
CHEMISTRY

9701/21

Paper 2 AS Level Structured Questions

May/June 2019

MARK SCHEME

Maximum Mark: 60

Published

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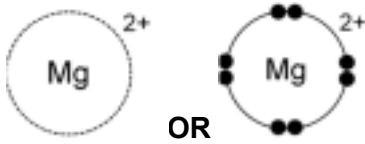
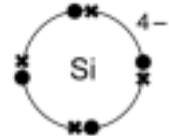
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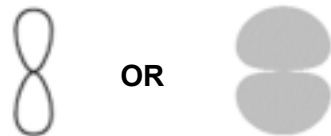
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Question	Answer	Marks
1(a)(i)	M1 (one) fewer (inner) shell of electrons / less shielding (effect) <i>ORA</i>	1
	M2 smaller distance of the outer electrons (from the nucleus) / stronger nuclear attraction to the (outer) electrons <i>ORA</i>	1
1(a)(ii)	$\text{Sr(s)} + 2\text{H}_2\text{O(l)} \rightarrow \text{Sr(OH)}_2\text{(aq)} + \text{H}_2\text{(g)}$	1
	M1 species AND balancing	
	M2 state symbols	1
1(a)(iii)	M1 strontium AND forms a more soluble hydroxide	1
	M2 strontium hydroxide is a stronger base / produces more OH^- / it dissociates more	1
1(a)(iv)	(white) solid dissolves / effervescence	1
1(b)(i)	Similarities (any two from the following list) (both have) +2 ion / (+2) same oxidation state / same stoichiometry of oxide / <u>carbonates</u> decompose (on heating)	2
	Difference (X) forms coloured compounds/oxides/ carbonates OR Group 2 elements form white compounds/oxides/carbonates	1
1(b)(ii)	XO	1
1(b)(iii)	$\text{XCO}_3 \rightarrow \text{XO} + \text{CO}_2$	1

Question	Answer	Marks
2(a)	M1 <i>magnesium</i> +2 charge on two Mg AND both with 0 or 8 electrons 	1
	M2 <i>silicide</i> -4 charge on one Si and 8 electrons 	1
2(b)	$\text{Mg}_2\text{Si(s)} + 4\text{H}_2\text{O(l)} \rightarrow 2\text{Mg(OH)}_2\text{(aq)} + \text{SiH}_4\text{(g)}$ M1 correct balancing and formulae	1
	M2 state symbols	1
2(c)	M1 simple (covalent) / molecular / molecules	1
	M2 weak IMF / (temporary) induced dipole (forces)	1
2(d)(i)	$\text{C}^{\delta-}-\text{H}^{\delta+}$	1
	$\text{Si}^{\delta+}-\text{H}^{\delta-}$	1
2(d)(ii)	M1 tetrahedral (molecule)	1
	M2 (so individual bond) dipoles / partial charges cancel	1
2(e)	M1 Si—H bond is (much) weaker than C—H bond	1
	M2 low activation energy <i>ORA</i>	1

Question	Answer	Marks
2(f)(i)	M1 sodium silicate / Na_2SiO_3	1
	M2 water / H_2O	1
2(f)(ii)	acid(ic)	1

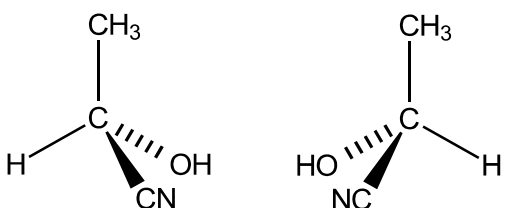
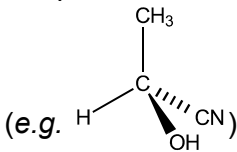
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3(a)	$\text{Ar}^+(\text{g}) \rightarrow \text{Ar}^{2+}(\text{g}) + \text{e}^{(-)}$ OR $\text{Ar}^+(\text{g}) - \text{e}^{(-)} \rightarrow \text{Ar}^{2+}(\text{g})$	1
3(b)	at $x = 8$, within range 13000–20000	1
	at $x = 9$, within range 35000–45000	1
3(c)		1
3(d)(i)	M1 correct conversions of data to SI/consistent units $p = 404\,000$; $V = 20 \times 10^{-6}$; $T = 298$	1
	M2 calculation of n ($= pV/RT$) from M1 values $n = \frac{404000 \times 20 \times 10^{-6}}{8.31 \times 298} = 3.263 \times 10^{-3} \text{ mol of Cl}_2$	1
	M3 finding the mass of Cl_2 $= 3.263 \times 10^{-3} \times 71.0 = 0.23 \text{ (g)}$	1

