

MARK SCHEME for the May/June 2014 series

9701 CHEMISTRY

9701/21

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

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

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Page 2	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2014	9701	21

Question	Mark Scheme	Mark	Total
1 (a)	The amount of energy required / energy change / enthalpy change when one electron is removed from each atom / (cat)ion in one mol of gaseous atoms / (cat)ions OR energy change when 1 mole of electrons is removed from one mole of gaseous atoms / ions $X(g) \rightarrow X^+(g) + e^-$ gains 2 marks	1 1 1	3
(b) (i)	Group V / 5 / 15 Big difference between fifth and sixth ionisation energies	1 1	2
(ii)	$1s^2 2s^2 2p^3$ ecf from (b)(i) if period 2	1	1
(c) (i)	(Weighted) mean / average mass of an atom(s) (of an element) Relative to $1/12^{\text{th}}$ of (the mass of an atom of) carbon-12 OR relative to carbon-12 which is (exactly) 12 (units) allow as an expression	1 1	2
(ii)	$\frac{Z}{A_r} \quad \frac{Cl}{35.5} = 1:2$ So $\frac{68.87/35.5}{31.13/A_r} = 2$ $A_r = \frac{2 \times 31.13 \times 35.5}{68.87} = 32.0923 = 32.1 \text{ to } 3\text{s.f.}$ Allow alternative correct methods	1 1	2

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Question	Mark Scheme	Mark	Total
(d) (i)	$\text{NaCl} (+ \text{aq}) \rightarrow \text{Na}^+ + \text{Cl}^-$ $\text{NaCl} + \text{H}_2\text{O} \rightarrow \text{Na}^+ + \text{Cl}^- + \text{H}_2\text{O}$ $\text{SiCl}_4 + 2\text{H}_2\text{O} \rightarrow \text{SiO}_2 + 4\text{HCl}$ $\text{SiCl}_4 + 4\text{H}_2\text{O} \rightarrow \text{Si(OH)}_4 + 4\text{HCl}$ $\text{SiCl}_4 + 4\text{H}_2\text{O} \rightarrow \text{SiO}_2 \cdot 2\text{H}_2\text{O} + 4\text{HCl}$ Allow correct equation with other molar amounts of water	1 1	2
(ii)	NaCl is ionic AND giant/lattice NaCl dissolves/does not react SiCl ₄ is <u>covalent</u> AND molecular/simple SiCl ₄ is hydrolysed/ reacts	1 1 1 1	4
(e)	shape of SF ₆ = Octahedral bond angle = 90°	1 1	2
			18
2 (a) (i)	(The MnO ₄ ⁻ ions cause the Fe ²⁺ ions to) lose electrons owtte/ora	1	1
(ii)	$\text{MnO}_4^-(\text{aq}) + 5\text{Fe}^{2+}(\text{aq}) + 8\text{H}^+(\text{aq}) \rightarrow \text{Mn}^{2+}(\text{aq}) + 5\text{Fe}^{3+}(\text{aq}) + 4\text{H}_2\text{O}(\text{l})$	1+1+1	3
(b) (i)	$\frac{20.0 \times 0.020}{1000} = 4(.00) \times 10^{-4} \text{ (mol)}$	1	1
(ii)	MnO ₄ ⁻ : Fe ²⁺ = 1 : 5 so amount of Fe ²⁺ = 5 × 4.00 × 10 ⁻⁴ = 2(.00) × 10 ⁻³ (mol) ecf from (b)(i)	1	1
(iii)	2.00 × 10 ⁻³ × 250/25 = 0.02(00) (mol) ecf from (b)(ii)	1	1

