CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Level

MARK SCHEME for the May/June 2015 series

9701 CHEMISTRY

9701/41 Paper 4 (Structured Questions), maximum raw mark 100

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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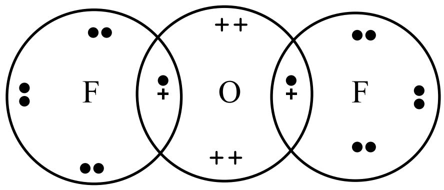
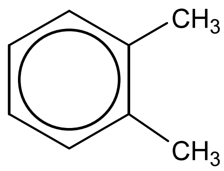
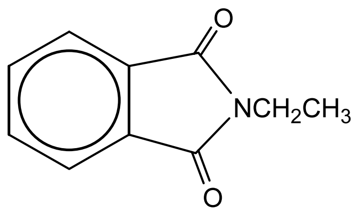
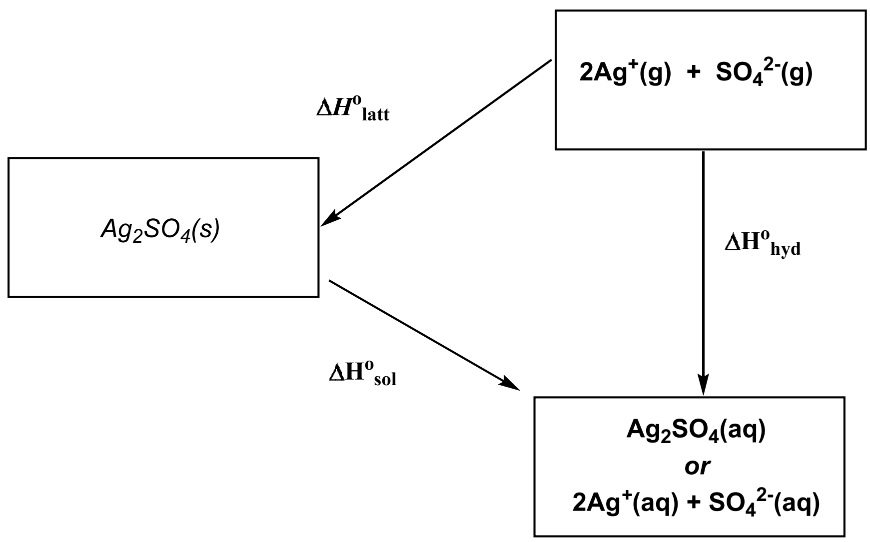
CAMBRIDGE
International Examinations

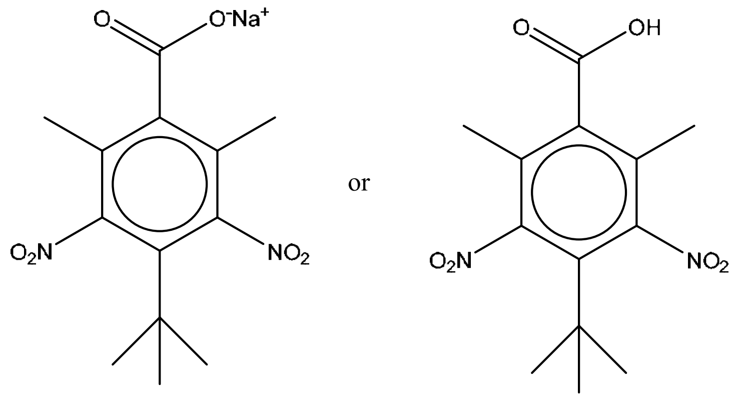
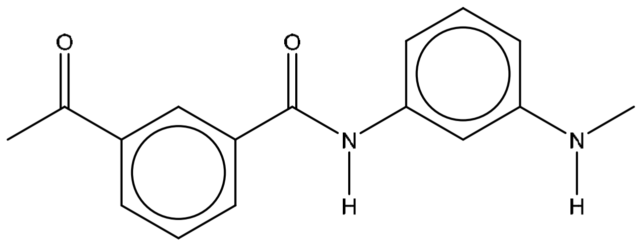
Question	Marking point	Marks
1 (a)	oxygen: $(1s^2)\ 2s^2 2p^4$ fluorine: $(1s^2)\ 2s^2 2p^5$	1
(b) (i)	F_2O / OF_2	1
(ii)		1
(iii)	bent ***or*** non-linear	1
(c) (i)	$E^\ominus$ values: $F_2 / F^- = 2.87\,V$ **and** $Cl_2 / Cl^- = 1.36\,V$ fluorine (has the more positive $E^\ominus$ so) is more oxidising	1 1
(ii)	redox	1
(iii)	$ClF + 2KBr \longrightarrow KCl + KF + Br_2$	1
		[Total: 8]
2 (a) (i)	hydrogen chloride ***or*** HCl	1
(ii)	***either*** (RCOC*l*) has two electron-withdrawing groups/atoms, making the **more** δ+/electron deficient ***or*** (RCOC*l*) has an oxygen, making the **carbon more** δ+/electron deficient ***or*** (RCOC*l*) has two electron-withdrawing groups, **weakening** the **C–C*l*** bond	1
(b) (i)	 **P**  **Q**	1 1
(ii)	step 1: heat with MnO_4^-/$KMnO_4$ (+ acid or alkali) step 2: PCl_3 + heat ***or*** $SOCl_2$ ***or*** PCl_5 step 4: $LiAlH_4$ (in dry ether)	1 1 1
		[Total: 7]

