

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the May/June 2015 series

9701 CHEMISTRY

9701/21

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

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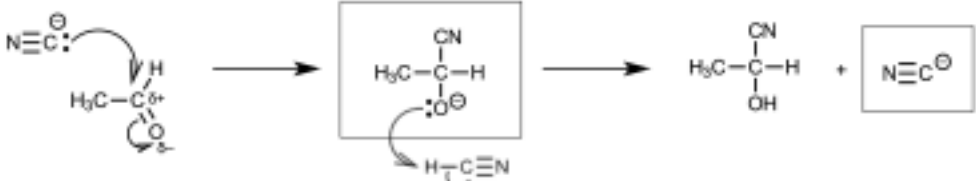
Page 2	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – May/June 2015	9701	21

Question	Mark Scheme	Mark	Total
1 (a)	sub-atomic particle		
	relative mass		
	relative charge		
	neutron	1	0
	electron	1/1836	-1
	proton	1	+1
(b) (i)	RAM = mean / average mass of the isotopes / an atom(s) relative to 1/12 the mass of an atom of ^{12}C / on a scale where an atom of ^{12}C is (exactly) 12 (units) isotope = atoms with the same number of protons / atomic number / proton number with different mass numbers / numbers of neutrons / nucleon number	[1] [1] [1]	[3]
(ii)	$\frac{(0.89 \times 74) + (9.37 \times 76) + (7.63 \times 77) + (23.77 \times 78) + (49.61 \times 80) + (8.73 \times 82)}{100}$ = 79.04 (2 d.p.) AND Se	[1] [1]	[2]
(c) (i)	Te $\frac{47.4}{128}$ $\frac{0.370}{0.370}$ 1 Cl $\frac{52.6}{35.5}$ $\frac{1.48}{0.370}$ 4 so EF = TeCl_4 Empirical Formula Mass = 270 so MF = TeCl_4	[1] [1] [1]	[3]
(c) (ii)	Covalent AND simple / molecular low melting point / reaction with water	[1] [1]	[2]
(iii)	$\text{TeCl}_4 + 3\text{H}_2\text{O} \rightarrow \text{H}_2\text{TeO}_3 + 4\text{HCl}$ OR $\text{TeCl}_4 + 2\text{H}_2\text{O} \rightarrow \text{TeO}_2 + 4\text{HCl}$	[1]	[1]
(d) (i)	Yellow / orange flame White fumes / solid Yellow / green gas disappears	[1] [1] [1]	[max 2]

Page 3	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – May/June 2015	9701	21

Question	Mark Scheme	Mark	Total
(ii)	NaCl giant/lattice AND ionic SiCl₄ simple/molecular AND covalent For NaCl large difference in electronegativity (of sodium/Na and chlorine/Cl/Cl₂) (indicates electron transfer/ions) For SiCl₄ smaller difference (indicates sharing/covalency) with (weak) van der Waals' / IM forces (between molecules) ora	[1] [1] [1] [1]	[4]
			[20]
2 (a) (i)	Straight line drawn horizontally from same intercept	[1]	[1]
(ii)	T ₁ because it shows greatest deviation/furthest from ideal	[1]	[1]
(iii)	reducing T (reduces KE of particles) so intermolecular forces of attraction become more significant	[1]	[1]
(iv)	greatest deviation is at high pressure increasing pressure decreases volume so volume of particles becomes more significant ora	[1] [1]	[2]
(b)	Mass of air = 100 × 0.00118 = 0.118 g Mass of flask = 47.930 – 0.118 = 47.812 g Mass of Y = 47.989 – 47.812 = 0.177 g $pV = nRT = \frac{m}{M_r} RT$ $M_r = \frac{mRT}{pV} = \frac{0.177 \times 8.31 \times 299}{1 \times 10^5 \times 100 \times 10^{-6}}$ = 44.0 (43.979 to 2 or more sf)	[1] [1] [1] [1]	[4]
(c) (i)	strong <u>triple</u> bond	[1]	[1]
(ii)	high temperature (needed for reaction between N ₂ and O ₂)	[1]	[1]
(iii)	2NO + 2CO → N₂ + 2CO₂ OR 2NO + C → N₂ + CO₂	[1]	[1]
(iv)	4NO ₂ + 2H ₂ O + O ₂ → 4HNO ₃	[1]	[1]
(v)	NO + ½O₂ → NO₂ NO₂ + SO₂ → NO + SO₃ OR NO₂ + SO₂ + H₂O → NO + H₂SO₄	[1] [1]	[2]
			[15]