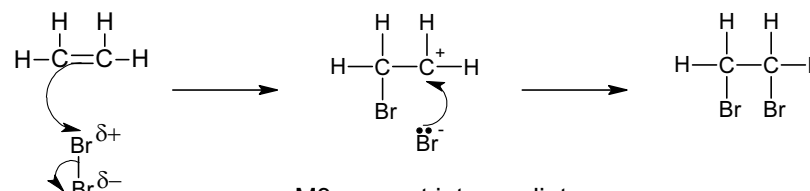
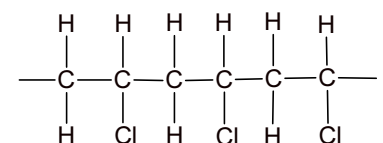
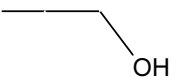
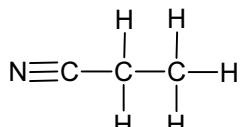
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Question	Mark Scheme	Mark	Total
(iv)	$3.40/0.02 = 170$ ecf from (b)(iii)	1	1
(v)	$170 - 151.8 = 18.2$ $18.2/18 = 1.01$ $x = 1$ ecf from (b)(iv) if appropriate	1	1
			9
3 (a) (i)	K = Cl^- / chloride / F^- / fluoride $H_2SO_4 + 2NaCl \rightarrow Na_2SO_4 + 2HCl$ (or equation with F or K for Cl) OR $H_2SO_4 + NaCl \rightarrow NaHSO_4 + HCl$ (or equation with F or K for Cl) ecf from identity of K so long as halide HK is acidic / HK is a gas / an acidic gas is produced	1 1 1	3
(ii)	L = I^- / iodide colour = yellow ecf from identity of L i.e. Cl^- (white) or Br^- (cream) $Ag^+ + I^- \rightarrow AgI$ (or equation with L) $AgNO_3 + NaI \rightarrow AgI + NaNO_3$ (or equation with L) ecf from identity of L so long as halide	1 1 1	3
(iii)	<u>Br₂/bromine</u> has fewer electrons than iodine / more electrons than chlorine intermolecular/van der Waals' forces (in Br ₂ /M ₂) weaker than in iodine / stronger than in chlorine	1 1	2
(b) (i)	B = chlorine / Cl_2 C = hydrogen / H_2 D = sodium hydroxide / NaOH	1 1 1	3

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Question	Mark Scheme	Mark	Total
(ii)	anode: $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$ cathode: $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$ OR $2\text{H}_2\text{O} + 2\text{e}^- \rightarrow 2\text{OH}^- + \text{H}_2$	1 1	2
			13
4 (a)	decolourisation with an alkene at room conditions / quickly / easily / OR alkane needs higher temp / UV / is slow at room conditions double / π / pi bond / $\text{C}=\text{C}$ present in alkenes	1 1	2
(b) (i)	UV light / sunlight / high temperature	1	1
(ii)	(Free) radical Substitution	1 1	2
(iii)	$\cdot\text{C}_2\text{H}_5 + \cdot\text{C}_2\text{H}_5 \rightarrow \text{C}_4\text{H}_{10}$	1	1
(iv)	$\text{C}_2\text{H}_5\text{Br} + \text{Br}\cdot \rightarrow \cdot\text{C}_2\text{H}_4\text{Br} + \text{HBr}$ OR $\cdot\text{C}_2\text{H}_4\text{Br} + \text{Br}_2 \rightarrow \text{C}_2\text{H}_4\text{Br}_2 + \text{Br}\cdot$	1	1
(c) (i)	Electrophilic Addition	1 1	2

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Question	Mark Scheme	Mark	Total
(ii)	 M1: 2 correct curly arrows M2: correct dipole M3: correct intermediate M4: curly arrow from lone pair on Br⁻ to C⁺		4
(d)	 minimum of three repeat units	2	2
(e) (i)	NaOH/KOH ethanolic/ alcoholic AND heat/ reflux	1 1	2
(ii)		1	1
(iii)	 Propanenitrile/ propanonitrile/ propionitrile/ ethyl cyanide/ cyanoethane	1 1	2
			20

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Question	Answers	Mark	Total
1 (a)	The (total) number of protons and neutrons (in the nucleus of an atom)	1	1
(b) (i)	Mass of an atom(s) or isotope relative to $\frac{1}{12}$ (the mass) of (an atom of) carbon–12 OR relative to carbon–12 which is (exactly) 12 (units) allow a correct expression	1 1	2
(ii)	^{79}Br ^{81}Br $78.92x$ $80.92(100-x)$ where x = % abundance of ^{79}Br so $\frac{78.92x + 80.92(100-x)}{100} = 79.9$ $x = 51$ hence $^{79}\text{Br} : ^{81}\text{Br} = 51 : 49$	1 1 1	3

