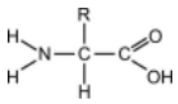
2. Biological Molecules

2.3 Proteins

Paper 2

Marking Scheme

Q1.

(d)(ii)	*all correct (NH_2 or COOH groups on left or right)* ; **A** H_2N  **A** COOH R-group / side chain, is variable **or** different amino acids have different, R-groups / side chains ; AW *this can be annotated on the diagram*	**2**

Q2.

(a)	secondary (structure) ;	**1**

(c)	*any **three** from:* fibrous ; **A** not globular **I** structural insoluble / does not dissolve / does not dissolve easily ; (high proportion of) disulfide bonds / disulfide bridges / covalent bonds (because of cysteines) ; high proportion of / many / AW, hydrogen bonds (between polypeptides) ; high proportion of / many, hydrophobic interactions ; **A** many, amino acids with hydrophobic R-groups / hydrophobic R-Groups tight / close, packing, of, chains / polypeptides / molecules ; **I** triple helix AVP ; e.g. arranged so peptide bonds are not accessible parts of molecule needing to bind to active site not accessible many amino acids with small R-groups / small amino acids **I** details specific to collagen e.g. gly every third amino acid amino acids	**3**

Q3.

(b)(i)	primary ;	**1**
(b)(ii)	*any **one** from:* carboxylic acid / carboxyl, group ; **A** both have C=O contain carbon / hydrogen / oxygen ;	**1**

Q4.

(a)	*any **three** from: accept gly for glycine throughout* glycine every third amino acid ; glycine, is, small / smallest, amino acid ; **A** has H as R-group glycine allows tight coiling of polypeptides to form triple helix ; AW **A** glycine presence allows a, compact / AW, triple helix gly (-NH) can form hydrogen bonds with (C=O in pro of) other polypeptides of triple helix ; **A** *idea that* H bonds can form with other polypeptides in the triple helix AVP ; e.g. pro / ala, also small amino acids (for tight coiling) high proportion of smaller amino acids / amino acids with small side chains **A** high proportion of glycine *if mp1 not given and mp2 is* pro can form hydroxyproline for stability ref. insoluble and (some), amino acids with non-polar R-groups (e.g. ala)	**3**

Q5.

(b)(i)	human antibodies, are made of four polypeptides / contain two light chains **and** two heavy chains ;	**1**

Q6.

(a)(i)	*any **two** from:* spherical / ball shaped ; (water-) soluble ; amino acids with hydrophilic R groups / hydrophilic amino acids, on outside of molecule ; **A** amino acids with hydrophobic R groups in centre of molecule physiological / metabolic, role ; carbonic anhydrase is an enzyme, (enzymes are globular proteins) ;	**2**

Q7.

(e)	*any four from* 1 (formation of), secondary / 2° / second level, structure with, alpha-helix / α-helix / beta-pleated sheet(s) / β-pleated sheet(s) ; **A** β-conformation for β-pleated sheet **I** incorrect detail of bonds 2 folding / coiling, to form tertiary / 3° / third level, structure ; **A** *ref. to* 3D structure as alternative to, folding / coiling **A** secondary structure, folds / coils, to form tertiary structure **R** alpha helix / beta-pleated sheet, coils / folds 3 *two of* hydrogen bonds / ionic or electrostatic bonds / disulfide bonds or bridges / hydrophobic interactions ; **I** peptide bonds *as part of a list that contains two correct bond types* *these must be in context of tertiary structure* 4 (formation of), quaternary / 4° / fourth level structure ; **A** description e.g. polypeptides held together by, interactions / hydrogen bonds / ionic bonds / disulfide bonds **R** if peptide bonds included 5 (globular protein) has hydrophilic, amino acids / R-groups / side chains, to, outside / AW ; **ora** hydrophobic, amino acids / R-groups / side chains, towards centre / AW 6 example of other post-translational modification ; e.g. removal, methionine / met addition sugar group / glycosylation addition phosphate group / phosphorylation addition prosthetic group	**4**

Q8.

(b)(i)	*idea that* (H-bonds) maintain / AW, (shape / structure, form of) α-helices / β-pleated sheets ; **A** allows formation of, α-helices / β-pleated sheets **R** if bonds are between R groups	**1**
(b)(ii)	*any two from* **1** *idea that* hydrogen bonds help to, stabilise / AW, further folding of, amylase / polypeptide / protein ; **2** between, R groups with amine and carboxyl groups ; **A** between R groups with -NH and, -CO / -OH **3** *idea that* may be between amino acids far apart in primary structure ; **4** *either* helps to maintain / form / AW, globular shape / 3D shape / structure (of amylase / polypeptide / protein) ***or*** maintains / forms / AW, (specific) shape / structure, of, active site / binding site ;	**2**

Q9.

