

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the October/November 2015 series

9701 CHEMISTRY

9701/21

Paper 2 (AS Structured Questions), maximum raw mark 60

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Page 2	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2015	9701	21

Question	Mark Scheme	Mark	Total
1 (a)	regular arrangement / lattice of cations / positive ions surrounded by delocalised electrons	[1] [1]	[2]
(b) (i)	electrical conductor corrosion resistant low density ductile owtte	[1] [1]	[max2]
(ii)	Giant / lattice	[1]	[1]
(iii)	(electrical) insulator	[1]	[1]
(c) (i)	Simple covalent / covalent molecule Weak intermolecular forces / VdW forces OR little energy needed to break down / overcome intermolecular / VdW forces	[1] [1]	[2]
(ii)	$\begin{array}{r} Al \quad Cl \\ 20.3 \quad 79.7 \\ \hline 27 \quad 35.5 \\ \\ 0.752 \quad 2.25 \\ \hline 0.752 \quad 0.752 \\ \\ 1 \quad 3 \quad AlCl_3 \end{array}$	[1] [1]	[2]

Page 3	Mark Scheme	Syllabus	Paper
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Question	Mark Scheme	Mark	Total
(iii)	$pV = \frac{m}{M_r}RT \quad M_r = \frac{mRT}{pV} = \frac{1.36 \times 8.31 \times 473}{100 \times 10^3 \times 200 \times 10^{-6}} = 267$ OR $pV = nRT \quad n = \frac{pV}{RT} = \frac{100 \times 10^3 \times 200 \times 10^{-6}}{8.31 \times 473} = 5.09 \times 10^{-3}$ $M_r = \frac{1.36}{5.09 \times 10^{-3}} = 267$	[1] [1] [1] [1]	 [2]
(iv)	Al_2Cl_6	[1]	[1]
			[13]
2 (a) (i)	The enthalpy change when one mole of a compound is formed from its element(s)	[1] [1]	[2]
(ii)	$S(s) + 1\frac{1}{2}O_2(g) \rightarrow SO_3(l)$	[1]	[1]
(b) (i)	$944 + (3 \times 436) = 2252$ $6 \times 390 = 2340$ $2252 - 2340 = -88 \text{ (kJ mol}^{-1}\text{)}$	[1] [1] [1]	[3]
(ii)	Fe catalyst 200 atm 400–500 (°)C	[1] [1] [1]	[3]
(iii)	High T increases rate AND Low T improves yield owtte Chosen temp is a compromise High P favours/increases (both rate and) yield owtte pressure chosen limited by cost (of compression and ‘thick walls’)	[1] [1] [1] [1]	[4]

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(c) (i)	$2\text{NH}_3 + \text{H}_3\text{PO}_4 \rightarrow (\text{NH}_4)_2\text{HPO}_4$	[1]	[1]
(ii)	NH_3 identified as base AND H_3PO_4 identified as acid base accepts protons AND acid donates protons	[1] [1]	[2]
(d) (i)	nitrates / fertilisers wash into rivers eutrophication / algal bloom / promote algal growth bacteria use up oxygen in decay process	[1] [1] [1]	[3]
(ii)	(oxides of nitrogen / NO_x / NOs) cause acid rain $2\text{NO}_2 + \text{H}_2\text{O} \rightarrow \text{HNO}_2 + \text{HNO}_3$ OR $4\text{NO}_2 + 2\text{H}_2\text{O} + \text{O}_2 \rightarrow 4\text{HNO}_3$ OR $\text{SO}_2 + \text{NO}_2 \rightarrow \text{SO}_3 + \text{NO}$ AND $\text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4$	[1] [1]	[2]
			[21]
3 (a) (i)	structural isomers: (different molecules with) same molecular formula but different structural formulae chiral: has a carbon / C attached to 4 different groups / atoms / chains OR has no plane / line of symmetry / has non-superimposable mirror images	[1] [1]	[2]
(ii)	$\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{CH}_3$ 3-methylhexane $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$ / $(\text{CH}_3)_2\text{CHCH}(\text{CH}_3)\text{CH}_2\text{CH}_3$ 2,3-dimethylpentane	[1] [1] [1] [1]	[4]
(b) (i)	$\text{C}_7\text{H}_{16} + 11\text{O}_2 \rightarrow 7\text{CO}_2 + 8\text{H}_2\text{O}$	[1]	[1]
(ii)	$\text{C}_7\text{H}_{16} + 4\text{O}_2 \rightarrow 7\text{C} + 8\text{H}_2\text{O}$	[1]	[1]

