
CHEMISTRY

9701/21

Paper 2 AS Structured Questions

October/November 2018

MARK SCHEME

Maximum Mark: 60

Published

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Question	Answer	Marks
1(a)(i)	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 (4s^0)$	1
1(a)(ii)	–1	1
1(b)	M1 attraction/hold M2 positive ions / cations AND delocalised electrons (may be seen in a labelled diagram)	2
1(c)(i)	M1 <u>acid rain</u> M2 • destroys / damages / weathers / erodes / buildings / statues • kills/harms fish / coral / plants / crops / trees / deforestation • leaches salts / ions (aluminium) from soil (into rivers / lakes) • leaches away soil nutrients • breathing difficulties • lowers pH / increases acidity of soil / rivers / oceans / seas	2
1(c)(ii)	balanced equation with $11O_2$ and $8SO_2$ M1: O_2 and SO_2 M2: 11 and 8	2
1(c)(iii)	M1 <i>is for process of calculating number of moles of Fe_2O_3</i> $33.18 \div 159.6 (= 0.2079 \text{ mol})$ M2 <i>for correct use of stoichiometry and 120.0 with candidate's M1</i> M2 $(0.2079) \times 4 / 2 \times 120.0 = 49.89 \text{ (g)}$	2
1(c)(iv)	$(0.37 / (0.37 + 49.89)) = 0.74$	1

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Question	Answer	Marks
2(a)(i)	1 mark for each bullet, max 2 - triple bond - non-polar / no dipole - needs a lot of energy to break / strong	2
2(a)(ii)	 6 e⁻ between atoms AND two electrons on each N atom	1
2(b)(i)	(lightning) provides the (high) activation energy	1
2(b)(ii)	M1 $\text{NO} + \frac{1}{2} \text{O}_2 \rightarrow \text{NO}_2$ M2 $2\text{NO}_2 + \text{H}_2\text{O} + \frac{1}{2} \text{O}_2 \rightarrow 2\text{HNO}_3$	2
2(c)	M1 fertiliser / nitrates dissolve in (river / ground water) OR fertiliser / nitrates are washed / leached out / flows into (river/groundwater) M2 algal bloom / promote algal growth / explosion of plant growth AND sunlight is blocked out (preventing photosynthesis) / plants can no longer carry out photosynthesis (and die) AND bacteria break down or decay dead organisms / plants / algae M3 drop in oxygen (concentration)	3
2(d)(i)	to increase / raise pH	1
2(d)(ii)	M1 ammonia / NH_3 M2 displaces NH_3	2

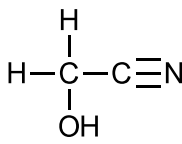
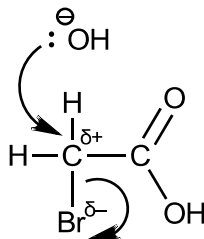
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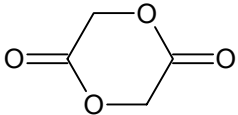
Question	Answer	Marks
2(d)(iii)	M1 effervescence / fizzing / bubbling M2 solid disappears	2
2(d)(iv)	$2\text{Ca}(\text{NO}_3)_2 \rightarrow 2\text{CaO} + 4\text{NO}_2 + \text{O}_2$	1

Question	Answer	Marks
3(a)(i)	M1 gas / vapour (particles / molecules) in equilibrium (with liquid / solid) M2 greater proportion of gas (particles) than liquid (particles) (in comparison to a liquid of lower vapour pressure)	2
3(a)(ii)	$-17.(0) \text{ (kJ mol}^{-1}\text{)}$ ✓✓✓ M1 $\Delta H_r = x(-482.2) + y(-92.3) - v(-103.2) - w(-273.3)$ where x y v and w are integers ≥ 1 (ignore stoichiometry) M2 use of correct stoichiometry where $x = 1$ $y = 2$ $v = 1$ and $w = 2$	3
3(a)(iii)	M1 in a different phase / state from reactants M2 a substance that speeds up a (chemical) reaction M3 catalyst is regenerated / not used up / undergoes temporary chemical change / recovered unchanged	3
3(b)(i)	Human activity creates / additional / more/increase / thicker layer in greenhouse gas(es) / CHClF_2 OR Human activity has an impact on climate change / temperature at earth's surface / temperature of sea	1
3(b)(ii)	M1 traps (more)heat M2 (in the atmosphere leading to) greater global warming or wtte	2
3(b)(iii)	ozone depletion / thinning	1
3(c)(i)	addition	1