Page 4	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – May/June 2015	9701	21

Question	Mark Scheme	Mark	Total
3 (a)	Bond breaking = C=O = 740 C–H = 410 = 1150 kJ Bond forming = C–C = 350 C–O = 360 O–H = 460 = 1170 kJ Enthalpy change = 1150 – 1170 = –20 kJ mol^{–1}	[1] [1] [1]	 [3]
(b) (i)	Stereoisomerism = (molecules with the same molecular formula and same structural formula but different spatial arrangements of atoms) Chiral centre = atom with four different atoms/groups attached	[1] [1]	 [2]
(ii)	(Planar) carbonyl so (equal chance of nucleophile) attacking either side	[1]	[1]
3 (c) (i)	 M1 = lone pair AND curly arrow from lone pair to carbonyl C M2 = partial charges on C=O AND curly arrow from bond (=) to O^{δ–} M3 = structure of intermediate including charge M4 = lone pair AND two correct curly arrows (from lone pair to H AND from H–C to C) M5 = CN[–]	[1] [1] [1] [1] [1]	 [5]
(ii)	(CN [–] regenerated so) catalyst	[1]	[1]
			[12]

Page 5	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – May/June 2015	9701	21

Question	Mark Scheme	Mark	Total
4 (a)	Diagram illustrating isomerism between four alcohols (A, B, C, D) shown in boxes: - A = <chem>CC(C)(C)O</chem> (tert-butanol) - B = <chem>CC(C)CO</chem> (2-methylpropan-1-ol) - C = <chem>CCCCO</chem> (butan-1-ol) - D = <chem>CC(C)CO</chem> (2-methylpropan-1-ol) Isomerism relationships: - A and B: chain isomerism - C and D: chain isomerism - A and C: position isomerism - B and D: position isomerism - OR: A and B: chain OR position isomerism - C and D: chain isomerism	[1] [1] [1] [1] [1] [1] [1]	[7]
(b) (i)	but-1-ene / 1-butene but-2-ene / 2-butene	[1] [1]	[2]
(ii)	but-2-ene AND two different groups on each carbon (of C=C) double bond means no free rotation	[1] [1]	[2]
(iii)	and (either way round)	[1+1]	[2]
			[13]

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	Cambridge International AS/A Level – May/June 2015	9701	22

