Past-paper walk-through

Halogen compounds ▪ 31.1

eXercise

Questions in this set

- 9701/41 N25 Q8 ▪ 13 marks
- 9701/44 N25 Q8 ▪ 11 marks

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 8

9701/41 N25 ▪ Q8 ▪ 13 marks

8 **(a)** In the electrophilic substitution of arenes, different substituents can direct to different ring positions.

(i) Describe the directing effect of the $–NO_2$ group. Explain your answer.

Question 8

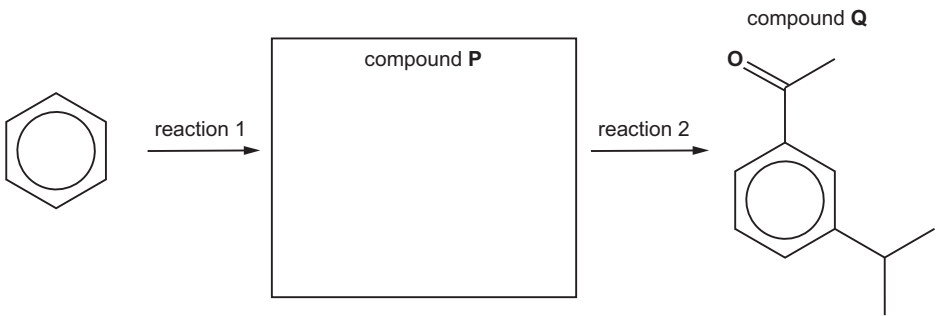
(ii) The nitration of arenes uses a mixture of concentrated HNO_3 and concentrated H_2SO_4 to generate the NO_2^+ electrophile.

Write an equation for the formation of the NO_2^+ electrophile.

Question 8

(b) Carbon-carbon bond formation is an important reaction in organic synthesis.

Fig. 8.1 shows the synthesis of compound **Q** from benzene in two reaction steps.



Question 8

Fig. 8.1

(i) Draw the structure of compound **P** in the box in Fig. 8.1. [1]

(ii) Suggest reagents and conditions for reactions 1 and 2 in Fig. 8.1.

Question 8

Question 8

[2]

(c) Separate samples of C_6H_5Br and $C_6H_5CH_2Br$ are added to warm $AgNO_3(aq)$.

State the expected observations, if any. Explain your answer.

Question 8

Question 8

Question 8

[3]

(d) Acyl bromides, RCOBr, react readily with H_2O.

The mechanism of this reaction is similar to that of the reaction of H_2O with acyl chlorides, RCOC*l*.

(i) Name the mechanism of this reaction.

Question 8

(ii) Complete the mechanism in Fig. 8.2 for the reaction of RCOBr with H_2O.

Include all relevant lone pairs of electrons, curly arrows, charges and dipoles.

Draw the structure of the intermediate.

Question 8

Question 8

Fig. 8.2

[4]

[Total: 13]

Solution 8

(a)(i)

Mark scheme

- NO2 group directs to 3 (and 5) / meta position AND due to being an electron-withdrawing / electronegative group
- 1

Solution 8

(a)(ii)

Mark scheme

- $HNO_3 + H_2SO_4 \rightarrow NO_2^+ + HSO_4^- + H_2O$
- OR $HNO_3 + 2H_2SO_4 \rightarrow NO_2^+ + 2HSO_4^- + H_3O^+$
- 1

Solution 8

(b)(i)

Mark scheme

- 1

(b)(ii)

Mark scheme

- M1: (reaction 1) ethanoyl chloride / CH3COCl AND Al Cl 3
- M2: (reaction 2) 2-bromopropane / (CH3)2CHBr AND FeBr3
- 2

Solution 8

(c) Mark scheme

- M1:
- with C6H5Br
- no change / no precipitate AND
- with C6H5CH2Br
- cream precipitate
- in C6H5Br
- M2: lone pair / p-orbital on Br delocalised / overlaps with ring / π system
- M3: C–Br bond stronger / has partially double bond character

Solution 8

- 3
- 9701/41
- October/November 2025

Solution 8

(d)(i)

Mark scheme

- (nucleophilic) addition–elimination
- 1

Solution 8

(d)(ii) Mark scheme

- M1 M2:
- ▪
- lone pair on O
- ▪
- curly arrow from (lone pair) O (in H2O) to C (of C=O)
- ▪
- correct dipole on C=O
- ▪

Solution 8

- curly arrow from the C=O bond to O atom
- any two [1], all four [2]
- M3: correct intermediate
- M4: curly arrow from (lone pair on) O(–) to C–O bond AND curly arrow from C–Br to Br
- 4

Question 8

9701/44 N25 ▪ Q8 ▪ 11 marks

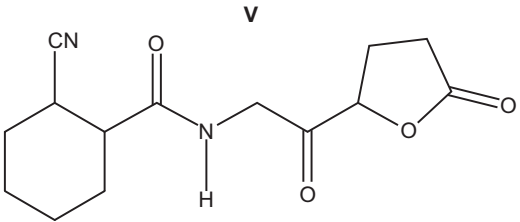
8 **(a)** Describe the difference in reactivity between ethanoyl chloride and chlorobenzene with water.

Explain your answer.

Question 8

(b) The structure of compound **V** is shown.

V



(i) Name all the functional groups in **V**.

Question 8

(ii) Deduce the number of possible optical isomers for **V**.