Page 3	Mark Scheme	Syllabus	Paper
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Question	Answers	Mark	Total
(c)	$\frac{A}{A_r} \quad \frac{Br}{79.9} = 1:3$ $\text{So } \frac{95.69/79.9}{4.31/A_r} = 3$ $A_r = \frac{3 \times 4.31 \times 79.9}{95.69} = 10.796 = 10.8 \text{ to 3 s.f.}$ 3 sig figs allow alternative correct methods	1 1 1	3
(d) (i)	Mg: bright/white light/flame OR white solid/smoke $\text{Mg} + \frac{1}{2} \text{O}_2 \rightarrow \text{MgO}$ allow correct multiples S: blue flame OR white/steamy fumes OR yellow solid disappears $\text{S} + \text{O}_2 \rightarrow \text{SO}_2$ allow correct multiples	1 1 1 1	4
(ii)	$\text{Al}_2\text{O}_3 + 2\text{NaOH} + 7\text{H}_2\text{O} \rightarrow 2\text{NaAl}(\text{OH})_4(\text{H}_2\text{O})_2 \text{ OR}$ $\text{Al}_2\text{O}_3 + 2\text{NaOH} + 3\text{H}_2\text{O} \rightarrow 2\text{NaAl}(\text{OH})_4 \text{ OR}$ $\text{Al}_2\text{O}_3 + 2\text{NaOH} \rightarrow 2\text{NaAlO}_2 + \text{H}_2\text{O} \text{ OR}$ $\text{Al}_2\text{O}_3 + 2\text{OH}^- + 7\text{H}_2\text{O} \rightarrow 2[\text{Al}(\text{OH})_4(\text{H}_2\text{O})_2]^- \text{ OR}$ $\text{Al}_2\text{O}_3 + 2\text{OH}^- + 3\text{H}_2\text{O} \rightarrow 2[\text{Al}(\text{OH})_4]^- \text{ OR}$ $\text{Al}_2\text{O}_3 + 2\text{OH}^- \rightarrow 2\text{AlO}_2^- + \text{H}_2\text{O}$ $\text{Al}_2\text{O}_3 + 6\text{HCl} \rightarrow 2\text{AlCl}_3 + 3\text{H}_2\text{O}$ allow correct ionic equations	1 1	2

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Question	Answers	Mark	Total
(e)	shape of PCl_5 = (trigonal) bipyramid(al) bond angles in PCl_5 = 120° and 90°	1 1	2
			17
2 (a) (i)	(The $C_2O_4^{2-}$ ions) lose electrons owtte/ora	1	1
(ii)	$2MnO_4^-(aq) + 5C_2O_4^{2-}(aq) + 16H^+(aq) \rightarrow 2Mn^{2+}(aq) + 10CO_2(aq) + 8H_2O(l)$	1+1+1	3
(b) (i)	$\frac{20.0 \times 0.100}{1000} = 2(.00) \times 10^{-3} \text{ (mol)}$	1	1
(ii)	$MnO_4^- : C_2O_4^{2-} = 2 : 5$ so amount of $C_2O_4^{2-} = (5/2) \times 2.00 \times 10^{-3} = 5(.00) \times 10^{-3} \text{ (mol)}$ ecf from (b)(i)	1	1
(iii)	$5.00 \times 10^{-3} \times 250/25 = 0.05(0) \text{ (mol)}$ ecf from (b)(ii)	1	1
(iv)	amount = mass / M_r so M_r = mass / amount = $6.30/0.05 = 126$ ecf from (b)(iii)	1	1
(v)	$126 - 90 = 36$ $36/18 = 2.00$ $x = 2$ Ecf from (b)(iv) if suitable	1	1
			9

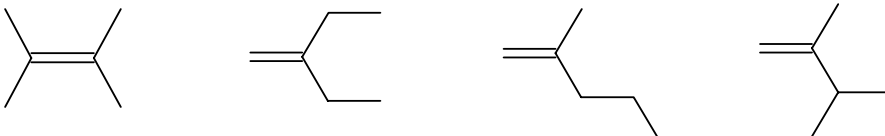
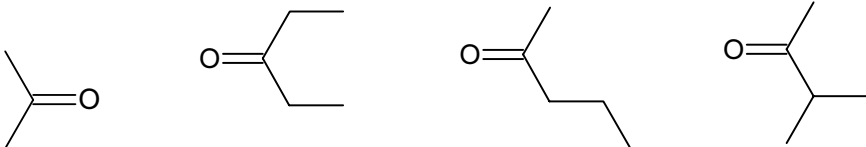
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Question	Answers	Mark	Total
3 (a) (i)	metallic bonding	1	3
	strength of attraction / metallic bonding increases (Na–Al) / more energy is needed to break 'bonds'	1	
	due to increasing cation charge / charge density / increasing number of delocalised electrons / decreasing ionic radius	1	
(ii)	van der Waals' (forces)	1	3
	are greatest / more in sulfur / relative magnitude of forces $S > P > Cl > Ar$	1	
	because sulfur has the greatest number of electrons / as no. of electrons (in the molecules) decreases	1	
(iii)	<u>Covalent</u> bond(s) broken OR (Si has a) giant covalent (structure)	1	1
(b) (i)	Nuclear charge (in Ar) greater (than Cl) AND same shielding owtte	1	1
(ii)	p subshell / orbital in Al at higher energy (than s subshell in Mg) ora OR p subshell / orbital more shielded ora	1	1
(iii)	repulsion due to electron pair (in same / p orbital)	1	1
			10