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1 (a)	name of particle		
	relative mass		
	relative charge		
	proton	1	+1
	electron	1/1836	-1
	neutron	1	0
(b) (i)	Mass of an atom(s)	[1]	
	relative to $1/12^{\text{th}}$ (the mass) of (an atom of) carbon-12 OR relative to carbon-12 which is (exactly) 12	[1]	[2]
(ii)	% of third isotope = 10	[1]	
	$\frac{(24 \times 79) + (26 \times 11.0) + 10x}{100} = 24.3$	[1]	
	$10x = 248$		
	$x = 24.8$ (3s.f.)	[1]	[3]
(c) (i)	anode $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$	[1]	
	cathode $\text{Mg}^{2+} + 2\text{e}^- \rightarrow \text{Mg}$	[1]	[2]
(ii)	Mg		
	O		
	H		
	Cl		
	31.65	20.84	1.31
	24.3	16	1
			35.5
	1.30	1.30	1.31
	1.30	1.30	1.30 = 1:1:1:1
	MgOHCl	[1]	[2]
(d) (i)	Na_2O basic/alkaline; Al_2O_3 amphoteric/acidic and basic; SO_3 acidic	[1]	
	Na_2O (giant) ionic AND SO_3 (simple/molecular) covalent	[1]	[2]
(ii)	$\text{Na}_2\text{O} + 2\text{HCl} \rightarrow 2\text{NaCl} + \text{H}_2\text{O}$	[1]	
	$\text{Al}_2\text{O}_3 + 6\text{HCl} \rightarrow 2\text{AlCl}_3 + 3\text{H}_2\text{O}$	[1]	
	$\text{Al}_2\text{O}_3 + 2\text{NaOH} + 7\text{H}_2\text{O} \rightarrow 2\text{NaAl}(\text{OH})_4(\text{H}_2\text{O})_2$ OR	[1]	
	$\text{Al}_2\text{O}_3 + 2\text{NaOH} + 3\text{H}_2\text{O} \rightarrow 2\text{NaAl}(\text{OH})_4$ 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		
	$\text{Al}_2\text{O}_3 + 2\text{OH}^- \rightarrow 2\text{AlO}_2^- + \text{H}_2\text{O}$		
	$\text{SO}_3 + \text{NaOH} \rightarrow \text{NaHSO}_4$ OR		
	$\text{SO}_3 + 2\text{NaOH} \rightarrow \text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$	[1]	[4]

Page 3	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – May/June 2015	9701	22

Question	Mark Scheme	Mark	Total
			[18]
2 (a) (i)	$2\text{PbS} + 3\text{O}_2 \rightarrow 2\text{PbO} + 2\text{SO}_2$ reagents and formulae balancing	[1] [1]	[2]
(ii)	S (is oxidised) –2 to (+)4 O (is reduced) 0 to –2	[1] [1]	[2]
(b) (i)	T = 400 – 600 °C (chosen as a compromise because) High T increases rate ora High T decreases yield / moves eqm left / makes less SO ₃ as forward reaction exothermic ora	[1] [1] [1]	[3]
(ii)	High pressure increases rate as collision frequency increases ora High pressure moves eqm right / favours forward reaction as more moles on left ora Uneconomic to use high pressures / high yield at low pressure	[1] [1] [1]	[3]
(c) (i)	Reaction (too) exothermic / acid spray produced	[1]	[1]
(ii)	$\text{SO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{H}_2\text{S}_2\text{O}_7$ $\text{H}_2\text{S}_2\text{O}_7 + \text{H}_2\text{O} \rightarrow 2\text{H}_2\text{SO}_4$	[1] [1]	[2]
(d)	Preservative owtte antimicrobial / antioxidant / reducing agent	[1] [1]	[2]
(e) (i)	$12.35 \times 0.01 / 1000 = 1.235 \times 10^{-4}$	[1]	[1]
(ii)	$1.235 \times 10^{-4} \times 1000 / 50 = 2.47 \times 10^{-3}$	[1]	[1]
(iii)	$2.47 \times 10^{-3} \times 64.1 = 0.158327 \text{ g} = 158 \text{ (3 sf only)}$	[1]	[1]
			[18]
3 (a) (i)	Bond breaking = $\text{Cl-Cl} = 242$ $\text{C-H} = 410 = 652 \text{ kJ}$ Bond forming = $\text{C-Cl} = 340$ $\text{H-Cl} = 431 = 771 \text{ kJ}$ Enthalpy change = $652 - 771 = -119$	[1] [1] [1]	[3]
(ii)	UV / High T / sunlight	[1]	[1]

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	Cambridge International AS/A Level – May/June 2015	9701	22