Question 8

(iii) Suggest **one** reason, other than better biological activity and lower dosage required, why it is beneficial to synthesise a single optical isomer of **V** for use as a drug.

Question 8

(c) A sample of **V** is hydrolysed with an excess of hot aqueous alkali.

The products are isolated from the reaction mixture at pH 12.

Draw the structures of the **two** organic products of the **complete** alkaline hydrolysis of **V** in Fig. 8.1.

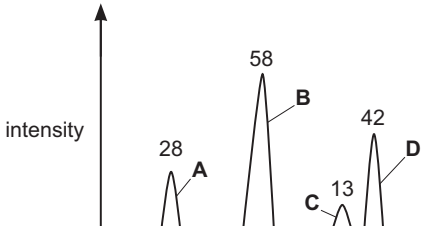
Question 8

Fig. 8.1

[3]

(d) A polypeptide formed from four amino acids, **A**, **B**, **C** and **D**, is completely hydrolysed and then analysed by gas–liquid chromatography.

The chromatogram produced is shown in Fig. 8.2.



Question 8

Question 8

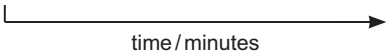


Fig. 8.2

The number above each peak represents the area under the peak.

The area under each peak is proportional to the mass of the respective amino acid in the mixture.

(i) Calculate the percentage by mass of amino acid **A** in the original mixture.

Question 8

(ii) The retention time for amino acid **D** is the longest.

Explain why **D** has a longer retention time than the **other** amino acids **A**, **B** and **C**.

Question 8

[Total: 11]

Important values, constants and standards

molar gas constant	$R = 8.31\,\text{J K}^{-1}\,\text{mol}^{-1}$
Faraday constant	$F = 9.65 \times 10^{4}\,\text{C mol}^{-1}$
Avogadro constant	$L = 6.02 \times 10^{23}\,\text{mol}^{-1}$
electronic charge	$e = -1.60 \times 10^{-19}\,\text{C}$
molar volume of gas	$V_m = 22.4\,\text{dm}^3\,\text{mol}^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0\,\text{dm}^3\,\text{mol}^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14}\,\text{mol}^2\,\text{dm}^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18\,\text{kJ kg}^{-1}\,\text{K}^{-1}$ ($4.18\,\text{J g}^{-1}\,\text{K}^{-1}$)

Question 8

	13	14	15	16	17	18
						2 He helium 4.0
	5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
12	13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium –	85 At astatine –	86 Rn radon –
112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0
98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

Question 8

The Periodic Table of Elements

Group

			1 H hydrogen 1.0			

Key

ımic number
ıic symbol
name
ɪe atomic mass

5	6	7	8	9	10	11
23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5
41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium –	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9
73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0
105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –

59 Pr aseodymium 140.9	60 Nd neodymium 144.2	61 Pm promethium –	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9
91 Pa rotactinium 231.0	92 U uranium 238.0	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –

1	2			
3 **Li** lithium 6.9	4 **Be** beryllium 9.0		ato atom relativ	
11 **Na** sodium 23.0	12 **Mg** magnesium 24.3	3	4	
19 **K** potassium 39.1	20 **Ca** calcium 40.1	21 **Sc** scandium 45.0	22 **Ti** titanium 47.9	
37 **Rb** rubidium 85.5	38 **Sr** strontium 87.6	39 **Y** yttrium 88.9	40 **Zr** zirconium 91.2	
55 **Cs** caesium 132.9	56 **Ba** barium 137.3	57–71 lanthanoids	72 **Hf** hafnium 178.5	
87 **Fr** francium –	88 **Ra** radium –	89–103 actinoids	104 **Rf** rutherfordium –	

lanthanoids	57 **La** lanthanum 138.9	58 **Ce** cerium 140.1	pr
actinoids	89 **Ac** actinium –	90 **Th** thorium 232.0	p

Solution 8

(a) Mark scheme

- ▪
- chlorobenzene is less reactive than ethanoyl chloride
- ▪
- p orbital / lone pair on Cl / –Cl will overlap / delocalise into the ring
- OR C of COCl has most electron deficient OR has an electronegative oxygen atom / two electronegative atoms / electron
- withdrawing C=O group
- ▪

Solution 8

- due to partial double C–Cl bond
- OR C–Cl bond strengthened (more) / stronger bond between Cl and benzene / ring
- OR C–Cl weakened in ROCl
- any two [1], all three [2]
- 2

Solution 8

(b)(i) Mark scheme

- ▪
- nitrile
- ▪
- amide
- ▪
- ketone / carbonyl
- ▪
- ester

Solution 8

- any two [1], all four [2]
- 2

Solution 8

(b)(ii)

Mark scheme

- 8 / eight
- 1

Solution 8

(b)(iii)

Mark scheme

- no need to separate optical isomers
- 1
- 9701/44
- October/November 2025

Solution 8

(c)

Mark scheme

- M1: amide bond hydrolysed and COO– and NH2 formed
- M2: nitrile bond hydrolysed and COO– formed
- M3: ester bond hydrolysed and COO– and OH formed
- 3

Solution 8

(d)(i)

Mark scheme

- percentage $= 100 \times 28 / (28 + 58 + 13 + 42) = 19.9$ (%) min 2sf
- 1

(d)(ii)

Mark scheme

- D is attracted more strongly to the stationary phase / forms stronger intermolecular forces with the stationary phase
- 1