Question	Answer	Marks
3(c)(ii)	$ \begin{array}{cc} \text{F} & \text{F} \\ & \\ \text{---C} & \text{---C---} \\ & \\ \text{F} & \text{F} \end{array} $	1
3(c)(iii)	molecule unreactive / inert	1
3(c)(iv)	non-biodegradable creates toxic / harmful gases / HF / CO ₂ / CO if burnt	2

Question	Answer				Marks
4(a)	reagent	observation with glycolic acid	does a reaction occur? ✓ / ×	functional group	4
	Na ₂ CO ₃ (aq)	effervescence / fizzing / bubbling	✓	COOH / carboxylic acid	
	2,4–DNPH	no visible reaction owtte	×	(no group required)	
	acidified Cr ₂ O ₇ ²⁻	orange to green	✓	–OH / alcohol	
	1 mark for each in column 2 (obs) 1 mark for COOH and OH				

Question	Answer	Marks
4(b)(i)		1
4(b)(ii)	hydrochloric / sulfuric / nitric / phosphoric acid	1
4(b)(iii)	free-radical substitution	1
4(b)(iv)	UV (light) / sunlight	1
4(b)(v)	 M1 lone pair on OH^- AND curly arrow from lone pair to C of C—Br M2 correct dipole on C—Br AND curly arrow from bond to Br	2
4(c)(i)	reducing agent / reductant	1
4(c)(ii)	$\text{C}_2\text{H}_2\text{O}_3 + 2[\text{H}] \rightarrow \text{C}_2\text{H}_4\text{O}_3$ M1 for correct molecular formulae $\text{C}_2\text{H}_2\text{O}_3$ and $\text{C}_2\text{H}_4\text{O}_3$ M2 for balancing	2

Question	Answer	Marks
4(d)(i)	EITHER Glycolic acid would have: M1 2500–3000 due to $\text{RCO}_2\text{-H}$ M2 range within 3200–3650 due to RO-H OR Spectrum Y would NOT have: M1 2500–3000 due to $\text{RCO}_2\text{-H}$ M2 range within 3200–3650 due to RO-H	2
4(d)(ii)	 M1 ANY ester group AND valid $\text{C}_4\text{H}_4\text{O}_4$ molecule M2 correct cyclic structure	2

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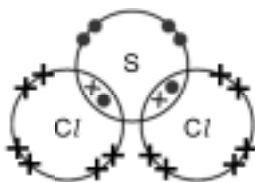
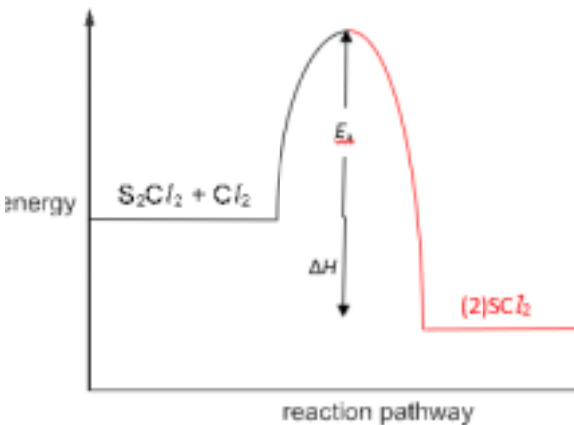
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Question	Answer					Marks
1(a)	particle	relative mass	relative charge	location	total number in an atom of ^{197}Au	4
	electron	0.0005	–1	shell(s) [1]	79	
	neutron	1.(001) [1]	0 [1]	nucleus	118 [1]	
1(b)	metallic					1
1(c)(i)	M1 (atoms of the same element) with the same proton / atomic number [1] M2 (but) different number of neutrons/mass number [1]					2
1(c)(ii)	same number of electrons/electronic structure					1
1(d)(i)	$(100 - 56.36 - 25.14) = 18.5(0)$					1
1(d)(ii)	M1 correct use of ^{63}Cu and ^{65}Cu and their % abundance [1] M2 $\div (56.36 + 25.14)$ AND answer correct to two decimal places [1]					2

