InkChemistry

ANSWER BOOK

Amino acids, proteins, enzymes and DNA

Aromatic chemistry and amines · Unit C21

AQA 3.3.13.1 to 3.3.13.5 · OCR A 6.2.2

19 questions · 63 marks

NAVY EDITION

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SECTION A · Short, 1 to 2 marks

A1 AAP-Q21

B1 any pH between 6.0 and 9.7, such as pH 8. **B1** at that pH glycine is above its isoelectric point and is negative, moving to the positive electrode, while lysine is below its isoelectric point and is positive, moving to the negative electrode. [2]

A2 AAP-Q23

B1 the trans isomer cannot bind to two neighbouring guanines, so it does not stop cancer cells dividing. **B1** it would still be taken up by cells and add to the side effects, and the dose of the active isomer in a mixture would be uncertain. [2]

SECTION B · Standard, 3 to 5 marks

B1 AAP-Q7

B1 a condensation reaction, forming a peptide link, –CONH–. **B1** the other product is water. **B1** $H_2NCH_2CONHCH(CH_2OH)COOH$, with glycine's carbonyl joined to serine's nitrogen. **B1** $H_2NCH(CH_2OH)CONHCH_2COOH$, with serine's carbonyl joined to glycine's nitrogen. [4]

B2 AAP-Q8

B1 the primary structure is the sequence of amino acids in the polypeptide chain. **B1** the secondary structure is an α-helix or a β-pleated sheet. **B1** the secondary structure is held by hydrogen bonds between the N–H of one peptide link and the C=O of another. **B1** the tertiary structure is the folding of the whole chain, held by hydrogen bonds, ionic bonds and disulfide bridges between side chains. [4]

B3 AAP-Q12

B1 the protein is heated under reflux with 6 mol dm^{-3} hydrochloric acid, which hydrolyses the peptide links. **B1** the mixture is spotted on a TLC plate beside known amino acids, and the plate is stood in a solvent below the spots. **B1** the dried plate is sprayed with ninhydrin or viewed under ultraviolet light to show the colourless spots. **B1** Rf values are calculated and each spot is matched with a known amino acid on the same plate. [4]

B4 AAP-Q15

B1 DNA is a polymer of nucleotides, each made of a phosphate group, 2-deoxyribose and a base. **B1** each strand has a backbone of alternating sugar and phosphate groups, with a base on each sugar. **B1** two strands are held together by hydrogen bonds between bases: adenine with thymine and cytosine with guanine. **B1** the two strands are twisted into a double helix. [4]

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B5 AAP-Q24 **B1** the shape of the active site and the groups lining it are known, so candidate molecules can be fitted into it on screen. **B1** each candidate is scored on how well it fits and the hydrogen bonds or ionic attractions it can make, so only the best are synthesised and tested. **B1** a molecule that binds the active site but does not react blocks the substrate, so the enzyme is inhibited. **B1** the active site is chiral, so only one enantiomer of a chiral drug fits; the other may be inactive or harmful. [4]

B6 AAP-Q2 **B1** optical activity needs a chiral centre, a carbon atom bonded to four different groups. **B1** the central carbon of glycine carries two hydrogen atoms, so it has no chiral centre and no enantiomers. **B1** the central carbon of alanine carries H, CH_3, NH_2 and COOH, four different groups, so alanine has two enantiomers. [3]

B7 AAP-Q3 **B1** at pH 2, $^+H_3NCH(CH_2OH)COOH$, both groups protonated. **B1** at pH 12, $H_2NCH(CH_2OH)COO^-$; ignore ionisation of the side-chain OH. **B1** the pH at which the amino acid exists as a zwitterion with no overall charge. [3]

B8 AAP-Q4 **B1** in alanine the COOH group donates a proton to the NH_2 group, forming the zwitterion $^+H_3NCH(CH_3)COO^-$. **B1** the zwitterions form an ionic lattice with strong attractions between opposite charges, which need a lot of energy to overcome. **B1** butanoic acid molecules are held only by hydrogen bonds and van der Waals forces, which are much weaker. [3]

