
CHEMISTRY

9701/21

Paper 2 AS Structured Questions

October/November 2016

MARK SCHEME

Maximum Mark: 60

Published

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Page 2	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9701	21

Question	Answer	Marks	
1(a)	6×10^{-3} (mol)	1	1
1(b)	$\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$	1	1
1(c)	6×10^{-3} (mol)	1	1
1(d)	4×10^{-3} (mol)	1	1
1(e)	4×10^{-3} (mol)	1	1
1(f)	1×10^{-3} (mol)	1	1
1(g)	170	1	1
1(h)	28(.0) Si/silicon	1 1	2
	Total:		9

Page 3	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks
2(a)(i)	Enthalpy/energy/heat change when one mole of a substance Burns/combusts/reacts in excess oxygen OR Completely burns/combusts/reacts in oxygen under standard conditions	1 3 1 1
2(a)(ii)	$\text{C}_2\text{H}_5\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O}$	1 1
2(b)(i)	6813.4/6813/6810/6800 (J)	1 1
2(b)(ii)	-1362.68/-1362.7/-1363/-1360/-1400 (kJ)	1 1
2(b)(iii)	Any 2 from: heat/energy losses (to air and/or to the container/surroundings) incomplete combustion (volatile) ethanol evaporated ethanol is impure not all energy is lost as heat	1 2 1
2(c)(i)	$3\text{C(s)} + 4\text{H}_2\text{(g)} + \frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{C}_3\text{H}_7\text{OH(l)}$ $3(-393.5)$ $\swarrow$ $4 \times (-285.8)$ $\swarrow$ -2021.0 $\swarrow$ $3\text{CO}_2 + 4\text{H}_2\text{O}$	1+1 3 1

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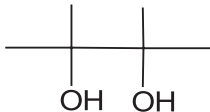
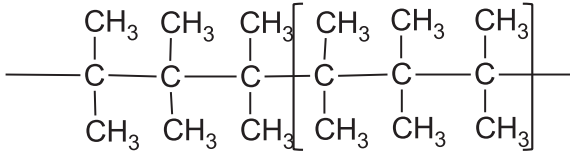
Question	Answer	Marks
2(c)(ii)	$\Delta H_f + (-2021.0) = 3(-393.5) + 4(-285.8)$ $\Delta H_f = -302.7 \text{ (kJ mol}^{-1}\text{)}$	1 2 1
	Total:	13

Question	Answer	Marks
3(a)(i)	(Atoms/ ions become larger as) the number of (electron) shells increases (down the group) Increased distance of (outer) electrons (from the nucleus) OR Increased shielding results in weaker (nuclear) attraction / pull	1 2 1
3(a)(ii)	top line / dotted line is atomic radii / bottom line / line with crosses is ionic radii (as atoms bigger than ions) Atom has one more shell (than corresponding ion) (ora) OR Atom loses two electrons / outer (shell) electrons / valency electrons (ora) OR Atom loses electrons and so (nuclear) attraction is stronger OR Nuclear charge in ion is greater than the electron(ic) charge (ora) OR Effective nuclear charge in ion is greater (ora)	1 2 1
3(b)(i)	Nitrate / Nitrate(V) / NO_3^-	1 1
3(b)(ii)	Ba / barium OR Sr / Strontium $\text{Ba}^{2+} + \text{SO}_4^{2-} \rightarrow \text{BaSO}_4$ OR $\text{Sr}^{2+} + \text{SO}_4^{2-} \rightarrow \text{SrSO}_4$	1 1