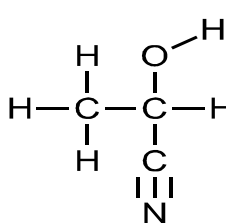
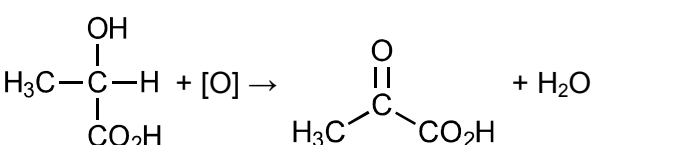
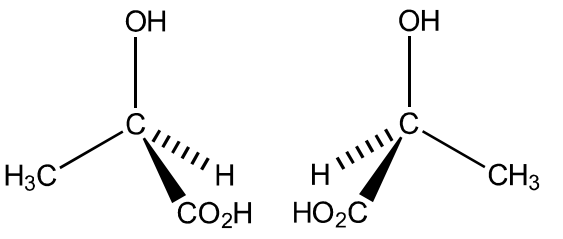
Question	Answer	Marks																				
2(a)	<table><tr><td>Na</td><td>Mg</td><td>Al</td><td>Si</td><td>P</td></tr><tr><td>metallic</td><td>metallic</td><td>metallic</td><td>covalent</td><td>covalent</td></tr><tr><td>Na₂O</td><td>MgO</td><td>Al₂O₃</td><td>SiO₂</td><td>P₄O₁₀</td></tr><tr><td>NaCl</td><td>MgCl₂</td><td>AlCl₃</td><td>SiCl₄</td><td>PCl₅</td></tr></table> [1] for each correct row	Na	Mg	Al	Si	P	metallic	metallic	metallic	covalent	covalent	Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	P ₄ O ₁₀	NaCl	MgCl ₂	AlCl ₃	SiCl ₄	PCl ₅	3
Na	Mg	Al	Si	P																		
metallic	metallic	metallic	covalent	covalent																		
Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	P ₄ O ₁₀																		
NaCl	MgCl ₂	AlCl ₃	SiCl ₄	PCl ₅																		
2(b)(i)		1																				
2(b)(ii)	 M1 profile for exothermic reaction [1] M2 identification of ΔH and E_a [1]	2																				
2(c)(i)	graph rises to maximum for Si, then falls	1																				

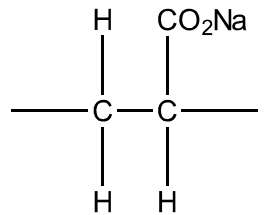
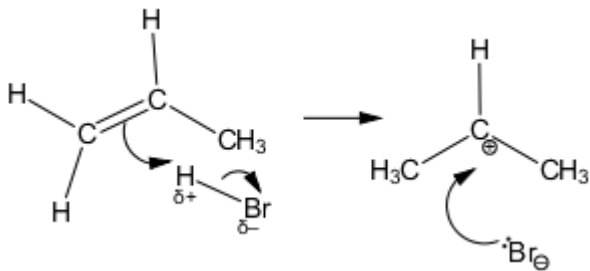
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2(c)(ii)	Max. 3 from: - increasing strength of metallic bond; Na < Mg < Al OR stronger attraction between delocalised electrons and (positive) ion so melting point of Na < Mg < Al - Si is giant covalent AND it has the highest melting point due to breaking / presence of strong (covalent) bonds OR Si requires the most energy because the covalent bonds in Si are stronger than metallic bonds (in Na / Mg / Al) - P and S have weak(er) intermolecular forces / induced dipoles / van der Waals forces (than covalent / metallic bonds) so have low(er) melting points - S₍₈₎ has stronger / more intermolecular forces / van der Waals forces / induced dipoles than P₍₄₎ so melting point of S₍₈₎ is higher	3
2(d)	$\text{P}_4\text{O}_{10} + 6\text{H}_2\text{O} \rightarrow 4\text{H}_3\text{PO}_4$	1
2(e)	M1 acid rain [1] M2 any of the following [1] - lowers pH / increases acidity of rivers / lakes / oceans / water supplies / seas / soil / ground water - kills / harms / damages fish / 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 - causes breathing difficulties	2
2(f)	M1 process of 'first ionisation energy' involves the loss/removal of an electron [1] M2 Mg and Al AND S and P (in either order) [1] M3 For Al 3p (orbital / sub-level / sub-shell) is higher in energy / further from the nucleus / more shielded (than Mg) [1] <i>ora</i> M4 For S the pair of electrons in the (3)p-orbital repel [1] <i>ora</i>	4