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Question	Answer	Marks
3(d)(ii)	Method 1 $M1 = 3.263 \times 10^{-3} \times 2$ Method 2 $M1 = \frac{0.23}{71.0} \times 2$ OR 6.53×10^{-3}	1
	$M2 = 6.02 \times 10^{23} \times M1$ $= 3.93 \times 10^{21}$ atoms of <i>Cl</i> $M2 = 6.02 \times 10^{23} \times M1$ $= 3.90 \times 10^{21}$ atoms of <i>Cl</i>	1
3(d)(iii)	M1 size / volume of molecule / particle becomes significant / non-negligible OR IMFs become significant / non-negligible	1
	M2 IMFs becomes significant / non-negligible / collisions are not elastic	1

Question	Answer	Marks
4(a)	3-chloroprop-1-ene	1
4(b)	$a = 109(.5)^{\circ}$	1
	$b = 120^{\circ}$	1
4(c)(i)	$C_3H_7ClO_2$	1
4(c)(ii)	oxidation	1

Question	Answer				Marks		
4(c)(iii)					1		
							alcohol group present in Z
						primary	✓
						secondary	✓
						tertiary	
4(d)(i)	A and B				1		
4(d)(ii)			Compound(s)	Observation	2		
		Reaction with Tollens' reagent	B ✓	silver mirror OR grey / black / brown / silver precipitate ✓			
			Compound(s)	Observation	3		
		Reaction with alkaline aq. iodine	A ✓ and C ✓	(Pale) yellow precipitate /solid ✓			
			Compound(s)	Observation	3		
		Reaction with sodium metal	C ✓ and D✓	Effervescence / sodium/solid disappears ✓			

Question	Answer	Marks
5(a)	M1 a lone pair / electron pair donor	1
	M2 $(:)\text{CN}^-$ / $-(:)\text{CN}$ / cyanide ion	1
5(b)(i)	optical	1
5(b)(ii)	 M1 one 3-D structure of correct molecule shown.	1
	M2 a mirror image of the molecule drawn in M1 OR same profile with two groups swapped  (e.g. $\text{H}-\text{C}(\text{CH}_3)(\text{OH})(\text{CN})$)	1
	M3 central chiral C shown as *	1
5(c)	$\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H}$ OR $\text{HO}_2\text{CCH}(\text{OH})\text{CH}_3$	1

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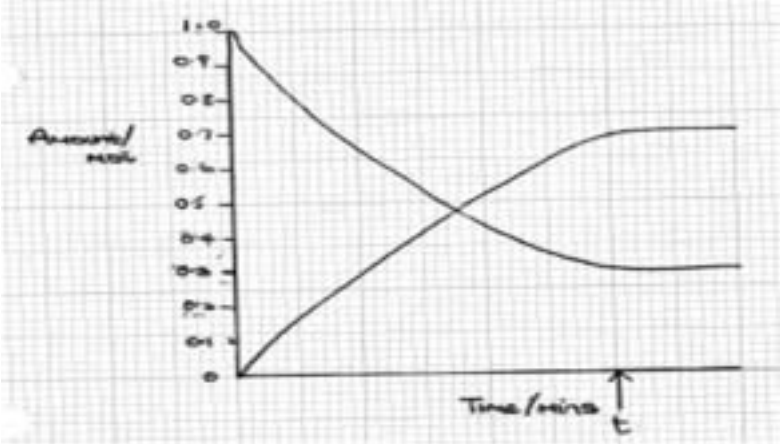
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1(a)(i)	C ₄ H ₁₀ / same molecular formula / OR same number of carbon (atoms) and hydrogen (atoms)	1
	different structural formula OR description of different structural formula which does not imply stereoisomerism	1
1(a)(ii)	structural / chain	1
1(b)	(forward reaction is) exothermic reaction	1
	the proportion of methylpropane / product decreases OR the proportion of butane / reactant increases	1