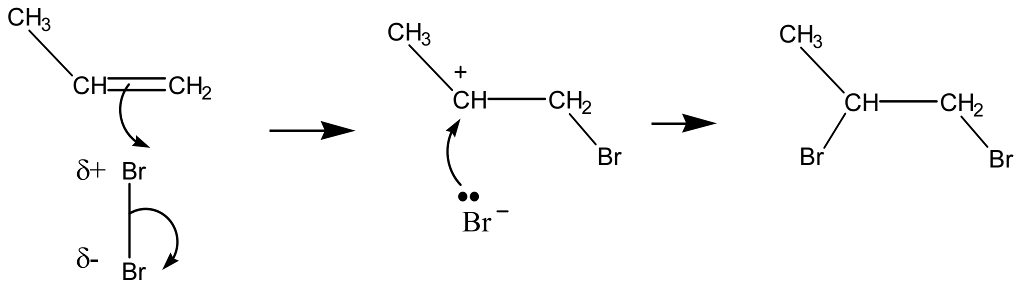
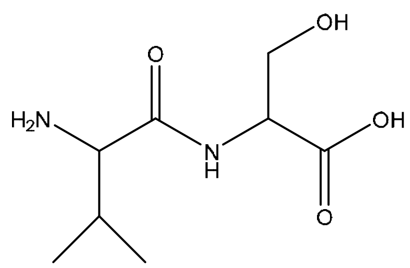
3 (a) (i)	<table><tr><th>isotope</th><th>relative abundance</th></tr><tr><td>^{24}Mg</td><td>**78–79**</td></tr><tr><td>^{25}Mg</td><td>**10**</td></tr><tr><td>^{26}Mg</td><td>**12–11**</td></tr></table> (**total must add up to 100 %**)	1
(ii)	e.g. 0.78x24 + 0.10x25 + 0.12x26 = **24.34**	1
(b) (i)	nitrates become more stable (down the group) as the ionic radius increases ***or*** charge density on cation / ion decreases decreasing its ability to distort / polarise the NO_3^- / nitrate ion	1 1 1
(ii)	$4LiNO_3 \longrightarrow 2Li_2O + 4NO_2 + O_2$	1
(iii)	the **charge density** of the other cations are too small (to polarise the anion sufficiently so the anion is more stable)	1
		[Total: 7]
4 (a) (i)	$K_{sp} = [Ag^+(aq)]^2[SO_4^{2-}(aq)]$ **and** units: mol^3dm^{-9}	1
(ii)	$K_{sp} = (2 \times 0.025)^2 \times (0.025) =$ **6.25×10^{-5}**	1
(b)		1 1 1 1
(c) (i)	$E^{\ominus}_{cell}$ (= 0.80 – 0.77 =) (+)**0.03V and** Ag^+ / Ag ***or*** Ag / silver ***or*** right	1
(ii)	E_{cell} would be less positive / more negative because the $[Ag^+(aq)]$ (in the Ag electrode) is less than 1.0 mol dm^{-3}	1
(iii)	• no change	1

