
CHEMISTRY

9701/21

Paper 2 AS Structured Questions

October/November 2019

MARK SCHEME

Maximum Mark: 60

Published

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This document consists of **9** printed pages.



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Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

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GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

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- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
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GENERIC MARKING PRINCIPLE 6:

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Question	Answer	Marks
1(a)(ii)	It oxidises chlorine from –1 to 0	1
1(a)(ii)	effervescence / fizzing / bubbling OR green gas formed OR solid dissolves / disappears / soluble	1
1(b)	M1: decreases (down the group) M2: increasing induced dipoles M3: greater number of electrons	3
1(c)(i)	M1: $\text{Cl}_2 + 2\text{NaOH} \rightarrow \text{NaCl} + \text{NaClO} + \text{H}_2\text{O}$ M2: chlorine is oxidised and reduced	2
1(c)(ii)	NaClO_3 / sodium chlorate(V)	1
1(d)	M1: chloric(I) acid / hypochlorous acid / HClO M2: kills bacteria / micro-organisms / microbes	2
1(e)(i)	ultra-violet (light) / sunlight	1
1(e)(ii)	$\text{C}_2\text{H}_6 + \text{Cl}_2 \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{HCl}$	1

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Question	Answer	Marks															
2(a)	<table><tr><td>Na₂O</td><td>MgO</td><td>Al₂O₃</td><td>SiO₂</td><td>SO₃</td></tr><tr><td>ionic</td><td>ionic</td><td>ionic</td><td>covalent</td><td>covalent</td></tr><tr><td>giant</td><td>giant</td><td>giant</td><td>giant / macro-molecular</td><td>simple / molecular</td></tr></table> Award one mark for each correct row.	Na₂O	MgO	Al₂O₃	SiO₂	SO₃	ionic	ionic	ionic	covalent	covalent	giant	giant	giant	giant / macro-molecular	simple / molecular	2
Na₂O	MgO	Al₂O₃	SiO₂	SO₃													
ionic	ionic	ionic	covalent	covalent													
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2(b)(i)	M1 SiO₂ has a network of strong bonds / SiO₂ has many strong bonds M2 SO₃ has weak intermolecular forces OR weak VdW forces (between molecules) M3 high(er) / more energy required to break bonds than overcome forces (between molecules)	3															
2(b)(ii)	M1: reacts with both acid and base / alkali M2: use any equation with Al₂O₃ and an acid, e.g. Al₂O₃ + 6HCl → 2AlCl₃ + 3H₂O M3: use any equation with Al₂O₃ and a base / alkali, e.g. Al₂O₃ + 2NaOH + 3H₂O → 2NaAl(OH)₄	3															
2(b)(iii)	solid dissolves / disappears OR gets warm / hot	1															
2(c)(i)	octahedral	1															

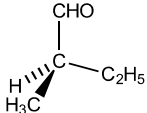
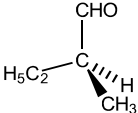
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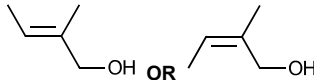
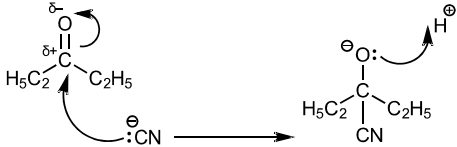
Question	Answer	Marks
2(c)(ii)	M1: use of the correct expression in terms of specific bond energies. $(514 - xE_{\text{Se-O}} = -346)$ M2: use of correct stoichiometry AND correct processing of expression given in M1. Provided the values 514 and 346 are used. $(514 - 2E_{\text{Se-O}} = -346)$ $= (+)430 \text{ (kJ mol}^{-1}\text{)}$	2
2(c)(iii)	$\text{SeO}_2 + 2\text{NaOH} \rightarrow \text{Na}_2\text{SeO}_3 + \text{H}_2\text{O}$	1

