CAMBRIDGE INTERNATIONAL AS & A LEVEL CHEMISTRY · 9701

CHEMISTRY



MARK SCHEME

15 HALOGEN COMPOUNDS

SCORE	PERCENTAGE
/	%

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Paper 1 Multiple Choice Answers: Halogen Compounds

Question	Paper	Q. No.	Answer
877	9701_m22_qp_12	28	A
878	9701_m22_qp_12	30	A
879	9701_m21_qp_12	25	A
880	9701_s21_qp_12	24	C
881	9701_s21_qp_12	25	A
882	9701_s21_qp_13	23	A
883	9701_w21_qp_12	25	D
884	9701_m20_qp_12	21	B
885	9701_s20_qp_11	23	B
886	9701_s20_qp_13	27	B
887	9701_w20_qp_11	23	D
888	9701_w20_qp_11	25	D
889	9701_m19_qp_12	23	C
890	9701_m19_qp_12	24	B
891	9701_s19_qp_11	23	D
892	9701_s19_qp_11	25	D
893	9701_s19_qp_12	25	B
894	9701_s19_qp_13	20	D
895	9701_s19_qp_13	24	C
896	9701_s19_qp_13	25	C
897	9701_w19_qp_11	23	C
898	9701_w19_qp_11	24	B
899	9701_w19_qp_12	23	A
900	9701_m18_qp_12	28	D
901	9701_s18_qp_11	22	A
902	9701_s18_qp_12	23	B
903	9701_s18_qp_12	24	C
904	9701_s18_qp_12	25	D
905	9701_s18_qp_13	23	C
906	9701_s18_qp_13	24	B
907	9701_w18_qp_11	25	B
908	9701_w18_qp_12	23	C
909	9701_w18_qp_12	25	D
910	9701_m17_qp_12	22	A
911	9701_s17_qp_11	26	C
912	9701_s17_qp_12	23	A
913	9701_s17_qp_12	26	B
914	9701_s17_qp_12	29	D
915	9701_w17_qp_12	25	B
916	9701_m16_qp_12	24	D
917	9701_m16_qp_12	25	B
918	9701_s16_qp_11	25	B
919	9701_s16_qp_12	20	B
920	9701_s16_qp_12	24	B
921	9701_s16_qp_13	25	A
922	9701_w16_qp_11	24	D

Paper 1 Multiple Choice Answers: Halogen Compounds (continued)

Question	Paper	Q. No.	Answer
923	9701_w16_qp_12	22	B
924	9701_s15_qp_11	24	D
925	9701_s15_qp_11	25	D
926	9701_s15_qp_11	26	C
927	9701_s15_qp_13	22	D
928	9701_s15_qp_13	26	B
929	9701_s15_qp_13	28	C
930	9701_s15_qp_13	29	A
931	9701_w15_qp_11	24	C
932	9701_w15_qp_12	24	A

118. 9701_s16_ms_23 Q: 3

(a) (i)	vaporise / boil / turn to gas	[1]
(ii)	increasing molecular size / no of carbon atoms per molecule / length of carbon chain	[1]
(iii)	increasing b.pt / decreasing volatility increasing viscosity increasing density increasing depth of colour decreasing flammability / decreasing 'cleanliness' of flame owtte	[1] [1]
(b) (i)	$C_{12}H_{26} \rightarrow 2C_2H_4 + C_8H_{18}$	[1]
(ii)	ethene use = <u>making</u> polythene / plastic / polymers feature of ethene = double bond / unsaturated octane / alkane use = fuel / petrol feature of octane / alkane = flammability / releases energy when burned / combusted	[1] [1] [1] [1]
(c) (i)	(produced by) reaction of (atmospheric) oxygen and nitrogen due to high temperature / engine provides energy / combustion provides energy	[1] [1]
(ii)	$2NO + 2CO \rightarrow N_2 + 2CO_2$ / $NO + CO \rightarrow \frac{1}{2}N_2 + CO_2$	[1]
(iii)	$NO + \frac{1}{2}O_2 \rightarrow NO_2$ $NO_2 + SO_2 \rightarrow SO_3 + NO$ $SO_3 + H_2O \rightarrow H_2SO_4$ / $2H^+ + SO_4^{2-}$ / $H^+ + HSO_4^-$	[1] [1] [1]
(iv)	lowers pH of rivers / lakes / kills fish leaches (toxic) aluminium from soil (into rivers / lakes) leaches away soil nutrients damage to buildings / statues / trees / plants / crops ocean acidification / damage to coral	[1] [1] [1] [1] [1]