Page 6	Mark Scheme	Syllabus	Paper
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Question	Answers	Mark	Total
4 (a)	physical: <u>fractional</u> distillation/fractionation	1	2
	chemical: crack(ing) (allow: reforming, isomerisation, thermal decomposition, desulfurisation)	1	
(b) (i)	Strong (C–C and C–H) bonds / high bond energies Non-polar / C and H have similar electronegativities	1 1	2
(ii)	109.5° AND 120° (117° – 122°)	1	1
(iii)	ethane = tetrahedral ethene = trigonal planar	1	1
(iv)	4 × σ /single bonds on Cs in ethane AND 3 × σ and 1 × π on Cs in ethene OR 2 × single and 1 × double on Cs in ethene allow from suitable labelled diagram	1	1
(c) (i)	$Cl_2 \rightarrow 2Cl\cdot$	1	5
	$C_2H_6 + Cl\cdot \rightarrow \cdot C_2H_5 + HCl$	1	
	$\cdot C_2H_5 + Cl_2 \rightarrow C_2H_5Cl + Cl\cdot$	1	
	$\cdot C_2H_5 + Cl\cdot \rightarrow C_2H_5Cl$	1	
	correct alternative terminations allowed		
	initiation, propagation, termination (correctly assigned)	1	
(ii)	$\cdot C_2H_5 + \cdot C_2H_5 \rightarrow C_4H_{10}$	1	1
			13

Page 7	Mark Scheme	Syllabus	Paper
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Question	Answers	Mark	Total
5 (a) (i)	decolourisation of bromine: P is an alkene / contains C=C / is unsaturated hot conc. manganate(VII): breaks C=C OR single product implies P is symmetrical OR single organic product implies terminal =CH₂ as methanal is oxidised to CO₂ 2,4-DNPH confirms >C=O / carbonyl / ketone in Q no reaction with Tollens': Q is not an aldehyde / is a ketone	1 1 1 1	4
(ii)	 (2,3-)dimethylbut-2-ene, 2-ethylbut(-1-)ene, 2-methylpent-1-ene, (2,3-)dimethylbut(-1-)ene	1 1	2
(iii)	 propan(-2-)one / acetone, pentan-3-one, pentan-2-one, 3-methylbutan(-2-)one ecf possible on (a)(ii)	1 1	2
(b)	any 3 of CH₃CH=C(CH₃)C₂H₅ CH₃CH=CHCH₂CH₂CH₃ CH₃CH=CHCH(CH₃)₂ C₂H₅CH=CHC₂H₅	1 1 1 1	max 3
			11

CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level

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1 (a)	the amount of substance containing $6(.02) \times 10^{23}$ (fundamental) particles of that substance (or; the amount of substance containing as many particles as there are atoms in 12 g of carbon-12)	(1)	[1]
(b) (i)	$2\text{NaOH} + \text{CO}_2 \rightarrow \text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$ allow ionic equations or formation of NaHCO_3	(1)	[1]
(ii)	$95 - 75 = 20 \text{ cm}^3$	(1)	[1]
(iii)	excess oxygen = 75 cm^3 so used = 25 cm^3	(1)	[1]
(iv)	$2\text{C}_x\text{H}_y + 5\text{O}_2 \rightarrow 4\text{CO}_2 + z\text{H}_2\text{O}$	(2)	[2]
(v)	$x = 2; y = 2; z = 2$ (or $z = 1$ if $\text{C}_x\text{H}_y + 2.5\text{O}_2 \rightarrow 2\text{CO}_2 + z\text{H}_2\text{O}$)	(1+1+1)	[3]
(c) (i)	W = $(\text{CH}_3)_2\text{C}=\text{CH}_2$ = 2-methylpropene X = $(\text{CH}_3)_2\text{CBrCH}_3$ = 2-bromo-2-methylpropane Y = $(\text{CH}_3)_2\text{CHCH}_2\text{Br}$ = 1-bromo-2-methylpropane Z = $(\text{CH}_3)_3\text{COH}$ = 2-methylpropan-2-ol	(1) (1) (1) (1)	[4]
(ii)	Markovnikov addition / H adds to C with most Hs tertiary carbocation more stable than primary inductive effect of three alkyl groups owtte	(1) (1) (1)	[Max 2]
		Total	15