Question	Answer	Marks
3(a)(i)	cracking	1
3(a)(ii)	enthalpy change of combustion / ΔH_c is high / large energy release (per mole / per unit mass) OR combust / burn easily	1
3(a)(iii)	$\text{C}_4\text{H}_8 + 4\text{O}_2 \rightarrow 4\text{CO} + 4\text{H}_2\text{O}$	1
3(a)(iv)	M1: infrared spectroscopy M2: Compare / measure (characteristic) wavelengths	2
3(b)(i)	$\text{C}_4\text{H}_4\text{S(l)} + 6\text{O}_2\text{(g)} \rightarrow 4\text{CO}_2\text{(g)} + 2\text{H}_2\text{O(l)} + \text{SO}_2\text{(g)}$ • correct species • balancing • state symbols Award one mark for two correct bullet points, award two marks for all three correct.	2

Question	Answer	Marks
3(b)(ii)	M1 (enthalpy change when) 1 mol of a substance M2 EITHER burns / combusts / reacts in excess air / oxygen OR completely burns / combusts / reacts in air / oxygen	2
3(b)(iii)	M1 $m = 200$ and $\Delta T = 37.5 - 18.5$ M2 $Q = mc\Delta T = 200 \times 4.18 \times (37.5 - 18.5) = 15\,884 \text{ (J)}$	2
3(b)(iv)	M1 mol of thiophene used $= 0.63 / 84.1$ OR $7.49(1\,082\,045) \times 10^{-3}$ M2 calculation $\div 1000$ AND negative sign $\Delta H_c = \frac{-(iii)}{1000} \div n = \frac{-(iii)}{21000} \div (0.63 / 84.1)$ $= -2120 \text{ (} -2120.39 \text{) (kJ mol}^{-1}\text{)}$	2

Question	Answer	Marks
4(a)(i)	(2,2-)dimethylpropanal	1
4(a)(ii)	sp^2	1
4(b)(i)	acidified potassium dichromate[(VI)] AND heat under reflux	1
4(b)(ii)	M1: A has H-bonding (between molecules) M2: B only has dipole–dipole / VdW forces (between molecules) M3: H-bonding is stronger / requires more energy to overcome	3
4(b)(iii)	$(CH_3)_3CCHO + 2[H] \rightarrow (CH_3)_3CCH_2OH$	1

Question	Answer	Marks								
4(b)(iv)	 M1: / $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$ M2: H_2SO_4 / sulfuric acid	2								
4(c)(i)	- orange / red / yellow precipitate - orange / red / yellow precipitate	1								
4(c)(ii)	Aldehyde	1								
4(c)(iii)	has a carbon / atom attached / bonded to four different atoms / groups / groups of atoms / chains	1								
4(c)(iv)	  M1: Correct 3D representation M2: Correct 3D representation of drawn enantiomer	2								
4(c)(v)	<table><tr><td>principal absorptions in the infra-red spectrum</td><td>bond responsible</td></tr><tr><td>3200–3600 cm⁻¹</td><td>RO-H / O-H</td></tr><tr><td>1630 cm⁻¹</td><td>C=C</td></tr><tr><td>1050 cm⁻¹</td><td>C—O</td></tr></table>	principal absorptions in the infra-red spectrum	bond responsible	3200–3600 cm ⁻¹	RO-H / O-H	1630 cm ⁻¹	C=C	1050 cm ⁻¹	C—O	1
principal absorptions in the infra-red spectrum	bond responsible									
3200–3600 cm ⁻¹	RO-H / O-H									
1630 cm ⁻¹	C=C									
1050 cm ⁻¹	C—O									

Question	Answer	Marks
4(c)(vi)	 M1: skeletal alkene group AND C5 structure M2: one alcohol group M3: branched chain AND capable of geometrical isomerism	3
4(c)(vii)	M1: Correct structure of X and correct dipole on C=O M2: curly arrow from C=O bond to O AND intermediate with CN attached and –ve charge on the O M3: curly arrow from lone pair on CN[–] to C(=O) in X AND curly arrow from lone pair in the intermediate to H⁺ 	3
4(c)(viii)	catalyst	1

