA • different mRNA codon • different tRNA anticodon • tRNA brings different amino acid

			within a level. **Level 3 (5–6 marks)** *A reference to the nature of the genetic code **AND** an outline of how alleles are transcribed and translated **AND*** a detailed explanation of why the y allele results in a different primary structure. *There is a well-developed line of reasoning which is clear and logically structured and uses scientific terminology at an appropriate level. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** An outline of some key aspects of transcription and translation **AND** an explanation of why a change in the sequence of bases in a gene causes a change in the primary structure of the polypeptide it codes for. **OR** A detailed explanation of why a change in the sequence of bases in a gene causes a change in the primary structure of the polypeptide it codes for. *There is a line of reasoning presented with some structure and use of appropriate scientific language. The information presented in the most part relevant and supported by some evidence.* **Level 1 (1–2 marks)** A reference to the mechanism of protein synthesis **AND** reference to the effects of a mutation or the nature of the genetic code. **OR** A description of some aspects of the mechanism of protein synthesis. **OR** A description of the nature of the genetic code or the effects of		• different sequence of amino acids • amino acid sequence is primary structure **Examiner's Comments** This level of response question allowed candidates to demonstrate their understanding of the key processes of protein synthesis and the effect of mutation on the polypeptide produced. Most candidates were able to gain some credit but the question discriminated well between candidates of differing ability. Many candidates made errors that prevented them from accessing either the higher marking levels or the communication mark within a level. Examples of this included failure to mention base or amino acid sequences, using bases in the context of amino acids, stating that bases code for the *production* of amino acids and stating that the amino acid sequence *codes for* the primary structure of a protein. The command word 'outline' should have encouraged candidates to give the main features of transcription and translation but many used the entire available writing space to detail every aspect of this process. Many answers described levels of protein structure beyond primary and even explored enzyme action. Although not incorrect, such information was outside the scope of the question and hence often resulted in the award of the lower mark within a level rather than the upper.

			mutation. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*		
		ii	(active) enzyme / protein / product, will still be synthesized even if you only have one Y allele	**1**	**CREDIT** you need 2 y alleles to prevent the (functional) enzyme being synthesized **Examiner's Comments** This question was intended to stretch the thinking of more able candidates and the mark was awarded to only 10% of answers. Many candidates did appear to understand the idea of dominant and recessive alleles but did not express their answer in terms of the proteins that would be synthesized. It was clear that many candidates did not really understand what recessive means; many thought that merely being mutated or less frequent in a population makes an allele recessive.
			Total	**7**	
22			*three from* (paper) chromatography (1) Set, blots / AW, of the two (urine) samples (1) separate / AW, with (aqueous / hydrophilic) solvent (1) (use a) stain / ninhydrin to visualise the spots (1) compare patterns (of separated components / colours) (1)	3	Max 2 marks if chromatography is not mentioned. **IGNORE** further detail of blot placement. The idea of overall pattern is wanted here, not just "compare colours, streaks" etc.
			Total	**3**	
23			*Name* amino acid (1) *Joined by* peptide, bond / link (1) between amine group and carboxyl group (of different amino acid) (1)	3	**ALLOW** amino group

			condensation / water is produced (1)		
			Total	**3**	
24		i	pigment A contains 2, components / molecules (1) pigments B and D contain 1, component / molecule (1) pigment C contains 3, components / molecules (1) *idea that* pigments A and C share 2, components / molecules (1) *idea that* pigments A and D **OR** pigments B and C **OR** pigments C and D share 1, component / molecule (1) all pigments are soluble (in liquid phase) (1)	3	
		ii	0.35 ± 0.01 (1)(1)	2	**ALLOW** 1 mark for evidence of 19 ÷ 55 1 mark maximum for incorrect s.f.
			Total	**5**	
25			A	1	**Examiner's Comments** This was one of the questions that would have advantaged those candidates who had carried out relevant practical work. Many candidates were able to successfully measure the distances and perform the calculation correctly.
			Total	**1**	
26		i	 ✓	**1**	**ACCEPT** any shape or mark that indicates the R group unambiguously **Examiner's Comments** Many candidates correctly identified the R group of leucine on Figure 1.1, although some omitted the CH_2 group above the alpha carbon, or circled the amine or carboxyl group. A surprising number of candidates made no attempt at all.
		ii	solubility / adsorption / interactions with the stationary phase, similar / same / AW ✓	**1 max**	**ACCEPT** leucine *slightly* more soluble / interacts *slightly* less with stationary phase **ACCEPT** both more soluble than Y