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2 (a)	$\text{NH}_4^+ + \text{OH}^- \rightarrow \text{NH}_3 + \text{H}_2\text{O}$	(1)	[1]
(b) (i)	Initial acid = $40 \times 0.4 / 1000 = 0.016$ (mol)	(1)	[1]
(ii)	$\frac{25 \times 0.12}{1000} = 3.0 \times 10^{-3}$ (mol) (of OH^- used)	(1)	[1]
(iii)	excess acid = $\text{OH}^- = 0.003$ acid reacted = $0.016 - 0.003 = 0.013$ (mol)	(1)	[1]
(iv)	$\text{NH}_4^+:\text{H}^+ = 1:1$ so = 0.013 (mol NH_4^+)	(1)	[1]
(v)	amount of Cu = mass / $M_r = 0.413 / 63.5 = 6.5 \times 10^{-3}$ (mol) so Cu: $\text{NH}_4 = 0.0065:0.013 = 1:2$ so x = 2	(1) (1)	[2]
(vi)	$M_r = 399.7$	(1)	[1]
		Total	8

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3	(a) (i)	(reaction between atmospheric N ₂ and O ₂) due to lightning / biological processes or bacteria <u>in soil</u> AND in car engines / power stations / metal refining / furnaces	(1)	[1]
	(ii)	2NO ₂ + H ₂ O → HNO ₂ + HNO ₃ OR 2NO ₂ + H ₂ O + 1/2O ₂ → 2HNO ₃ OR 3NO ₂ + H ₂ O → 2HNO ₃ + NO	(1)	[1]
	(iii)	SO ₂ + NO ₂ → SO ₃ + NO	(1)	
		NO + 1/2O ₂ → NO ₂	(1)	
		SO ₃ + H ₂ O → H ₂ SO ₄	(1)	[3]
	(b) (i)	$K_p = p\text{N}_2\text{O}_4 / (p\text{NO}_2)^2$	(1)	[1]
	(ii)	moles of NO ₂ = 0.32	(1)	[1]
	(iii)	x(N ₂ O ₄) = 1.84 / 2.16 = 0.85	(1)	
		x(NO ₂) = 0.32 / 2.16 = 0.15 ecf from (b)(ii)	(1)	[2]
	(iv)	pN ₂ O ₄ = 0.85 × 140 = 119 (kPa)	(1)	
		pNO ₂ = 0.15 × 140 = 21 (kPa) ecf from (b)(iii)	(1)	[2]
	(v)	$K_p = 119 / 21^2 = 0.270 \text{ kPa}^{-1}$ ecf from (b)(i) and (b)(iv)	(2)	[2]
			Total	13

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4	(a) (i)	decreases down the group ora	(1)	[1]
	(ii)	X–X bond strength decreases from Cl–Cl to I–I But decreasing strength of H–X down group more significant	(1) (1)	 [2]
	(b) (i)	$\text{CaCl}_2 + \text{H}_2\text{SO}_4 \rightarrow \text{CaSO}_4 + 2\text{HCl}$ OR $\text{CaCl}_2 + 2\text{H}_2\text{SO}_4 \rightarrow \text{Ca}(\text{HSO}_4)_2 + 2\text{HCl}$	(1)	[1]
	(ii)	HI/I [–] reduces/is oxidised by conc H ₂ SO ₄ /because iodine is produced instead	(1)	[1]
	(iii)	brown gas/fumes produced $2\text{H}_2\text{SO}_4 + 2\text{KBr} \rightarrow \text{SO}_2 + \text{Br}_2 + 2\text{H}_2\text{O} + \text{K}_2\text{SO}_4$ (or ionic)	(1) (1+1)	[3]
	(c) (i)	CH ₃ CH ₂ CH ₂ CH ₂ Br primary	(1)	[4]
		CH ₃ CH ₂ CHBrCH ₃ secondary	(1)	
		(CH ₃) ₂ CHCH ₂ Br primary	(1)	
	(ii)	(CH ₃) ₃ CBr tertiary	(1)	[3]
		2-bromobutane	(1)	
			(1+1)	
(d)		halide ions liberated (by hydrolysis of halogenoalkanes) form precipitate with Ag ⁺ OR $\text{Ag}^+ + \text{X}^- \rightarrow \text{AgX}$	(1)	[2]
		order due to decreasing bond strength (C–I < C–Br < C–Cl)	(1)	

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(e) (i)	nucleophilic substitution	(2)	[2]
(ii)	M1 = curly arrow from lone pair on OH⁻; M2 for curly arrow from C-Br bond to Br AND dipole	(2)	[2]
(f) (i)	inert or volatile owtte	(1)	[1]
(ii)	destroy ozone	(1)	
	(in stratosphere) C-Cl bond broken by UV/free radicals produced	(1)	[2]
		Total	24