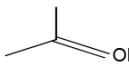
119. 9701_s21_ms_21 Q: 6

Question	Answer	Marks
(a)	addition	**1**
(b)	**M1** *catalyst* = sulfuric acid / phosphoric(V) acid	**1**
	M2 *conditions of reaction* = steam / heat (and pressure)	**1**
(c)	<table><tr><td></td><td>σ</td><td>π</td></tr><tr><td>C_3H_6</td><td>8</td><td>1</td></tr><tr><td>C_3H_8O</td><td>11</td><td>0</td></tr></table>	**2**
(d)(i)	**M1** more stable = $CH_3C^+(H)(CH_3)$ 	**1**
	M2 less stable = $CH_3CH_2C^+(H_2)$ / 	**1**
	M3 greater (positive) inductive effect of two alkyl groups OR greater electron donation of two alkyl groups owtte	**1**
(d)(ii)	propan-2-ol	**1**
(e)(i)	elimination	**1**
(e)(ii)	**M1** NaOH / KOH	**1**
	M2 ethanolic solution / ethanol / alcohol + heat	**1**

120. 9701_w21_ms_21 Q: 2

Question	Answer	Marks
(a)(i)	hydrogen / H_2	1
(a)(ii)	$Ca(NO_3)_2 \rightarrow CaO + 2NO_2 + ½O_2$	1
(a)(iii)	(thermal stability) increases	1
(a)(iv)	$CaCO_3 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2$	1
(b)	reduces acidity of soil	1
(c)(i)	Mixing / overlap / combination of one / an s and one / a p orbital	1
(c)(ii)	*Sketch a diagram to show HOW two sp hybrid orbitals can form a SIGMA bond* **M1**  **M2** 	2
(d)(i)	**M1** moles of $NH_3 = 1.50 \times 10^6 \times 10^6 \div 17 = 8.82 \times 10^{10}$ **M2** mass of $CaCN_2 = \frac{½ \times M1 \times 80.1}{10^6} = 3.53 \times 10^6$	2
(d)(ii)	CH_3CH_2CN / $CH_3CH_2CO_2H$ $CH_3C(OH)(CN)CH_3$	3

121. 9701_s20_ms_22 Q: 4

(a)(i)	Bromine / Br	1
(a)(ii)	$Ag^+(aq) + X^-(aq) \rightarrow AgX(s)$ OR $Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)$	1
(a)(iii)	**M1** *reagent* Add (aqueous) ammonia **M2** *expected result* **EITHER** (Dilute ammonia) – partial amount precipitate dissolves OR not much precipitate dissolves **OR** add concentrated ammonia – precipitate dissolves	2
(b)(i)	$CH_3CH_2CH_2CH_2CH_2Br$	1
(b)(i)	**M1** primary/ 1° (carbo)cation formed is not very stable **M2 EITHER** (as) only one alkyl group exerting an inductive effect **OR** only one alkyl group so the charge is (more) localised on the C+	2
(c)(i)	elimination	1
(c)(ii)	$C_4H_9Cl + NaOH \rightarrow C_4H_8 + NaCl + H_2O$	1
(c)(iii)	 ONLY	1
(c)(iv)	**M1** 2-chloro(-2-)methylpropane **M2** 1-chloro(-2-)methylpropane ALLOW in any order	2