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Question	Mark Scheme	Mark	Total
(iii)	global dimming / PAN / smog / global warming	[1]	[1]
(c) (i)	(Free) Radical Substitution	[1]	[1]
(ii)	$Cl_2 \rightarrow 2Cl\cdot$ OR $Cl_2 \rightarrow Cl\cdot + Cl\cdot$ $C_7H_{16} + Cl\cdot \rightarrow \cdot C_7H_{15} + HCl$ $\cdot C_7H_{15} + Cl_2 \rightarrow C_7H_{15}Cl + Cl\cdot$ $\cdot C_7H_{15} + Cl\cdot \rightarrow C_7H_{15}Cl$ OR $\cdot C_7H_{15} + \cdot C_7H_{15} \rightarrow C_{14}H_{30}$ Initiation; Propagation; Termination (used correctly)	[1] [1] [1] [1]	[5]
			[15]
4 (a) (i)	$CH_3CH_2OH + HCl \rightarrow CH_3CH_2Cl + H_2O$ or $CH_3CH_2OH + PCl_5 \rightarrow CH_3CH_2Cl + HCl + POCl_3$ or $CH_3CH_2OH + SOCl_2 \rightarrow CH_3CH_2Cl + HCl + SO_2$	[1+1]	[2]
(ii)	NaOH / KOH warm / heat / reflux AND aqueous	[1] [1]	[2]
(b) (i)	$CH_2=CH_2$ / ethane / C_2H_4 / CH_2CH_2	[1]	[1]
(ii)	<u>White</u> ppt / solid / suspension	[1]	[1]
(iii)	$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$	[1]	[1]
(c) (i)	CH_3CHO / ethanal	[1]	[1]

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Question	Mark Scheme	Mark	Total
(ii)	CH ₃ CH ₂ OH higher bpt than CH ₃ CHO ora	[1]	[3]
	due to hydrogen bonding in ethanol/stronger IMFs	[1]	
	prevents further oxidation owtte	[1]	
			[11]

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Question	Mark Scheme					Mark	Total
1 (a)	name of isotope	type of particle	charge	symbol	electron configuration	[5]	[5]
	carbon-13	atom	0	$^{13}_6\text{C}$	$1s^2 2s^2 2p^2$		
	chloride(-37)	anion	1-	Cl^-	$1s^2 2s^2 2p^6 3s^2 3p^6$		
	sulfur-34	atom	0	$^{34}_{16}\text{S}$	$1s^2 2s^2 2p^6 3s^2 3p^4$		
	iron-54	cation	2+	$^{54}_{26}\text{Fe}^{(2+)}$	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$		
(b) (i)	ability / tendency / power of an atom / nucleus to attract / pull electron(s)					[1]	[2]
	in a covalent bond / shared pair of electrons / bonding pair of electrons					[1]	
(ii)	Covalent overlap of orbitals OR shared <u>pair</u> (s) (of electrons)					[1] [1]	[2]
	OR metallic positive ions / cations surrounded by delocalised electrons					[1] [1]	
(iii)	Ionic/electrovalent (electrostatic) Attraction between oppositely charged / +ve and -ve <u>ions</u>					[1] [1]	[2]
(c) (i)	similar strength / amount / number of intermolecular forces / induced dipole / van der Waals' / VdW / London forces / LDF / dispersion forces					[1]	[2]
	therefore similar energy needed					[1]	