			R / functional / residual, groups, similar / AW ✓		**IGNORE** size / charge **Examiner's Comments** Some candidates failed to provide a suitable statement about the chemical properties about leucine and amino acid X, often simply stating that their chemical properties or their R_f values would be similar. However, many candidates appreciated that they would have similar solubilities or R groups, which gained credit.
		iii	a mark shown on the diagram at 1.5 cm from the origin ✓✓✓	**3**	***Correct answer = 3 marks (indicated by 3 ticks on diagram) even if no working shown*** **ACCEPT** a mark in the range 1.4 –1.6 cm **ACCEPT** centre of dot on or within guidelines ***Max 2 for calculation if mark not drawn on the diagram within this range, OR if two dots drawn and second dot incorrect*** Marks for seeing in calculation: *(R_f* of Y =) 2.5 / 5 = 0.5 / *(R_f* of Y =) 25 / 50 = 0.5 ✓ *(R_f* of Z =) 0.5 − 0.2 = 0.3 ✓ **ALLOW ECF** for *R_f value* of Y (Distance moved by Z) = 0.3 x 5 = 1.5 / (Distance moved by Z) = 0.3 x 50 = 15 ✓ **ALLOW ECF** for *R_f value* of Z **Examiner's Comments** Many candidates placed a spot at the correct point on Figure 1.1, gaining full marks. Where the position was incorrect, some were able to score marks for their working. Some mis-measured the distance travelled by amino acid Y and / or the solvent front, but then understood that 0.2 should be subtracted from their calculated R_f value and then multiplied by 5, which gained credit. Others calculated the correct R_f value, subtracted 0.2 but then failed to multiply by 5. A minority of candidates did not take into account the R_f value of Y at all and simply multiplied 0.2 by 5, which gained no credit.
			Total	**5**	

27	a		1 digest / hydrolyse / break down, collagen into amino acids ✓ **and** 2 place, sample / AW, on, chromatography paper / chromatography plate / stationary phase ✓ 3 dry and repeat ✓ 4 place, (chromatography) paper / (chromatography) plate/ stationary phase, in solvent ✓ 5 additional detail ✓ *max 2*	3 max (AO1.2 / 2.7)	**ALLOW** 'collagen' for 'sample' unless mp 1 awarded **DO NOT ALLOW** ethanol or water for solvent but allow Butanol or ethanoic acid EG: Place sample on pencil line Draw pencil line close to end of paper Stop movement before solvent reaches top of paper / plate Use pencil line to mark solvent front Use stain to make amino acids visible Ensure solvent does not reach sample **Examiner's Comments** This question relied on practical experience in describing how to carry out chromatography
	b	i	Rf values 0.23 +/-0.02 and 0.70 +/-0.03 ✓✓ 42/60 = 0.70 14/60 = 0.23	2 (AO2.8)	**ALLOW** 0.21-0.25 and 0.67-0.73 **IGNORE** additional decimal places **Examiner's Comments** This question required candidates to have experienced calculating Rf values. These questions were not well answered by many candidates.
		ii	(Rf value shows amino acids are) glycine and leucine / isoleucine / phenylalanine ✓ Proline low concentration ✓	2 (AO3.2)	**ALLOW** ecf amino acid from incorrect calculation in cii **IGNORE** any response that refers to the chromatogram and does not refer to the table **Examiner's Comments** Many candidates did not use the table provided to accurately identify the amino

					acids for which they had calculated the Rf values.  **AfL** Try providing students with a graph they have not previously seen. Ask them to describe the graph – this can be done as a description exercise in which one student has sight of the graph and another has to draw it from the description given. Students can then be asked to interpret the information provided in the graph and explain the shape of the curve.
			Total	**7**	