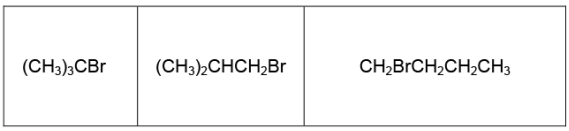
122. 9701_s19_ms_23 Q: 5

(a)(i)	pentanenitrile	1
(a)(ii)	a lone pair / electron pair donor	1
(a)(iii)	(:)CN^- / $^-$(:)CN / cyanide ion	1
(a)(iv)	Br (atom) is replaced (with / by CN / nitrile)	1
(b)	**M1** *reagent* Ammonia **M2** *conditions* heat with under pressure / heat in a sealed tube	2
(c)(i)	**M1** Increasing reactivity from C*l* → Br → I **M2** Due to decreasing strength of C-X bond (from C-C*l* to C-Br to C-I) OR Less energy needed to break C-X (from C-C*l* to C-Br to C-I)	2
(c)(ii)	**M1** tertiary / 3° halogenoalkane **M2** (carbo)cation / intermediate is stable **M3** due to (3) electron releasing/donating methyl groups / + I groups (attached to central C) OR (positive) inductive effect of the (three) methyl groups /	3
(c)(iii)	*Any* **formula / name** for *any* **primary** halogenoalkane i.e. 1-chlorobutane / 1-bromobutane / 1-iodobutane	1

123. 9701_s19_ms_23 Q: 6

(a)(i)	Orange / brown **to** colourless / decolourises	1
(a)(ii)	any non-ambiguous structures of:	
	X $(CH_3)_2C = CH_2$ / $(CH_3)_2CCH_2$	1
	Y $CH_3CH_2CH = CH_2$ / $C_2H_5CHCH_2$	1
	Z $CH_3CH = CHCH_3$ / $CH_3CHCHCH_3$	1
(a)(iii)	C_4H_8	1
(b)(ii)	V = primary / 1° alcohol	1
	W = tertiary / 3° alcohol	1
(b)(ii)	$CH_3(CH_2)_2CH_2OH + Na \rightarrow CH_3(CH_2)_2CH_2ONa + ½ H_2$	1
(b)(iii)	**M1** Reagent $H^+ / Cr_2O_7^{2-}$ **M2** Observations for V orange to green **M3** Observations for W no change / remains orange	3

124. 9701_s18_ms_23 Q: 4

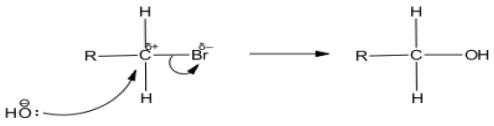
(a)(i)	2-bromobutane	**1**
(a)(ii)	ketone	**1**
(b)	 3 correct = 2 marks 2 correct = 1 mark	**2**
(c)(i)	S = substitution N = nucleophilic	**1**
(c)(ii)	 M1 = dipole and curly arrow M2 = intermediate carbocation IGNORE CH_2CH_3 shown as C_2H_5 M3 = OH^- with lone pair and curly arrow from lone pair to the 'C'	**3**
(d)	• C_4H_9Cl slower (than C_4H_9Br) • C_4H_9I faster (than C_4H_9Br) • C–Cl bond stronger than C–Br OR C–Cl 340 C–Br 280 • C–I bond weaker then C–Br OR C–Br 280 C–I 240 1 mark for each point, max 3	**3**
(e)	ethanolic (instead of aqueous)	**1**
	hotter/higher temperature (heat under) reflux	**1**

125. 9701_w17_ms_21 Q: 3

(a) **6**

reaction	reagent(s) and conditions	reaction type(s)
1	aqueous / aq / dilute NaOH / KOH OR water	substitution OR hydrolysis
2	alcoholic / ethanolic NaOH / KOH	elimination
3	NaCN / KCN in ethanol / alcohol	substitution
4	aqueous /dilute H_2SO_4 / H^+(aq)	hydrolysis OR substitution OR addition-elimination
5	acidified / H^+ (with) $K_2Cr_2O_7$ / $Cr_2O_7^{2-}$ (and distil) NOT reflux	oxidation OR elimination
6	acidified / H^+ $K_2Cr_2O_7$ / $Cr_2O_7^{2-}$ Fehling's / Tollens' / Benedict's (reagent)	oxidation

(b) **2**



M1 lone pair on O of $^-$OH AND curly arrow from lone pair to C(—Br)
M2 correct dipole on $C^{\delta+}$—$Br^{\delta-}$ AND curly arrow from bond to Br