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Question	Answer	Marks
3(a)	$\Delta H_r = (-692.9) + 3(-61.8) - (-182.1) - 3(-204.6)$ $= -82.4 \text{ (kJ mol}^{-1}\text{)}$ M1 $\Delta H_r = x(-692.9) + y(-61.8) - v(-182.1) - w(-204.6)$ where x y v and w are integers ≥ 1 [1] M2 use of correct stoichiometry where $x = 1$ $y = 3$ $v = 1$ and $w = 3$ [1] M3 -82.4 [1]	3
3(b)(i)	1 mark for each bullet, max 3 - particles / molecules have (mass but) negligible size / volume (compared to total volume of gas / container) - no / negligible forces / interactions between particles / molecules - collision between particles / molecules are elastic - gas obeys (all) basic gas laws	3
3(b)(ii)	M1 particles / molecules are (so) close [1] M2 particle / molecule size becomes significant [1] OR <u>repulsive</u> forces between particle / molecules become significant	2
3(c)(i)	$\text{CHCl}_3 + \frac{1}{2}\text{O}_2 \rightarrow \text{COCl}_2 + \text{HCl}$	1
3(c)(ii)	M1 X marked on peak at $1670\text{--}1740 \text{ cm}^{-1}$ [1] M2 CHCl_3 has no C=O [1]	2
3(c)(iii)	(It / CHCl_3 has a) peak at $2850\text{--}2950 \text{ (cm}^{-1}\text{)}$ OR carbonyl dichloride spectrum has no peak $2850\text{--}2950 \text{ (cm}^{-1}\text{)}$	1

Question	Answer	Marks
4(a)(i)		1
4(a)(ii)	dehydration	1
4(a)(iii)		1
4(a)(iv)	$\text{Na}_2\text{Cr}_2\text{O}_7 / \text{K}_2\text{Cr}_2\text{O}_7$ AND (dilute) $\text{H}_2\text{SO}_4 / \text{H}^+(\text{aq})$ / acidified	1
4(b)(i)	(Molecules that are) non-super(im)posable mirror images	1
4(b)(ii)	 M1 correct 3-d drawing of one isomer of Q [1] M2 correct pair of 3-d structures of the optical isomers of Q [1]	2

Question	Answer	Marks
4(c)	 OR -CH₂CH(CO₂Na)-	3
4(d)(i)	M1 I experiences a (greater positive) inductive effect due to more alkyl groups OR I contains more electron donating alkyl groups (than II) [1] M2 which stabilises the charge / reduces the charge (on the ion/intermediate) OR spreads the charge across the ion / molecule / intermediate [1]	2
4(d)(ii)	 M1 curly arrow from double bond to H of H—Br [1] M2 curly arrow from H—Br bond to Br AND correct dipole on H—Br [1] M3 curly arrow from lone pair on Br⁻ to C⁺ [1]	3
4(d)(iii)	nucleophilic substitution	1
4(e)(i)	CH₃COCO₂H + 6[H] → CH₃CHOHCH₂OH + H₂O M1 correct organic product CH₃CHOHCH₂OH [1] M2 [H] present as reactant with H₂O as product and balancing [1]	2
4(e)(ii)	1s ² 2s ² 2p ⁶ (3s ⁰)	1