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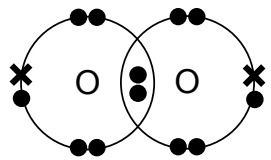
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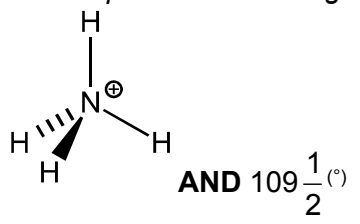
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Question	Answer	Marks
1(a)(i)		1
1(a)(ii)	$\text{Si(g)} \rightarrow \text{Si}^+(\text{g}) + \text{e}^-$	1
1(a)(iii)	M1: similar shielding AND increase in proton number / atomic number / nuclear charge M2: increased nuclear attraction	2
1(a)(iv)	M1: 3 OR 13 M2: large(r) <i>increase</i> between third and fourth ionisation energies OR large(r) <i>increase</i> after third electron removed	2
1(b)(i)	M1: $\frac{(92.2 \times 28) + ({}^{29}\text{Si} \times 29) + ({}^{30}\text{Si} \times 30)}{100} = 28.09$ M2: ($x =$) 6.6 OR $28.09 = 28.078 + x$ (where x = abundance of Si-29) M3: 7.8 – <i>M2 calculated correctly to one decimal place (or more)</i> (=) 1.2%	3
1(b)(ii)	M1 giant (molecule) M2 strong covalent bonds (between atoms / particles) M3 no mobile charged particles / carriers	3
1(c)(i)	$\text{C}_2\text{H}_5\text{SH} + 4\frac{1}{2}\text{O}_2 \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O} + \text{SO}_2$	1

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Question	Answer	Marks
1(c)(ii)	M1: (causes) acid rain OR reacts/dissolves with (rain)water (vapour) to form (sulfuric / sulfurous) acid M2: one point from the following list. - lowers pH / increases acidity of rivers / lakes / oceans / water supplies / seas / soil / ground water - kills/harms / damages fish - kills / harms / damages plants / damages coral / aquatic life / plants / crops / trees or deforestation - leaches (toxic) aluminium (ions / salts) from soil (into rivers / lakes) - leaches away soil nutrients / soil unfit for agriculture - damages / weathers / erodes / destroys buildings / statues	2
1(d)(i)	M1: no effect / none M2: equal mol(es) (<i>of gas</i>) on both sides (of equilibrium / equation) owtte	2
1(d)(ii)	M1: (forward reaction is) endothermic M2: Any temperature higher than 300 K	2

Question	Answer	Marks										
2(a)	<table><tr><td>Na₂O</td><td>Al₂O₃</td><td>SiO₂</td><td>P₄O₁₀ / P₄O₆ / P₂O₃ / P₂O₅</td><td>SO₃</td></tr><tr><td>basic</td><td>amphoteric</td><td>acidic</td><td>acidic</td><td>acidic</td></tr></table> M1: all formulae correct M2: all acid / base behaviour correctly stated	Na ₂ O	Al ₂ O ₃	SiO ₂	P ₄ O ₁₀ / P ₄ O ₆ / P ₂ O ₃ / P ₂ O ₅	SO ₃	basic	amphoteric	acidic	acidic	acidic	2
Na ₂ O	Al ₂ O ₃	SiO ₂	P ₄ O ₁₀ / P ₄ O ₆ / P ₂ O ₃ / P ₂ O ₅	SO ₃								
basic	amphoteric	acidic	acidic	acidic								
2(b)(i)	reacts with both acid and base	1										
2(b)(ii)	OH ⁻ + H ⁺ → H ₂ O	1										
2(b)(iii)	reaction with strontium / reaction 1 will effervesce / fizz / bubble OR no fizzes / bubbles / effervescence with SrO	1										
2(b)(iv)	increases	1										
2(c)(i)	M1: correct conversion of quantities V = 5(.00) × 10⁻⁴ (m³) T = 293 (K) p = 5.37(0) × 10³ (Pa) M2: calculation to find n using n = PV / RT (n) = 1.1 × 10⁻³ (mol)	2										
2(c)(ii)	(i) × 78 = 0.0860 g	1										
2(c)(iii)	 M1: bonding pair between the two O M2: total of 14 electrons distributed equally between the two O	2										