B9 AAP-Q9 **B1** the SH groups in the side chains of two cysteine residues form a covalent S–S bond. **B1** the bond holds two parts of the chain together, fixing the folded tertiary structure. **B1** a covalent bond is far stronger than a hydrogen bond, so much more energy is needed to break it. [3]

B10 AAP-Q11 **M1** two peptide links form, so two molecules of water are lost. **M1** Mr = 75.0 + 89.0 + 75.0 - 2 × 18.0. **A1** Mr of the tripeptide = 203.0, with no unit. [3]

B11 AAP-Q13 **B1** the enzyme is built from one enantiomer of each amino acid, so its active site is chiral. **B1** only one enantiomer of the substrate has its groups in the positions to bind at the site's binding points. **B1** the other enantiomer does not fit, so it is not converted: the enzyme is stereospecific. [3]

B12 AAP-Q14 **B1** a molecule is designed with a shape similar to the substrate's, so that it binds in the active site. **B1** the molecule does not react, so it blocks the active site and stops the substrate binding. **B1** computer modelling is used to test how candidate molecules fit and bond in the site before they are made. [3]

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B13 AAP-Q16 **B1** only these pairs line up hydrogen bond donors, N–H, opposite acceptors, N or O, at the right distance. **B1** adenine and thymine are joined by two hydrogen bonds. **B1** cytosine and guanine are joined by three hydrogen bonds. [3]

B14 AAP-Q19 **B1** pH 7 is below the isoelectric point, so lysine holds more protons than in its neutral form. **B1** $^{+}H_3N(CH_2)_4CH(NH_3^{+})COO^{-}$, both amine groups protonated and the acid group ionised. **B1** the overall charge is +1. [3]

B15 AAP-Q20 **B1** at pH 6.0 alanine is at its isoelectric point, so it exists as the zwitterion with no overall charge. **B1** a species with no overall charge is not attracted to either electrode, so alanine does not move. **B1** pH 6.0 is above aspartic acid's isoelectric point, so both COOH groups have lost protons, the ion is negative and it is attracted to the positive electrode. [3]

B16 AAP-Q22 **B1** $H_2NCH_2COOH + CH_3CH_2OH \rightleftharpoons H_2NCH_2COOCH_2CH_3 + H_2O$. **B1** heated with a concentrated sulfuric acid catalyst. **B1** in the acid the amine group is protonated, so the ester is present as its salt, $^{+}H_3NCH_2COOCH_2CH_3$. [3]

SECTION C · Long, 6 marks or more

C1 AAP-Q17 **Indicative content** [6]

B1 inside the cell the chloride concentration is low, so the two chloride ligands are replaced, first by water and then by DNA. **B1** the platinum forms coordinate bonds to a nitrogen atom on each of two neighbouring guanine bases on one strand of DNA. **B1** this kinks the DNA so the strands cannot be separated and copied, replication is prevented and the cell cannot divide. **B1** cancer cells divide rapidly, so they are affected most, which is the benefit that makes cisplatin an effective treatment. **B1** it also acts on healthy cells that divide quickly, causing hair loss and sickness, and it damages the kidneys. **B1** the harm is limited by the lowest effective dose given in courses with breaks, and is judged worth the risk against an untreated cancer.

Levels

Level 3 (5–6 marks) both the mechanism and the evaluation are complete: ligand replacement of chloride by water and then by DNA, coordinate bonds to the nitrogen atoms of two guanine bases, the prevention of replication and division, the benefit to rapidly dividing cancer cells, the harm to healthy dividing cells, and a judgement on balance.

Level 2 (3–4 marks) platinum binding to DNA bases and the halt to replication are described with a benefit and a side effect; the ligand substitution, water and then guanine replacing chloride, or the final judgement is not given.

Level 1 (1–2 marks) cisplatin is said to kill cancer cells, often by 'attacking' them or their membranes, with no binding to DNA and no harm to healthy cells weighed.

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