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Question	Answer	Marks	
3(b)(iii)	Ba(NO ₃) ₂ OR Sr(NO ₃) ₂ 2Ba(NO ₃) ₂ → 2BaO + 4NO ₂ + O ₂ OR 2Sr(NO ₃) ₂ → 2SrO + 4NO ₂ + O ₂	1 1	2
3(c)(i)	H ⁺ + OH ⁻ → H ₂ O OR Ca(OH) ₂ + 2H ⁺ → Ca ²⁺ + 2H ₂ O 2H ⁺ + CO ₃ ²⁻ → CO ₂ + H ₂ O OR CaCO ₃ + 2H ⁺ → Ca ²⁺ + CO ₂ + H ₂ O OR H ⁺ + CO ₃ ²⁻ → HCO ₃ ⁻ OR CaCO ₃ + H ⁺ → Ca ²⁺ + HCO ₃ ⁻	1 1	2
3(c)(ii)	Calcium carbonate is insoluble /less soluble (ora) Calcium carbonate is less likely to be / won't get washed away (ora) OR Calcium carbonate lasts longer (ora) OR Calcium carbonate is less reactive / reacts more slowly (ora)	1 1	2
3(d)	Mg(OH) ₂ MgO	1 1	2
	Total:		14

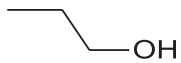
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Question	Answer	Marks	
4(a)(i)	4-methylhex-2-ene	1	1
4(a)(ii)	(Molecules with the) same structural formula (and same molecular formula) with different arrangement of atoms/groups (in space)	1	1
4(a)(iii)	4 double-bond / alkene (2) different groups on each double-bonded carbon (one) chiral carbon (centre) / (one) carbon atom has 4 different groups attached / is asymmetric / is chiral	1 1 1 1	4
4(b)(i)	2,3-dimethylbut-2-ene	1	1
4(b)(ii)		1	1
4(b)(iii)	Propanone	1	1
4(b)(iv)		1	1
4(c)(i)	(2-)methylprop(-1-)ene	1	1

Page 7	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks	
4(c)(ii)		4	4
4(c)(iii)	(tertiary carbocat)ion / (tertiary) intermediate is / C⁺ with least number of hydrogen atoms bonded to it is more stable (than primary) due to (positive) inductive effect of three/more methyl groups (cf one) / three / more electron releasing methyl groups three / more electron donating methyl groups reducing charge (density) on C⁺	1 1 1	3
	Total:		18

Page 8	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks	
5(a)		1	1
5(b)	$\text{H}^+ / \text{Cr}_2\text{O}_7^{2-}$ (heat under) reflux	1 1	2
5(c)	$\text{H}^+ / \text{Cr}_2\text{O}_7^{2-}$ (heat and) distil	1 1	2
5(d)	(1-)propyl propanoate	1	1
	Total:		6

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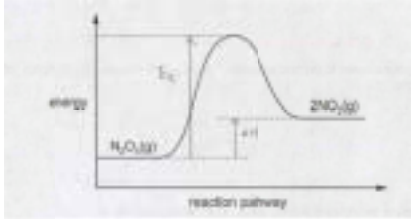
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Page 2	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
1(a)	0.04 OR 4×10^{-2}	1
1(b)(i)	$\text{Na}_2\text{CO}_3 + 2\text{HCl} \rightarrow 2\text{NaCl} + \text{CO}_2 + \text{H}_2\text{O}$	1
1(b)(ii)	0.00075 OR 7.5×10^{-4}	1
1(b)(iii)	0.0015 OR 1.5×10^{-3}	1
1(b)(iv)	0.015 OR 1.5×10^{-2}	1
1(b)(v)	0.025 OR 2.5×10^{-2}	1
1(b)(vi)	0.0125 OR 1.25×10^{-2} OR 0.013 OR 1.3×10^{-2}	1
1(b)(vii)	40	1
	Ca / calcium	1
	Total:	9