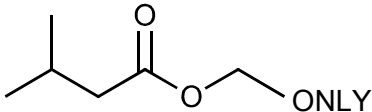
Question	Answer	Marks
3(a)(i)	green gas fades OR white solid / white powder / white smoke / white fumes	1
3(a)(ii)	hydrolysis	1
3(a)(iii)	• P goes from 0 to (+)5 / (+)V • P is oxidised • N goes from (+)5 / (+)V to (+)4 / (+)IV • N is reduced Award one mark for two correct bullet points, award two marks for all four correct.	2
3(b)(i)	accepts a proton / H^+ OR donates a (lone) pair of e^-	1
3(b)(ii)	3-D shape AND bond angle  AND $109\frac{1}{2}^{\circ}$	1
3(b)(iii)	fertilisers	1
3(c)(i)	$C_2H_5OH + PCl_5 \rightarrow C_2H_5Cl + POCl_3 + HCl$	1
3(c)(ii)	substitution	1

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Question	Answer	Marks
3(c)(iii)	EITHER M1: HI / I⁻ is a strong(er) reducing agent (than HCl / Cl⁻) M2: HI / I⁻ is oxidised (to iodine but the chloride is not) OR M1: H₂SO₄ is a (strong enough) oxidising agent (to react with HI / I⁻ here) M2: HI / I⁻ forms iodine OR M1: phosphoric acid is a weak / not an oxidising agent M2: (so) does not react with iodide (where M2 is dependent on M1 here)	2
3(c)(iv)	M1: C₂H₅I reacts fastest AND C₂H₅Cl reacts slowest OR C₂H₅Cl < C₂H₅Br < C₂H₅I M2: C—I bond is the weak(est) AND C—Cl bond strong(est)	2

Question	Answer	Marks
4(a)	M1: curly arrow from lone pair on O of OH⁻ to C of C—Cl M2: correct dipole on C—Cl AND curly arrow from C—Cl bond to Cl^{δ-}	2
4(b)(i)		1
4(b)(ii)	(CH ₃) ₂ CHCH(OH)CH ₂ OH	1
4(b)(iii)	optical (isomerism)	1
4(b)(iv)	C ₅ H ₁₂ O ₂ + 3[O] → C ₅ H ₈ O ₃ + 2H ₂ O	1
4(c)(i)	Add bromine water / Br ₂ (aq) AND turns (from orange / brown to) colourless	1
4(c)(ii)		1
4(d)(i)	3-methylbutan-1-ol	1
4(d)(ii)	heterogeneous	1

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Question	Answer	Marks
4(d)(iii)	M1: skeletal formula of Q  M2: one commercial use of Q (ethyl isovalerate / ethyl 3methylbutyrate) solvents / perfumes / flavourings	2
4(e)(i)	1500–1680 (cm ⁻¹) AND C=C	1
4(e)(ii)	potassium cyanide / KCN / sodium cyanide / NaCN	1
4(e)(iii)	(acidic) hydrolysis	1
4(e)(iv)	M1: recognise this reaction involves less stable intermediate 1° (carbo)cation (intermediate) is less stable (than 3°) M2: explain difference in reactivity in terms of positive inductive effect – comparative answer lower (positive) inductive effect / lower (+)I OR inductive effect of less alkyl groups	2

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1(c)(i)	M1: $\text{Cl}_2 + 2\text{NaOH} \rightarrow \text{NaCl} + \text{NaClO} + \text{H}_2\text{O}$ M2: chlorine is oxidised and reduced	2
1(c)(ii)	NaClO_3 / sodium chlorate(V)	1
1(d)	M1: chloric(I) acid / hypochlorous acid / HClO M2: kills bacteria / micro-organisms / microbes	2
1(e)(i)	ultra-violet (light) / sunlight	1
1(e)(ii)	$\text{C}_2\text{H}_6 + \text{Cl}_2 \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{HCl}$	1

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2(b)(iii)	solid dissolves / disappears OR gets warm / hot					1
2(c)(i)	octahedral					1