(c)	if detail is linked to incorrect level of structure or levels of structure not named, **max 3** **1** primary structure detail ; e.g. sequence of amino acids / ref. to sequence in Fig 3.1 (many) amino acids joined by peptide bonds **2** secondary structure detail ; e.g. has, α / alpha, helices has β / beta, pleated sheets **A** β / beta, pleats has areas of random coils / AW **3** tertiary structure detail ; e.g. interactions between, side chains / R groups (R group interactions are) H bonds, ionic bonds, hydrophobic interactions, disulfide bridges *any two* folding and coiling *in context of polypeptide chain* **4** quaternary structure detail; e.g. three (identical) polypeptide chains ref. to interaction of polypeptide chains **A** polypeptides *for polypeptide chains*	**4**

Q10.

(b)	*any **three** from:* secondary structure ; alpha / α, helix ; *bonding* hydrogen bonding ; further detail ; e.g. between NH and CO of different amino acids four, amino acids / places, ahead hydrogen of the NH and oxygen of the CO	**3**

Q11.

(c)(i)	peptide (bond) ;	**1**
(c)(ii)	*any three from* collagen, structural / fibrous, protein *or* collagen gives strength / flexibility ; glycine / gly, small / smallest, amino acid ; **A** has H as, R-group / side chain glycine / gly, regular / every third amino acid ; (so) triple helix tightly packed / three polypeptides closely associated / AW ; *ref. to* (peptide bond) NH of gly can form hydrogen bond with (peptide bond) C=O of adjacent amino acid (in other polypeptide) ;	**3**

Q12.

(d)	**C** ;	1

Q13.

(b)	each polypeptide shows primary, secondary and tertiary structure ; **A** description of levels of structure both (forms of G6PD / enzyme) composed of more than one polypeptide (so have quaternary structure) ;	2

Q14.

(b)(iii)	*any **four** from:* three polypeptide chains ; (three polypeptides) form triple helix ; **A** coil around each other **R** *ref. to* alpha helix hydrogen bonds hold the three. polypeptides / strands. together ; the three polypeptides, lie close together / form a tight coil / are tightly wound ; every third amino acid (in the polypeptide chain) is glycine / many glycine-proline alanine repeats / many gly-pro-ala repeats ; glycine is found on the inside of each, polypeptide / strand; AVP ; e.g. detail hydrogen bonds, between peptide bond NH (of a glycine) and C=O group in adjacent polypeptide	4

(b)(iv)	*allow reference to collagen fibrils instead of collagen molecules, in correct context (collagen molecules form fibrils, which form fibres)* *any **one** from:* (many) collagen molecules lie parallel ; *no weak points because* strong / covalent, (cross) links between molecules ; (ends of) molecules (in, fibril / fibre), are staggered ;	1

Q15.

(a)(i)	**A** amino / amine group ; **B** carboxyl (group) ; **A** carboxylic acid	2
(a)(ii)	peptide bond joining nitrogen from amine group to carbon of carboxyl group on adjacent amino acid ; C = O and N – H shown correctly in the dipeptide ; formation of water molecule ;	3

Q16.

(a)	*any three from:* *secondary structure* **I** α-helix **1** (many) β-pleated / beta-pleated, sheets ; **R** 'B' **2** random structure / irregular structures / loops / beta turns / AW ; *tertiary structure* **3** folding / coiling, of, (each) polypeptide chain(s) / secondary structure ; **R** *idea of* polypeptide chains interacting (quaternary structure) **4** *ref. to* globular **A** description, e.g. spherical **I** circular / round **or** *ref. to* 3D, shape / structure ; **A** 3D arrangement	**3**

Q17.

(c)	*two from:* (information could be) sequence of amino acids ; **A** idea that a polypeptide/protein has amino acids arranged in an order / AW **I** primary structure / chains of amino acids (different) proteins have, different / specific, sequences (of amino acids) ; (up to) 20 different amino acids in proteins ; **A** approximately 20 *idea that* there is a great variety in protein structure ; **I** have many functions	**2**

Q18.

(a)	**E** – haem / porphyrin (ring) ; **I** iron / iron-containing group **A** conjugated group / prosthetic group **F** – α helix ; **R** a helix **G** – tertiary structure ; **A** 3° structure **H** – primary structure ; **A** 1° structure **J** – quaternary structure / 4° structure / 2α and 2β globins ; **A** polypeptides for globins	**5**

Q19.

(a)(i)	*any three from* haem group containing iron (atom) ; four haem groups (per molecule of haemoglobin) ; each iron (atom) / haem / prosthetic group, binds one oxygen molecule ; **or** four oxygen molecule per haemoglobin molecule ; cooperative binding / allosteric effect described ; AVP ;	**3**
(a)(ii)	*any two from* *ref.* folding of polypeptide chain(s) / globin(s) fold (to give globular structure) ; **A** *ref.* to, tertiary structure / quaternary structure (so) hydrophilic R groups (of amino acids) are on the outside of the molecule / hydrophobic R groups (of amino acids) on the inside of the molecule ; **A** hydrophilic and hydrophobic amino acids hydrogen bonds form with water (molecules) ;	**2**