Question	Answer	Marks
1(c)(i)	t shown on graph which corresponds to start of the horizontal part of both curves. 	1
1(c)(ii)	concentration of butane = 0.3 mol dm^{-3} AND concentration of methylpropane = 0.7 mol dm^{-3}	1
1(c)(iii)	$[\text{methylpropane}] / [\text{butane}]$ OR $[(\text{CH}_3)_2\text{CHCH}_3] / [\text{CH}_3(\text{CH}_2)_2\text{CH}_3]$	1

Question	Answer	Marks
1(c)(iv)	M1 <i>value for K_c</i> $K_c = \frac{\text{value of methylpropane in (ii)}}{\text{value of butane in (ii)}} = 0.7 / 0.3 = 2.3$ (3)	1
	M2 <i>units consistent with expression used in M1</i> no units / dimensionless / none	1

Question	Answer	Marks
2(a)	<i>trend in volatility down the group</i> decrease (in volatility)	1
	<i>identification of specific IMF increasing</i> increasing (strength of) induced dipole (id) (interactions between molecules)	1
	<i>explanation in terms of electrons</i> increasing number of electrons	1
2(b)(i)	<i>Conditions for reaction with Cl_2 at room temperature</i> ultra-violet / uv	1

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Question	Answer	Marks
2(b)(ii)	$\text{I}_2(\text{g} / \text{s}) + \text{H}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$	1
	M1 correctly balanced equation	
	M2 correct state symbols AND use of <u>equilibrium</u> sign	1
2(c)(i)	proton / H^+ donor	1
2(c)(ii)	acid HCl AND conjugate base Cl^-	1
2(c)(iii)	co-ordinate / dative (covalent)	1
2(c)(iv)	(triangular / trigonal) pyramid(al)	1
	107 ⁽⁰⁾	1

Question	Answer	Marks								
3(a)(i)	$\text{SiCl}_4(l) + 2\text{H}_2\text{O}(l) \rightarrow \text{SiO}_2(s) + 4\text{HCl}(aq / g)$ (state symbols required)	1								
3(a)(ii)	hydrolysis	1								
3(a)(iii)	NaCl – ionic	1								
	SiCl ₄ – covalent	1								
3(a)(iv)	M1 statement correctly comparing the difference in electronegativity between Si and Cl AND Na and Cl OR Na is less electronegative than Si OR A	1								
	M2 NaCl transfer of electrons	1								
	M3 SiCl ₄ shared (pair of) electrons	1								
3(b)(i)	<table><tr><td>Chlorine containing species</td><td>Cl₂</td><td>HCl</td><td>HOCl</td></tr><tr><td>Oxidation number of chlorine</td><td>0</td><td>–1</td><td>(+)1</td></tr></table> Award 2 marks for 3 correct oxidation numbers Award 1 Mark for 2 correct oxidation numbers	Chlorine containing species	Cl ₂	HCl	HOCl	Oxidation number of chlorine	0	–1	(+)1	2
Chlorine containing species	Cl ₂	HCl	HOCl							
Oxidation number of chlorine	0	–1	(+)1							
3(b)(ii)	disproportionation	1								
3(b)(iii)	kills micro-organisms	1								

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Question	Answer	Marks
3(c)	$2\text{NaOH} + \text{HCl} + \text{HClO} \rightarrow \text{NaCl} + \text{NaClO} + 2\text{H}_2\text{O}$ M1 Identifies the product NaClO M2 Correctly balances the equation OR The overall equation may be seen as: $\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$ AND $\text{NaOH} + \text{HClO} \rightarrow \text{NaClO} + \text{H}_2\text{O}$	2

Question	Answer	Marks
4(a)	name of source crude oil / petroleum	1
	outline of separation of hydrocarbons (separation of molecules according to) different boiling points	1
4(b)(i)	cracking	1
4(b)(ii)	$2\text{C}_7\text{H}_{16} \rightarrow \text{C}_4\text{H}_{10} + \text{C}_6\text{H}_{14} + 2\text{C}_2\text{H}_4$	1