(c)(i)

(different molecules) with same molecular formula / same numbers of atoms (each type) of element	**1**
different structural formulae / displayed formulae	**1**
chain / skeletal functional group position(al) / regioisomerism two types correct = 1 mark, all three correct = 2 marks	**2**

(c)(ii)

S_N / nucleophilic substitution	**1**
$((CH_3)_3CBr$ / tertiary halogenoalkane) forms a stable (carbo)cation / stable intermediate (as charge density on cation is reduced) OR (in) 1-bromobutane / primary halogenoalkane there is no (stable) (carbo)cation / intermediate formed	**1**
(because) there are (3 /more) alkyl / methyl groups AND (+) I / (greater) inductive effect OR (because) there is only one / fewer alkyl / methyl group(s) (compared to reaction with 2-bromo-2-methyl propane / tertiary halogenoalkane) AND limited (+) I / (less) inductive effect	**1**

(d)(i)

(different molecules) with the same (molecular and) structural formula /	**1**
with different arrangements of atoms in space / spatial arrangement of atoms	**1**

(d)(ii)

mirror images are super(im)posable / no chiral carbon / no chiral centre / it is achiral	**1**
(one) C of double bond has identical groups / H (atoms) (attached) OR (one) end of double bond has identical groups / 2 H (atoms) (attached)	**1**

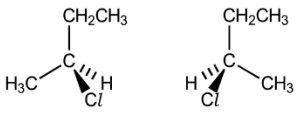
(d)(iii)

X = 2-chlorobutane	**1**
Y = 1-chlorobutane	**1**

(d)(iv)

optical (isomerism)	**1**

(d)(v)

one acceptable 3D structure of 2-chlorobutane	**1**
the 2nd optical isomer EITHER drawn as a mirror image of the first OR the same bond pattern is shown but two of the groups swap positions. 	**1**

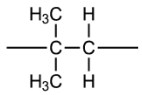
126. 9701_w17_ms_22 Q: 4

<table>
<tr><td>(a)</td><td>
<table>
<tr><td>1</td><td>concentrated H_2SO_4 / H_3PO_4 AND NaBr

OR (red) P / Br_2
OR HBr</td><td>substitution</td></tr>
<tr><td>2</td><td>aqueous / dilute NaOH / KOH</td><td>hydrolysis
OR substitution</td></tr>
<tr><td>3</td><td>concentrated H_2SO_4 / H_3PO_4
OR Al_2O_3 / P_4O_{10} / pumice / porous pot / SiO_2</td><td>dehydration</td></tr>
<tr><td>4</td><td>(ethanolic) HBr</td><td>addition</td></tr>
</table>
4 marks for column 1 (one per row) 1 mark for col 2
</td><td>5</td></tr>
<tr><td>(b)</td><td>

M1
correct dipole on $^{\delta+}C—Br^{\delta-}$ AND curly arrow from C—Br bond to Br

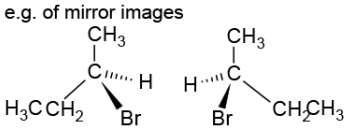
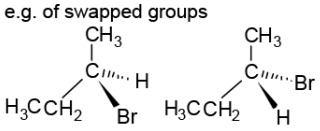
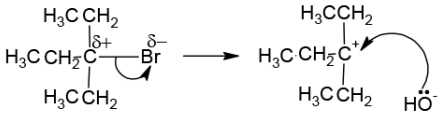
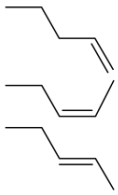
M2 correct intermediate with + charge