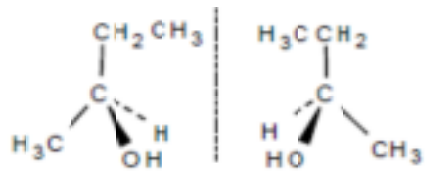
Page 3	Mark Scheme	Syllabus	Paper
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Question	Mark Scheme	Mark	Total
(ii)	M1 HCl polar / has a dipole AND F ₂ non-polar / has no dipole OR (permanent) dipole (-dipole) attractions / forces between HCl (molecules) AND induced dipole (-induced dipole) attractions / forces / LDFs between F ₂ (molecules)	[1]	[2]
	M2 more energy needed for HCl than F ₂ OR pd-pd forces stronger than id-id forces OR IMFs / VdWs in HCl stronger than in F ₂	[1]	
(iii)	Hydrogen bonding (between methanol molecules)	[1]	[2]
	Stronger than IMFs / van der Waals' in other three / is the strongest intermolecular force	[1]	
			[17]
2 (a)	M1 <u>Heat</u> (energy) change (or H _{prod} – H _{react}) measured at constant pressure OR enthalpy change when the amount / moles of reactants as shown in a (reaction) <u>equation</u> react together to give products	[1]	[2]
	M2 measured at standard conditions	[1]	
(b) (i)	q = 2125.53	[1]	[1]
(ii)	amount = 0.025(0)	[1]	[1]
(iii)	–85.(0)	[1]	[1]

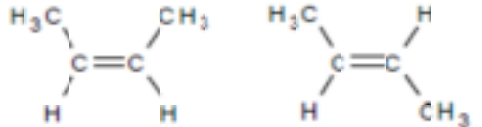
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(iv)	$\begin{array}{ccc} & \text{(MgSO}_4\text{(s)} + 7\text{H}_2\text{O(l)} \rightarrow \text{MgSO}_4 \cdot 7\text{H}_2\text{O(s)} \text{)} & \\ & \swarrow \quad \searrow & \\ -85.0 \text{ (kJ mol}^{-1}\text{)} & & (+)9.60 \text{ (kJ mol}^{-1}\text{)} \\ & \searrow \quad \swarrow & \\ & \text{MgSO}_4\text{(aq)} & \end{array}$	[1]	[1]
(v)	$\begin{aligned} \Delta H + 9.6 &= -85.0 \\ \Delta H &= -85.0 - 9.6 = -94.6 \text{ (kJ mol}^{-1}\text{)} \end{aligned}$	[1]	[1]
			[7]
3 (a) (i)	Na ₂ O or Na ₂ O ₂ ; MgO; P ₄ O ₁₀ or P ₄ O ₆ ; SO ₂	[1] [1]	[2]
(ii)	Na: Yellow / orange / gold flame / white solid / powder / smoke $4\text{Na} + \text{O}_2 \rightarrow 2\text{Na}_2\text{O}$ or $2\text{Na} + \text{O}_2 \rightarrow \text{Na}_2\text{O}_2$ S: Blue flame / (yellow) solid melts / turns red / amber / white fumes $\text{S} + \text{O}_2 \rightarrow \text{SO}_2$	[1] [1] [1] [1]	[4]
(b) (i)	acidic P and S amphoteric Al and basic Na and Mg	[1] [1]	[2]
(ii)	acidic: covalent (bonding) basic: ionic (bonding)	[1] [1]	[2]