Question	Answer	Marks
4(c)	<i>method 1</i>	<i>method 2</i>
	M1 $1 / 28 (= 0.035714)$	$1 : 88 / 28 (= 3.14286)$
	M2 $2 \times M1 (= 1 / 14 = 0.07143)$	$M1 / 44 (= 0.071429)$
	M3 $M2 \times 24 = 1.7 \text{ dm}^3$	$M2 \times 24 = 1.7 \text{ dm}^3$
4(d)(i)	unpaired electron(s)	1
4(d)(ii)	homolytic (fission)	1
	one electron goes to each chlorine / atom OR pair of electrons is shared out (equally between the two atoms)	1
4(d)(iii)	propagation	1
4(d)(iv)	$\text{CH}_4 + (\bullet)\text{Cl} \rightarrow (\bullet)\text{CH}_3 + \text{HCl}$ OR $\text{CH}_4 + (\bullet)\text{Cl} \rightarrow \text{HCl} + \text{CH}_3(\bullet)$	1

Question	Answer	Marks
4(d)(v)	M1 identify bond types in alkanes and alkenes bonds in alkanes are (all) sigma / σ AND alkenes have (C = C made of) sigma AND pi / σ AND π	1
	M2 electrons in π (of the C = C) are responsible for the reaction electrophiles are attracted to / attack to electrons in pi / π OR electrophiles react with pi / π	1

Question	Answer	Marks
5(a)(i)	(n-)propyl ethanoate	1
5(a)(ii)	NaOH / sodium hydroxide	1
5a(iii)	$ \begin{array}{ccccccc} & \text{H} & \text{H} & \text{H} & & & \\ & & & & & & \\ \text{H} & -\text{C} & -\text{C} & -\text{C} & -\text{O} & & \\ & & & & \backslash & & \\ & \text{H} & \text{H} & \text{H} & \text{H} & & \end{array} $	1
5(a)(iv)	perfume / solvent	1

Question	Answer	Marks
5(b)(i)	M1 divide by A_r C 54.5 / 12 H 9.1 / 1 O 36.4 / 16	1
	M2 divide by smallest number 4.54 / 2.275 (= 2 OR 1.99) 9.1 / 2.275(=4) 2.275 / 2.275 (=1)	1
	M3 empirical formula based on correctly rounded values of M2 C₂H₄O	1
5(b)(ii)	(relative) molecular mass / M_r	1
5(c)(i)	C ₃ H ₆ O ₂	1
5(c)(ii)	X and Z – no reaction / no (visible) change	1
	Y – effervesces	1
5(d)	2HCO ₂ H + Na ₂ CO ₃ → 2HCO ₂ Na + CO ₂ + H ₂ O	1

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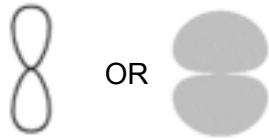
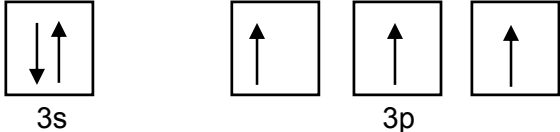
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1(a)(i)	All have the same nucleon number OR same sum / total number of protons + neutrons	1
1(a)(ii)	(different) number of protons, neutrons and electrons	1
1(b)	M1 $x / 100 \times 32 + (100 - x / 100 \times 34) = 32.09$ M2 $(32x + 3400 - 34x) = 3209$ so $x = 95.5$ M3 S^{32} 95.5% AND S^{34} 4.5%	3
1(c)(i)	1s	1
1(c)(ii)		1
1(c)(iii)	M1 3p M2 It is less attracted to the nucleus (so takes less energy to lose) OR It is the highest energy orbital (which is occupied) / it is in the highest energy orbital	2
1(d)(i)		1
1(d)(ii)	M1 (in S, the electron is removed from the) 2 electrons in (3) p orbital OR a pair of electrons in (3) p (orbital / sub-shell) M2 (paired electrons) repel	2

