# Section A

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| **A1.** | (a) | M1: H and/or Br can join either C on C=C |
|  | (b) | M2: curly arrow from C=C to H in H-Br, dipole on H-Br (δ+- δ-), curly arrow from H-Br to Br (any 2)  M3: carbocation: CH3CH+CH3  M4: Br-, curly arrow from lone pair on Br to C+, CH3CHBrCH3 (any 2) |
|  | (c) | CH3CH2CH2Br  [5] |
| **A2.** | (a) | M1: curly arrow from C-I to I  M2: carbocation: CH3CH2CH+CH3  M3: curly arrow from lone pair on C in CN- to C+ in C-I |
|  | (b) | M4: S = substitution, CN replaces I, N = nucleophilic, CN- is the nucleophile (any 3)  M5: 1 – first order reaction overall, or zero order wrt CN-  [5] |
| **A3.** | (a) | M1 and M2: curly arrow from lone pair on O in O-H to H+, CH3CH2CH(OH2+)CH3, curly arrow from C1-H to C1-C2 or C3-H to C2-C3, curly arrow from C-O to O-, H+ regenerated (any 4 = 2, any 2 = 1)  M3: if curly arrow from C1-H,orif curly arrow from C3-H |
|  | (b) | Any two of the alkenes shown for M3 not already awarded for M3  [5] |
| **A4.** | (a) | M1: Br2 🡪 2Br  M2: C2H6 + Br 🡪 C2H5 + HBr  M3: C2H5 + Br2 🡪 C2H5Br + Br |
|  | (b) | break Br-Br bond to form Br radical or homolytic fission (award mark for break Br-Br bond if radical shown in (a)) |
|  | (c) | 1,2-dibromoethane or 1,1-dibromoethane or any other C2 molecule with 2 – 6 Br atoms or butane  [5] |
| **A5.** | (a) | M1: Curly arrow from lone pair of O on O-H to C on C-Cl, dipole on C=O (δ+- δ-), curly arrow from C=O to O (any 2)  M2: CH3CCl(O+H2CH3)O-  M3: dipole on C-Cl (δ+- δ-), curly arrow from C-Cl to Cl, curly arrow from H-O to O (any 2) |
|  | (b) | M4: nucleophilic addition-elimination |
|  | (b) | M5: reaction violent or toxic HCl given off  [5] |

# Section B

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| **B1.** | (a) | M1: nucleophilic substitution or SN2 (not SN1)  M2 and M3: curly arrow from lone pair of O on O-H to C in C-Br, dipole on C-Br, curly arrow from C-Br to Br, both curly arrows shown simultaneously (all 3 = 2, any 2 = 1)  M4: CH3CH2CH2CH2OH, Br- dipole on C-Br (δ+- δ-) (any 2) (can award species marks if shown in equation below)  M5: C4H9Br + OH- 🡪 C4H9 OH + Br-  M6: nucleophile  (6) | |
|  | (b) | (i) | M1: (a) is SN2 but (b) is SN1  M2: Br leaves before nucleophilic attack in SN1 but at same time as nucleophilic attack in SN2 |
|  |  | (ii) | M3: SN1 mechanism forms carbocation  M4: tertiary carbocations more stable than primary carbocations |
|  |  | (iii) | M5: Change [OH-] and measure change in rate  M6: changing [OH-] changes rate for SN2 but not SN1  (6) |
|  | (c) | M1: Elimination  M2, M3: curly arrow from lone pair on O in OH- to H on H-C2,curly arrow from H-C2 to C2-C1,curly arrow from C-Br to Br (all 3 = 2, any 2 = 1)  M4: C4H10Br + OH- 🡪 C4H8 + H2O + Br-  M5: base  M6: use ethanol as solvent + either higher temperature or distillation  (6) | |
|  | (d) | (i) | M1: CH3CH2CHBrCH3 |
|  |  | (ii) | M2: Electrophilic addition |
|  |  | (iii) | M3: carbocation more likely on C2 than C1  M4: because secondary carbocations are more stable than primary carbocations  (4) |
|  | (e) | M1: C4H10 + Br2 🡪 C4H9Br + HBr  M2: Br can substitute on any position or Br can substitute more than once  M3: So many other products formed  (3)  Total 25 marks | |

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| **B2.** | (a) | M1: electrophile = electron pair acceptor  M2: substitution = replacement of one atom or group of atoms by another  M3: π-bonds/ring/delocalised system in benzene is an area of high electron density  M4: which can donate a pair of electrons to electrophiles  M5: delocalised system makes benzene stable  M6: addition reactions would disrupt it/substitution reactions preserve it  (6) | |
|  | (b) | (i) | M1: electrophile = C2H5+  M2: C2H5Br + FeBr3 🡪 C2H5+ + FeBr4- |
|  |  | (ii) | M3: Curly arrow from delocalised ring to C of C2H5+  M4:  (crescent should cover 4 or 5 atoms, + not closer to C1 than any other C)  M5: curly arrow from C-H towards ring or +  M6: H+ and C6H5C2H5  M7: ethylbenzene |
|  |  | (iii) | M8: H+ + FeBr4- 🡪 HBr + FeBr3 |
|  |  | (iv) | M9 and M10: C6H4(C2H5)2 with C2H5 on 1,2 or 1,3 or 1,4 or C6H3(C2H5)3 with C2H5 on 1,2,3 or 1,2,4 or 1,3,5 etc (any 2)  (10) |
|  | (c) | (i) | M1: C6H6 + C2H4 🡪 C6H5C2H5 |
|  |  | (ii) | M2: C2H4 + HBr 🡪 C2H5+ + Br- or C2H4 + HBr + FeBr3 🡪 C2H5+ + FeBr4- |
|  |  | (iii) | M3: FeBr3 prevents Br- from attacking the carbocation  M4: Which allows the benzene to attack the carbocation  (4) |
|  | (d) | (i) | M1: C6H5CH2CH2CH3  M2: C6H5CH(CH3)2 |
|  |  | (ii) | M3: C6H5CH(CH3)2  M4: Because the intermediate is a secondary carbocation or because the intermediate producing the minor product is a primary carbocation  M5: Secondary carbocations are more stable than primary carbocations |
|  |  | (iii) | M6: from 1-bromopropane or 1-chloropropane or CH3CH2CH2Cl or CH3CH2CH2Br  (6)  Max 25 marks |