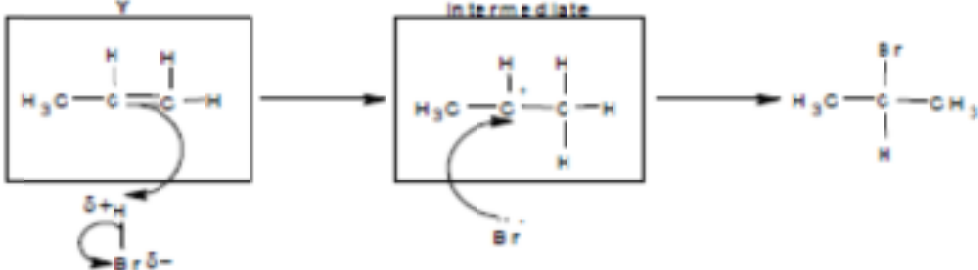
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(iii)	$\text{Al}_2\text{O}_3 + 6\text{HCl} \rightarrow 2\text{AlCl}_3 + 3\text{H}_2\text{O}$ OR $\text{Al}_2\text{O}_3 + 6\text{H}^+ \rightarrow 2\text{Al}^{3+} + 3\text{H}_2\text{O}$ $\text{Al}_2\text{O}_3 + 2\text{NaOH} + 7\text{H}_2\text{O} \rightarrow 2\text{NaAl}(\text{OH})_4(\text{H}_2\text{O})_2$ OR $\text{Al}_2\text{O}_3 + 2\text{NaOH} + 3\text{H}_2\text{O} \rightarrow 2\text{NaAl}(\text{OH})_4$ OR $\text{Al}_2\text{O}_3 + 2\text{NaOH} \rightarrow 2\text{NaAlO}_2 + \text{H}_2\text{O}$ OR $\text{Al}_2\text{O}_3 + 2\text{OH}^- + 7\text{H}_2\text{O} \rightarrow 2[\text{Al}(\text{OH})_4(\text{H}_2\text{O})_2]^-$ OR $\text{Al}_2\text{O}_3 + 2\text{OH}^- + 3\text{H}_2\text{O} \rightarrow 2[\text{Al}(\text{OH})_4]^-$ OR $\text{Al}_2\text{O}_3 + 2\text{OH}^- \rightarrow 2\text{AlO}_2^- + \text{H}_2\text{O}$	[1] [1]	[2]
(c)	sulfur forms $\text{SO}_2/\text{SO}_2 + / \text{mixes } \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3$ or in words OR $\text{SO}_2 + / \text{mixes } \text{H}_2\text{O} (\rightarrow \text{acid}) /$ or in words OR $\text{SO}_2 + / \text{mixes } \text{H}_2\text{O} + (1/2\text{O}_2) \rightarrow \text{H}_2\text{SO}_4$ / or in words	[1] [1]	[2]
			[14]
4 (a) (i)	Nucleophilic Substitution	[1]	[1]
(ii)	Has a chiral centre / carbon OR has a <u>carbon / C</u> attached to 4 different groups / atoms / chains OR has no plane / line of symmetry	[1]	[1]
(iii)		[1+1]	[2]
(iv)	Elimination	[1]	[1]

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(v)	 <i>cis-but-2-ene</i> <i>trans-but-2-ene</i>	[1] [1]	[2]
(vi)	But-1-ene 2 Hs on one of the double-bonded Cs OR does not have 2 different groups on both atoms / each atom in C=C	[1] [1]	[2]
(b) (i)	ammonia / NH ₃	[1]	[1]
(ii)	propanoyl chloride / C ₂ H ₅ COCl	[1]	[1]
(iii)	CH ₃ CH(NHCOC ₂ H ₅)CH ₃	[1]	[1]
(iv)	Reduction LiAlH ₄ / lithium aluminium hydride / lithium tetrahydridoaluminate	(1) [1] [1]	[2]
(v)	aluminium oxide	[1]	[1]

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(vi)	 M1 = correct structure of Y and curly arrow from double bond to H M2 = dipole and curly arrow from H-Br bond to Br M3 = correct intermediate M4 = Br⁻ with lone pair and curly arrow from lone pair to C(+)	 [1] [1] [1] [1]	[4]
(vii)	electrophilic addition	[1]	[1]
(viii)	secondary carbocation more stable than primary due to electron releasing character / (positive) inductive effect of alkyl groups	[1] [1]	[2]
			[22]

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