Question	Mark Scheme	Mark	Total
(iii)	Initiation $\text{Cl}_2 \rightarrow 2\text{Cl}\cdot$ Propagation $\text{C}_2\text{H}_6 + \text{Cl}\cdot \rightarrow \cdot\text{C}_2\text{H}_5 + \text{HCl}$ $\cdot\text{C}_2\text{H}_5 + \text{Cl}_2 \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{Cl}\cdot$ Termination $\cdot\text{C}_2\text{H}_5 + \cdot\text{C}_2\text{H}_5 \rightarrow \text{C}_4\text{H}_{10}$ All three names correctly assigned	[1] [1] [1] [1] [1]	[5]
(b) (i)	ethene	[1]	[1]
(ii)	KOH/NaOH ethanolic AND heat/reflux	[1] [1]	[2]
(iii)	H_2 AND Pt or Ni (catalyst)	[1]	[1]
			[13]
4 (a) (i)	A = $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CHO}$ B = $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CHO}$ C = $(\text{CH}_3)_2\text{CHCH}_2\text{CHO}$ D = $(\text{CH}_3)_3\text{CCHO}$	[1] [1] [1] [1]	[4]
(ii)		[1+1]	[2]
(b) (i)	Fehling's/Benedict's OR Tollens' OR dichromate OR manganate Warm/heat Fehling's/Benedict's =(Brick)-red ppt Tollens' = silver/mirror OR grey/black precipitate Dichromate = orange to green Manganate = purple to colourless	[1] [1] [1]	[3]
(ii)	(2,4-)DNP(H)/Brady's reagent Orange/yellow/red-orange/yellow-orange ppt	[1] [1]	[2]
			[11]

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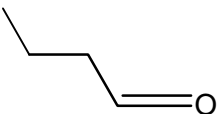
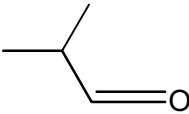
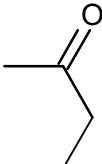
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Question	Mark Scheme	Mark	Total
1 (a)	$(1s^2)2s^22p^6$	[1]	[1]
(b) (i)	The amount of energy required/energy change when one electron is removed from each atom in one mol of gaseous atoms	[1] [1] [1]	[3]
(ii)	Greater nuclear charge/number of protons Same shielding/number of shells/energy level	[1] [1]	[2]
(c) (i)	mean/average mass of the isotopes/an atom(s) relative to 1/12 of the mass of an atom of ^{12}C /on a scale where an atom of ^{12}C is (exactly) 12	[1] [1]	[2]
(ii)	$20.2 = \frac{(20 \times 90.48) + (21 \times 0.27) + (9.25y)}{100}$ $\frac{2020 - 1815.27}{9.25} = 22.133$ $y = 22$	[1] [1]	[2]
(d) (i)	$pV = \frac{mRT}{M_r}$ $M_r = \frac{mRT}{pV} = \frac{0.275 \times 8.31 \times 298}{100 \times 10^3 \times 200 \times 10^{-6}}$ $M_r = 34.05/34.1$	[1] [1]	[2]
(ii)	(Let % Ne = x so % Ar = 100-x) $\frac{20.2x + 39.9(100 - x)}{100} = 34.05$ % Ne = 29.7	[1] [1]	[1]
1 (e) (i)	Van der Waal's/London/dispersion Uneven electron distribution/temporary dipole Induced dipole-dipole attraction	[1] [1] [1]	[3]
(ii)	more electrons more polarisable/greater attraction/stronger IMFs	[1] [1]	[2]
			[18]

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	Cambridge International AS/A Level – May/June 2015	9701	23