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Question	Answer	Marks
2(a)(i)	held in regular / uniform arrangement	1
2(a)(ii)	M1 covalent (bonds) AND (temporary) induced dipoles M2 (temporary) induced dipoles	2
2(b)(i)	2	1
2(b)(ii)	iodine (atom / s) donates a pair of electrons (to the Al-I covalent bond / s).	1
2(c)(i)	$2\text{H}_2\text{SO}_4 + 14\text{HI} \rightarrow 7\text{I}_2 + 8\text{H}_2\text{O} + \text{H}_2\text{S} + \text{S}$ M1 correct species M2 correctly balanced equation	2
2(c)(ii)	<i>explain with ref to ox no's why the reaction in (c)(i) is a redox reaction</i> M1 I (oxidation number increases) from -1 to 0 = oxidation / reducing agent M2 S (oxidation number decreases) from $(+) 6$ to 0 OR -2 = reduction / oxidising agent	2

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3(a)	white light / flame AND (produces a) white / grey solid / ash / powder / smoke	1
3(b)(i)	$\text{MgO} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2\text{O}$	1
3(b)(ii)	neutralisation	1
3(c)	M1 giant (structure / lattice) M2 (so) lots of energy needed to break the bonds OR strong bonds	2
3(d)(i)	$\text{MgCO}_3(\text{s}) \rightarrow \text{MgO}(\text{s}) + \text{CO}_2(\text{g})$	1
3(d)(ii)	(thermal) decomposition	1

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Question	Answer	Marks
4(a)	M1 sulfur impurities OR sulfur in fossil fuels M2 converted into SO ₂ by combustion / burning sulfur OR heat sulfur with oxygen (from the air)	2
4(b)(i)	M1 1 mol SO ₂ → 1 mol H ₂ SO ₄ 64.1 g / tonne → 98.1 g / tonne M2 SO ₂ → $98.1 / 64.1 \times 1590 = 2433.369735$ tonnes	2
4(b)(ii)	high (enough) temperature / (a lot of) heat (energy) is produced AND to break (strong) triple bond in N ₂ / break N≡N AND nitrogen (and oxygen) from the air / atmosphere react Award two marks for three correct points Award one mark for two correct points	2
4(b)(iii)	lightning	1
4(b)(iv)	M1 nitrogen dioxide increases the rate OR lowers the activation energy M2 (NO ₂) is regenerated by reaction of NO with O ₂ (in the air) OR NO (formed) reacts with O ₂ (in air) to (re)form NO ₂	2

Question	Answer	Marks
5(a)(i)	pentanenitrile	1
5(a)(ii)	a lone pair / electron pair donor	1
5(a)(iii)	$(:)\text{CN}^-$ / $^-(:)\text{CN}$ / cyanide ion	1
5(a)(iv)	Br (atom) is replaced (with / by CN / nitrile)	1
5(b)	M1 <i>reagent</i> Ammonia M2 <i>conditions</i> heat with under pressure / heat in a sealed tube	2
5(c)(i)	M1 Increasing reactivity from $\text{Cl} \rightarrow \text{Br} \rightarrow \text{I}$ M2 Due to decreasing strength of C-X bond (from C-Cl to C-Br to C-I) OR Less energy needed to break C-X (from C-Cl to C-Br to C-I)	2
5(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
5(c)(iii)	Any formula / name for any primary halogenoalkane i.e. 1-chlorobutane / 1-bromobutane / 1-iodobutane	1

Question	Answer	Marks
6(a)(i)	Orange / brown to colourless / decolourises	1
6(a)(ii)	any non-ambiguous structures of:	
	X $(\text{CH}_3)_2\text{C} = \text{CH}_2 / (\text{CH}_3)_2\text{CCH}_2$	1
	Y $\text{CH}_3\text{CH}_2\text{CH} = \text{CH}_2 / \text{C}_2\text{H}_5\text{CHCH}_2$	1
	Z $\text{CH}_3\text{CH} = \text{CHCH}_3 / \text{CH}_3\text{CHCHCH}_3$	1
6(a)(iii)	C_4H_8	1
6(b)(ii)	V = primary / 1° alcohol	1
	W = tertiary / 3° alcohol	1
6(b)(ii)	$\text{CH}_3(\text{CH}_2)_2\text{CH}_2\text{OH} + \text{Na} \rightarrow \text{CH}_3(\text{CH}_2)_2\text{CH}_2\text{ONa} + \frac{1}{2} \text{H}_2$	1
6(b)(iii)	M1 Reagent $\text{H}^+ / \text{Cr}_2\text{O}_7^{2-}$ M2 Observations for V orange to green M3 Observations for W no change / remains orange	3