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Question	Answer	Marks
4(e)(iii)	Ions/elements have more shells / energy levels (as the group is descended)	1

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2(c)	M1 fertiliser / nitrates dissolve in (river / ground water) OR fertiliser / nitrates are washed / leached out / flows into (river/groundwater) M2 algal bloom / promote algal growth / explosion of plant growth AND sunlight is blocked out (preventing photosynthesis) / plants can no longer carry out photosynthesis (and die) AND bacteria break down or decay dead organisms / plants / algae M3 drop in oxygen (concentration)	3
2(d)(i)	to increase / raise pH	1
2(d)(ii)	M1 ammonia / NH_3 M2 displaces NH_3	2

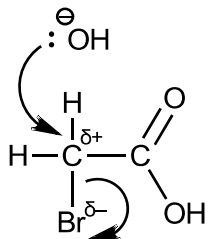
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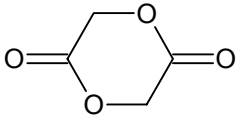
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3(a)(iii)	M1 in a different phase / state from reactants M2 a substance that speeds up a (chemical) reaction M3 catalyst is regenerated / not used up / undergoes temporary chemical change / recovered unchanged	3
3(b)(i)	Human activity creates / additional / more/increase / thicker layer in greenhouse gas(es) / CHClF_2 OR Human activity has an impact on climate change / temperature at earth's surface / temperature of sea	1
3(b)(ii)	M1 traps (more)heat M2 (in the atmosphere leading to) greater global warming or wtte	2
3(b)(iii)	ozone depletion / thinning	1
3(c)(i)	addition	1

Question	Answer	Marks
3(c)(ii)	$ \begin{array}{cc} \text{F} & \text{F} \\ & \\ \text{---C} & \text{---C---} \\ & \\ \text{F} & \text{F} \end{array} $	1
3(c)(iii)	molecule unreactive / inert	1
3(c)(iv)	non-biodegradable creates toxic / harmful gases / HF / CO ₂ / CO if burnt	2

Question	Answer				Marks
4(a)	reagent	observation with glycolic acid	does a reaction occur? ✓ / ×	functional group	4
	Na ₂ CO ₃ (aq)	effervescence / fizzing / bubbling	✓	COOH / carboxylic acid	
	2,4–DNPH	no visible reaction owtte	×	(no group required)	
	acidified Cr ₂ O ₇ ²⁻	orange to green	✓	–OH / alcohol	
	1 mark for each in column 2 (obs) 1 mark for COOH and OH				

Question	Answer	Marks
4(b)(i)	$ \begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{C}\equiv\text{N} \\ \\ \text{OH} \end{array} $	1
4(b)(ii)	hydrochloric / sulfuric / nitric / phosphoric acid	1
4(b)(iii)	free-radical substitution	1
4(b)(iv)	UV (light) / sunlight	1
4(b)(v)	 M1 lone pair on OH^- AND curly arrow from lone pair to C of C—Br M2 correct dipole on C—Br AND curly arrow from bond to Br	2
4(c)(i)	reducing agent / reductant	1
4(c)(ii)	$\text{C}_2\text{H}_2\text{O}_3 + 2[\text{H}] \rightarrow \text{C}_2\text{H}_4\text{O}_3$ M1 for correct molecular formulae $\text{C}_2\text{H}_2\text{O}_3$ and $\text{C}_2\text{H}_4\text{O}_3$ M2 for balancing	2

Question	Answer	Marks
4(d)(i)	EITHER Glycolic acid would have: M1 2500–3000 due to $\text{RCO}_2\text{-H}$ M2 range within 3200–3650 due to RO-H OR Spectrum Y would NOT have: M1 2500–3000 due to $\text{RCO}_2\text{-H}$ M2 range within 3200–3650 due to RO-H	2
4(d)(ii)	 M1 ANY ester group AND valid $\text{C}_4\text{H}_4\text{O}_4$ molecule M2 correct cyclic structure	2