Page 3	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
2(a)	Arrow vertically up from N₂O₄ line to 2NO₂ line labelled enthalpy change / ΔH Arrow vertically up from N₂O₄ line to dashed line from peak labelled activation energy / E_a 	1 1
2(b)(i)	$M_r = \frac{m \times R \times T}{p \times V} \quad \left(= \frac{4.606 \times 8.31 \times 323}{1.68 \times 10^5 \times 1 \times 10^{-3}} \right)$ = 73.6	1 1
2(b)(ii)	2n	1
2(b)(iii)	0.05 – n + 2n OR 0.05 + n	1
2(b)(iv)	$\frac{2n}{(0.05 + n)}$	1
2(b)(v)	N₂O₄ = 0.0375 NO₂ = 0.0250	1 1
2(b)(vi)	$K_p = \frac{p\text{NO}_2^2}{p\text{N}_2\text{O}_4}$	1

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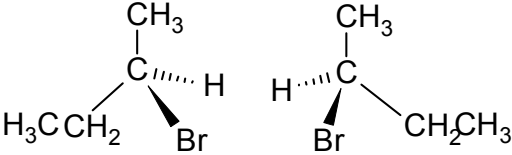
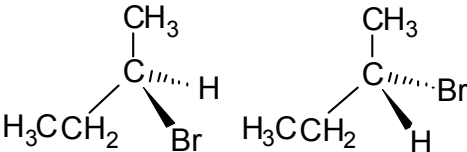
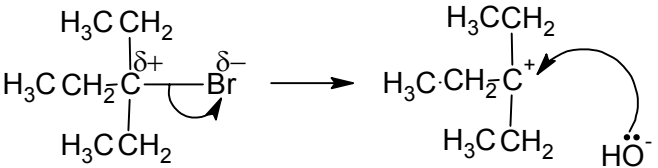
Question	Answer	Mark
2(b)(vii)	$(0.4 \times 1.68 \times 10^5)^2 / (0.6 \times 1.68 \times 10^5)$ OR $0.4^2 \times 1.68 \times 10^5 / 0.6$	1
	44800 OR 44.8	1
	Pa OR kPa	1
	Total:	13

Question	Answer	Mark
3(a)(i)	Increasing nuclear attraction	1
	Increasing nuclear charge / number of protons AND constant / similar shielding / same shell	1
3(a)(ii)	From 12 / Mg to 13 / Al: (Outer) electron in '13' / Al in (3)p (whereas outer electron in '12' / Mg in (3)s) (3p =) higher energy level / more shielded	1 1
	From 15 / P to 16 / S electron repulsion ('16' / S has a) pair of electrons in a (3)p orbital / a (3)p orbital is full ORA	1 1
3(a)(iii)	(decreasing IE down Group 0) due to decreasing nuclear attraction	1
	increasing shielding / increasing number of shells / energy levels / increasing distance of (outer) electrons (from nucleus)	1

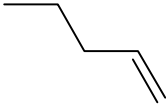
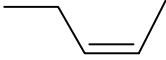
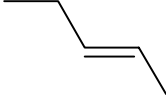
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Question	Answer	Mark
3(b)(i)	Increasing strength of / more energy needed to break (metallic) bonding / increasing strength of attraction between (cat)ion / nucleus and delocalised / free / sea of / cloud of electrons	1
	Increasing number of delocalised electrons / decreasing (cat)ion size / increasing charge / charge density of (cat)ion	1
3(b)(ii)	Attraction for electrons too strong to fully delocalise all 3 in Al OR difference in size between 12/Mg ²⁺ and 13/Al ³⁺ is less than difference in size between 11/Na ⁺ and 12/Mg ²⁺ OR magnitude of increase in charge is less from 2+ to 3+ than from 1+ to 2+	1
3(b)(iii)	Increase (15/P to 16/S) then decrease (to 17/Cl and 18/Ar) OR general decrease (from 15/P to 18/Ar) with an increase from 15/P to 16/S OR S ₍₈₎ >P ₍₄₎ >Cl ₍₂₎ >Ar (melting point depends on strength of) VdW/IMFs	1
	The greater the number of electrons in the molecule (atom for Ar) the greater the strength of VdW/IMFs OR the greater the melting point ora	1
3(b)(iv)	Giant covalent (structure) / many (strong) covalent bonds (need breaking)	1
	Total:	15