Question	Mark Scheme	Mark	Total
2	(a) (i) Reactivity increases down the group OR reference to observations that indicate trend Outer electrons lost more easily down group Due to increased distance/shielding of outer electrons from nucleus	[1] [1] [1]	[3]
	(ii) $\text{Mg} + 2\text{H}_2\text{O} \rightarrow \text{Mg}(\text{OH})_2 + \text{H}_2$	[1]	[1]
	(iii) Magnesium hydroxide sparingly soluble/insoluble	[1]	[1]
	(iv) $\text{Mg} + \text{H}_2\text{O} \rightarrow \text{MgO} + \text{H}_2$	[1]	[1]
	(b) (i) $\text{MgO} + 2\text{HNO}_3 \rightarrow \text{Mg}(\text{NO}_3)_2 + \text{H}_2\text{O}$	[1]	[1]
	(ii) (thermal stability) increases down the group	[1]	[1]
	(iii) $2\text{Mg}(\text{NO}_3)_2 \rightarrow 2\text{MgO} + 4\text{NO}_2 + \text{O}_2$	[1]	[1]
	(iv) N from (+)5 to (+)3 O from -2 to 0 N is reduced and O is oxidised	[1] [1] [1]	[3]
	(c) (Very) strong electrostatic attraction/ionic bond High charge (density) of cation and anion/ Mg^{2+} and O^{2-}	[1] [1]	[2]
	(d) (i) $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$ $\text{CaO} + \text{H}_2\text{O} \rightarrow \text{Ca}(\text{OH})_2$	[1] [1]	[2]
	(ii) $2\text{H}^+ + \text{CO}_3^{2-} \rightarrow \text{CO}_2 + \text{H}_2\text{O}$	[1]	[1]
	(iii) $1 \times 10^{-4} \times 8000 = 0.8 \text{ mol H}^+$ $\frac{0.8}{2} \times 100.1 = \text{mass CaCO}_3 = 40 \text{ g}$	[1] [1]	[2]
			[19]
3	(a) (i) A/B =   C = 	[1] [1] [1]	[3]
	(ii) Chain	[1]	[1]
	(iii) Silver mirror/ppt/solid (black/grey)	[1]	[1]

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	Cambridge International AS/A Level – May/June 2015	9701	23

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(b) (i)	D $\text{CH}_2=\text{C}(\text{CH}_3)\text{CH}_2\text{OH}$	[1]	
	E $\begin{array}{c} \text{H}_3\text{C} \quad \text{H} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{H} \quad \text{CH}_2\text{OH} \end{array}$ trans OR <i>E</i>	[1+1]	
	E $\begin{array}{c} \text{H}_3\text{C} \quad \text{CH}_2\text{OH} \\ \diagdown \quad \diagup \\ \text{C}=\text{C} \\ \diagup \quad \diagdown \\ \text{H} \quad \text{H} \end{array}$ cis OR <i>Z</i>	[1]	
	F $\text{H}_2\text{C}=\text{CHCH}_2\text{CH}_2\text{OH}$	[1]	
(ii)	Hydrogen	[1]	[5]
(c) (i)	$\text{C}_3\text{H}_6\text{O} + [\text{O}] \rightarrow \text{C}_3\text{H}_6\text{O}_2$	[1]	[1]
(ii)	$\text{C}_3\text{H}_6\text{O} + 2[\text{H}] \rightarrow \text{C}_3\text{H}_8\text{O}$	[1]	[1]
			[13]
4 (a) (i)	$\begin{array}{c} \text{H}_3\text{C} \quad \text{CH}_2\text{OH} \\ \quad \\ \text{H}_3\text{C}-\text{C}-\text{C}-\text{CH}_3 \\ \quad \\ \text{HO} \quad \text{OH} \end{array}$	[1]	[1]
(ii)	$\begin{array}{c} \text{CH}_3 \\ \\ \text{H}_3\text{C}-\text{C}=\text{O} \end{array}$	[1]	
	$\begin{array}{c} \text{COOH} \\ \\ \text{O}=\text{C} \\ \\ \text{CH}_3 \end{array}$	[1]	

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(b) (i)	M1 = 2 curly arrows M2 = intermediate ion M3 = Br with -ve charge, lone pair and curly arrow to C+	[1] [1] [1]	[3]
(ii)	dipole is <u>induced</u> by proximity to C=C	[1]	[1]
(iii)	Optical	[1]	[1]
(iv)		[1+1]	[2]
			[10]