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| **B3.** | (a) | (i) | M1: lone pair on N can be donated  M2: C-Cl bond polar so C in C is δ+ve in chloroalkanes (can award if dipole shown in (ii))  M3: C-Cl bond and/or C=O bond polar so C is δ+ve in acid chlorides (can award if either dipole shown in (iii)) |
|  |  | (ii) | M4: C2H5Cl + NH3 🡪 C2H5NH2 + HCl or C2H5Cl + 2NH3 🡪 C2H5NH2 + NH4Cl  M5 and M6: curly arrow from lone pair on N in NH3 to C in C-Cl AND curly arrow from C-Cl to Cl AND both shown simultaneously (all 3 = 2, any 2 = 1)  M7: C2H5NH3+ and curly arrow from N-H to N |
|  |  | (iii) | M8: CH3COCl + NH3 🡪 CH3CONH2 + HCl or CH3COCl + 2NH3 🡪 CH3CONH2 + NH4Cl  M9: curly arrow from lone pair on N in NH3 to C in C=O AND curly arrow from C=O to O  M10: CH3C(NH3+)ClO-  M11: curly arrow from lone pair on O- to C-O and curly arrow from N-H to N |
|  |  | (iv) | M12: C in ethanoyl chloride more δ+ve because it is attached to two electronegative atoms (ORA) OR C=O π-bond weaker than C-Cl  (12) |
|  | (b) | (i) | C2H5Cl + CH3NH2 🡪 C2H5NHCH3 + HCl or C2H5Cl + 2CH3NH2 🡪 C2H5NHCH3 + 2NH4Cl  M1: balanced equation  M2: correct structure of product |
|  |  | (ii) | M8: CH3COCl + CH3NH2 🡪 CH3CONHCH3 + HCl or CH3COCl + 2CH3NH2 🡪 CH3CONHCH3 + NH4Cl  M1: balanced equation  M2: correct structure of product  (4) |
|  | (c) | (i) | M1 and M2: curly arrow from lone pair on C in CN- to C in C=O, curly arrow from C=O to O, CH3CH2CHCNO-, curly arrow from lone pair on O to H+ (all 4 = 2 marks, any 2 = 1 mark)  M3: dipole on C=O (δ+- δ-), HCN 🡪 H+ + CN-, CH3CH2CH(OH)CN (any 2)  M4: CH3CH2CHO + HCN 🡪 CH3CH2CH(OH)CN |
|  |  | (ii) | M5: below pH 3 dissociation of HCN difficult so insufficient CN- (for step 1)  M6: above pH 5 insufficient H+ (for step 2) |
|  |  | (iii) | M7: HCN very poisonous |
|  |  | (iv) | M8: H-  M9: C3H6O + 2[H] 🡪 C3H8O or C3H6O + H- + H2O 🡪 C3H8O + OH-  (9)  Total 25 marks |

# Section C

**Answer one or two questions from this section.**

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| **C1.** | (a) | (i) | What are aromatic compounds? Give four examples of aromatic compounds. | | |
|  |  | (ii) | State four characteristics of organic compounds. | | |
|  | (b) | Give the IUPAC names of the following compounds: | | | |
|  |  | (i) | | (ii) | (iii) |
|  |  | (iv) | | (v) |  |
|  | (c) | Draw the structures of the following compounds: | | | |
|  |  | (i) | Amylopectin | | |
|  |  | (ii) | Amylose  Total 25 marks | | |

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| **C2.** | (a) | Using an appropriate chemical equation, comment on the following methods of reducing the carbon chain length in aldoses: | |
|  |  | (i) | Wohl’s method |
|  |  | (ii) | Rutt’s method |
|  | (b) | Give the products of the following reactions: | |
|  |  | (i) |  |
|  |  | (ii) | C6H6 + HNO3 🡪 ? + ? |
|  |  | (iii) |  |
|  | (c) | Give the structures of any four heterocyclic compounds.  Total 25 marks | |
| **C3.** | (a) | (i) | What are essential amino acids? |
|  |  | (ii) | Give the structures of the following acids: arginine, phenylalanine, valine, tyrosine, proline. |
|  | (b) | (i) | Give the molecular formulae of the following fatty acids: lauric acid, stearic acid, palmitic acid, oleic acid, linolenic acid, linoleic acid |
|  |  | (ii) | What are osazones? Give the mechanism for the formation of an osazone. |
|  | (c) | Define the following carbohydrates and give two examples of each: | |
|  |  | (i) | Glycosides |
|  |  | (ii) | Polysaccharides |
|  |  | (iii) | Disaccharides |
|  |  | (iv) | Monosaccharides |
|  |  | (v) | Oligosaccharides  Total 25 marks |

## END OF QUESTION PAPER