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Question	Answer	Mark
4(a)(i)	2-bromobutane	1
4(a)(ii)	e.g. of mirror images  e.g. of swapped groups 	1+1
4(a)(iii)	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$ $(\text{CH}_3)_2\text{CHCH}_2\text{Br}$ $(\text{CH}_3)_3\text{CBr}$	1 1 1
4(b)(i)	3-bromo-3-ethylpentane	1
4(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 <u>on O</u> to $\text{C}(+)$	1 1 1
4(b)(iii)	$\text{S}_{\text{N}}1$ / nucleophilic substitution	1

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Question	Answer	Mark
4(c)(i)	Sodium / potassium hydroxide	1
	Ethanol / alcohol AND heat	1
4(c)(ii)	elimination	1
4(c)(iii)		1
		1
		1
	Total:	17

Page 8	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
5(a)(i)	$Cl\bullet$ and $\bullet CH_3$	1
5(a)(ii)	Cl^- and $^+CH_3/CH_3^+$	1
5(b)(i)	Oxidation OR reduction	1
5(b)(ii)	Condensation	1
5(b)(iii)	Reduction OR oxidation OR addition	1
5(b)(iv)	Addition	1
	Total:	6

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1(c)	6×10^{-3} (mol)	1	1
1(d)	4×10^{-3} (mol)	1	1
1(e)	4×10^{-3} (mol)	1	1
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1(g)	170	1	1
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2(b)(i)	6813.4/6813/6810/6800 (J)	1 1
2(b)(ii)	-1362.68/-1362.7/-1363/-1360/-1400 (kJ)	1 1
2(b)(iii)	Any 2 from: heat/energy losses (to air and/or to the container/surroundings) incomplete combustion (volatile) ethanol evaporated ethanol is impure not all energy is lost as heat	1 2 1
2(c)(i)	$3\text{C(s)} + 4\text{H}_2\text{(g)} + \frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{C}_3\text{H}_7\text{OH(l)}$ $3(-393.5)$ $\swarrow$ $4 \times (-285.8)$ $\swarrow$ -2021.0 $\swarrow$ $3\text{CO}_2 + 4\text{H}_2\text{O}$	1+1 3 1

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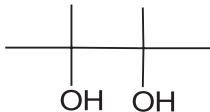
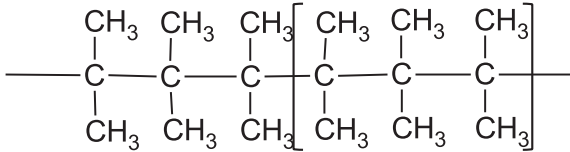
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3(b)(i)	Nitrate / Nitrate(V) / NO_3^-	1 1
3(b)(ii)	Ba / barium OR Sr / Strontium $\text{Ba}^{2+} + \text{SO}_4^{2-} \rightarrow \text{BaSO}_4$ OR $\text{Sr}^{2+} + \text{SO}_4^{2-} \rightarrow \text{SrSO}_4$	1 1

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3(c)(i)	H ⁺ + OH ⁻ → H ₂ O OR Ca(OH) ₂ + 2H ⁺ → Ca ²⁺ + 2H ₂ O 2H ⁺ + CO ₃ ²⁻ → CO ₂ + H ₂ O OR CaCO ₃ + 2H ⁺ → Ca ²⁺ + CO ₂ + H ₂ O OR H ⁺ + CO ₃ ²⁻ → HCO ₃ ⁻ OR CaCO ₃ + H ⁺ → Ca ²⁺ + HCO ₃ ⁻	1 1	2
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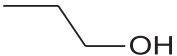
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4(b)(iv)		1	1
4(c)(i)	(2-)methylprop(-1-)ene	1	1

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	Total:		6