M3 curly arrow from lone pair on $\overset{\ominus}{:}OH$ to C^+ of carbocation</td><td>3</td></tr>
<tr><td>(c)(i)</td><td>(different molecules) same molecular formula / same numbers of atoms of each (type of) element</td><td>1</td></tr>
<tr><td></td><td>different structural formulae / displayed formulae</td><td>1</td></tr>
<tr><td></td><td>chain / skeletal
functional group
position(al) / regioisomerism
two types correct = 1 mark, all three correct = 2 marks</td><td>2</td></tr>
<tr><td>(c)(ii)</td><td>S_N / nucleophilic substitution</td><td>1</td></tr>
<tr><td></td><td>no (stable) (carbo)cation / intermediate is formed</td><td>1</td></tr>
<tr><td></td><td>only one alkyl group / fewer alkyl / methyl groups (compared to reaction 2) AND limited (+)I / inductive effect / less electron donating (effect)</td><td>1</td></tr>
<tr><td>(d)(i)</td><td>mirror images are super(im)posable
OR not chiral / no chirality / no chiral/asymmetric carbon/centre / achiral</td><td>1</td></tr>
<tr><td></td><td>one or both C/end of double bond has identical groups / 2 methyl groups / 2 H (atoms)</td><td>1</td></tr>
<tr><td>(d)(ii)</td><td>addition</td><td>1</td></tr>
<tr><td></td><td>

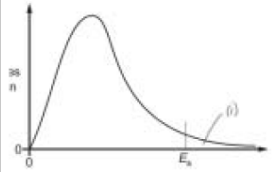
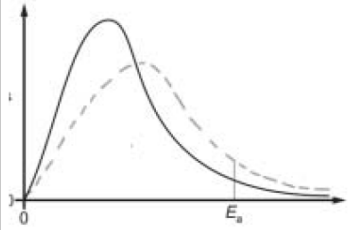
marking points:
• correct number of tetravalent carbon atoms in backbone, with extension bonds
• correct groups on backbone carbon atoms and only one repeat unit</td><td>2</td></tr>
<tr><td>(d)(iii)</td><td>not/non- biodegradable / harmful combustion products</td><td>1</td></tr>
<tr><td>(e)</td><td>2-bromo-2-methylpropane</td><td>1</td></tr>
<tr><td></td><td>1-bromo-2-methylpropane</td><td>1</td></tr>
</table>

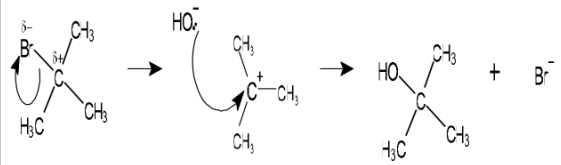
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127. 9701_w16_ms_22 Q: 4

(a)(i)	2–bromobutane	**1**
(a)(ii)	e.g. of mirror images  e.g. of swapped groups 	**1+1**
(a)(iii)	$CH_3CH_2CH_2CH_2Br$ $(CH_3)_2CHCH_2Br$ $(CH_3)_3CBr$	**1** **1** **1**
(b)(i)	3-bromo-3-ethylpentane	**1**
(b)(ii)	 M1 = dipole and curly arrow from bond to (or just beyond) Br M2 = correct carbocation M3 = OH^- with curly arrow from lone pair on O to C(+)	**1** **1** **1**
(b)(iii)	S_N1 / nucleophilic substitution	**1**
(c)(i)	Sodium / potassium hydroxide Ethanol / alcohol **AND** heat	**1** **1**
(c)(ii)	elimination	**1**
(c)(iii)		**1** **1** **1**
	Total:	**17**

128. 9701_s21_ms_22 Q: 3

Question	Answer	Mark
(a)	change in amount of substance with time	1
(b)(i)	label **area** under the original curve to the right of E_a. 	1
(b)(ii)	**M1** *curve starts at the origin but peak lies to the right of original.*	1
	M2 *peak at higher temperature is lower than the original AND graph crosses the original once only – beyond the peak of original* 	1
(b)(iii)	no change / none	1

Question	Answer	Mark
(c)(i)	 **M1** correct dipole on haloalkane AND arrow from bond to Br or just beyond	1
	M2 correct intermediate	1
	M3 arrow from lone pair on O of OH^- / ^-OH to central C of their intermediate shown in M2 OR arrow from lone pair on O of OH^- / ^-OH to central C of 2-bromo 2-methylpropane if S_N2 mechanism shown	1
(c)(ii)	nucleophilic substitution	1
(d)	**M1** more time (because the rate is lower)	1
	M2 C-C*l* (bond) is stronger (than C-Br)	1