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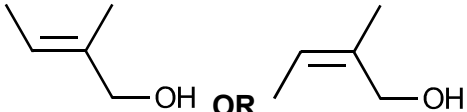
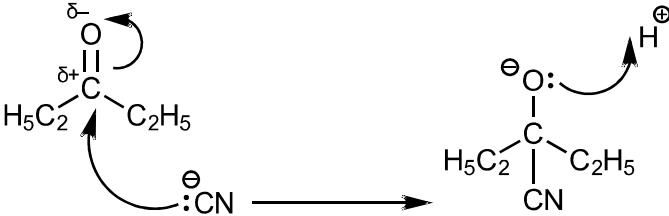
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Question	Answer	Marks
3(b)(ii)	M1 (enthalpy change when) 1 mol of a substance M2 EITHER burns / combusts / reacts in excess air / oxygen OR completely burns / combusts / reacts in air / oxygen	2
3(b)(iii)	M1 $m = 200$ and $\Delta T = 37.5 - 18.5$ M2 $Q = mc \Delta T = 200 \times 4.18 \times (37.5 - 18.5) = 15\,884 \text{ (J)}$	2
3(b)(iv)	M1 mol of thiophene used $= 0.63 / 84.1$ OR $7.49(1\,082\,045) \times 10^{-3}$ M2 calculation $\div 1000$ AND negative sign $\Delta H_c = \frac{-(iii)}{1000} \div n = \frac{-(iii)}{21000} \div (0.63 / 84.1)$ $= -2120 \text{ } (-2120.39) \text{ (kJ mol}^{-1}\text{)}$	2

Question	Answer	Marks
4(a)(i)	(2,2–)dimethylpropanal	1
4(a)(ii)	sp^2	1
4(b)(i)	acidified potassium dichromate[(VI)] AND heat under reflux	1
4(b)(ii)	M1: A has H-bonding (between molecules) M2: B only has dipole–dipole / VdW forces (between molecules) M3: H-bonding is stronger / requires more energy to overcome	3
4(b)(iii)	$(CH_3)_3CCHO + 2[H] \rightarrow (CH_3)_3CCH_2OH$	1

Question	Answer	Marks								
4(b)(iv)	HO M1: / CH₃CH(OH)CH₃ M2: H₂SO₄ / sulfuric acid	2								
4(c)(i)	- orange / red / yellow precipitate - orange / red / yellow precipitate	1								
4(c)(ii)	Aldehyde	1								
4(c)(iii)	has a carbon / atom attached / bonded to four different atoms / groups / groups of atoms / chains	1								
4(c)(iv)	CHO H H₃C C₂H₅ CHO H₅C₂ H CH₃ M1: Correct 3D representation M2: Correct 3D representation of drawn enantiomer	2								
4(c)(v)	<table><tr><td>principal absorptions in the infra-red spectrum</td><td>bond responsible</td></tr><tr><td>3200–3600 cm⁻¹</td><td>RO-H / O-H</td></tr><tr><td>1630 cm⁻¹</td><td>C=C</td></tr><tr><td>1050 cm⁻¹</td><td>C—O</td></tr></table>	principal absorptions in the infra-red spectrum	bond responsible	3200–3600 cm ⁻¹	RO-H / O-H	1630 cm ⁻¹	C=C	1050 cm ⁻¹	C—O	1
principal absorptions in the infra-red spectrum	bond responsible									
3200–3600 cm ⁻¹	RO-H / O-H									
1630 cm ⁻¹	C=C									
1050 cm ⁻¹	C—O									

Question	Answer	Marks
4(c)(vi)	 M1: skeletal alkene group AND C5 structure M2: one alcohol group M3: branched chain AND capable of geometrical isomerism	3
4(c)(vii)	M1: Correct structure of X and correct dipole on C=O M2: curly arrow from C=O bond to O AND intermediate with CN attached and –ve charge on the O M3: curly arrow from lone pair on CN[–] to C(=O) in X AND curly arrow from lone pair in the intermediate to H⁺ 	3
4(c)(viii)	catalyst	1