	• more negative/less positive	1
(iv)	the $[Ag^+(aq)]$ will decrease $E_{electrode}$ becomes less positive ***or*** due to the common ion effect	 1
(d)	$[Fe^{3+}(aq)] = 0.2$ mol dm^{-3} $[H^+] = \sqrt{(c.K_a)} = \sqrt{(0.2 \times 8.9 \times 10^{-4})}$ or 1.33×10^{-2} (mol dm^{-3}) pH = –log($[H^+]$) = **1.9** *(or 1.87–1.89)*	1 1
	[Total: 13]	
5 (a)	(see table below)	1 1
(b)	CCl_4: no reaction $GeCl_4$ and $SnCl_4$: for **each** steamy fumes evolved *or* white solid produced $GeCl_4 + 2H_2O \longrightarrow GeO_2 + 4HCl$ $SnCl_4 + 2H_2O \rightarrow SnO_2 + 4HCl$	1 1 1 1
(c)	Ge/Sn **use** d–orbitals ***or*** Ge/Sn have low lying d orbitals ***or*** carbon cannot expand its octet ***or*** carbon cannot accommodate more than 4 bonded pairs	1
(d)	$Sn^{4+}/Sn^{2+} = +0.15V$ **and** $Pb^{4+}/Pb^{2+} = +1.69V$ **and** $Cl_2/Cl^- = +1.36V$ Sn^{2+} is oxidised by Cl_2 because its $E^⦵$ is less positive/more negative ***or*** Sn^{2+} is a good reducing agent due to its smaller *E* value than Cl_2 **ora** **or** Pb^{4+} is a stronger oxidising agent than Cl_2 so Pb^{2+} with Cl_2 reaction is not feasible **or** Sn^{4+} is a weaker oxidising agent than Cl_2 so Sn^{2+} with Cl_2 reaction is feasible $SnCl_2 + Cl_2 \longrightarrow SnCl_4$ ***or*** $Sn^{2+} + Cl_2 \longrightarrow Sn^{4+} + 2Cl^-$ ***or*** $SnCl_2 + Cl_2 + 2H_2O \longrightarrow SnO_2 + 4HCl$	1 1 1
(e) (i)	F = Le	1
(ii)	moles of $O_2(g) = 130/24000 = 5.417 \times 10^{-3}$ mol moles of electrons needed = $4 \times 5.417 \times 10^{-3}$ ***or*** 2.17×10^{-2} mol no. of coulombs passed = 1.2 x 30 x 60 ***or*** 2160 C no. of electrons passed = $2160/1.6 \times 10^{-19}$ ***or*** 1.35×10^{22} no. of electrons per mole = $1.35 \times 10^{22}/2.17 \times 10^{-2}$ = $\mathbf{6.2 \times 10^{23}}$ (mol^{-1})	1 1 1 1
	[Total: 15]	

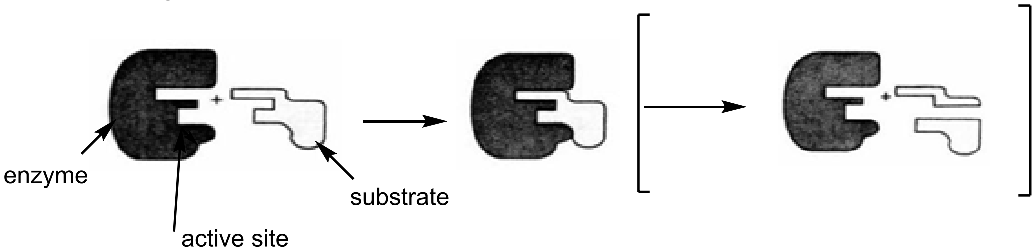
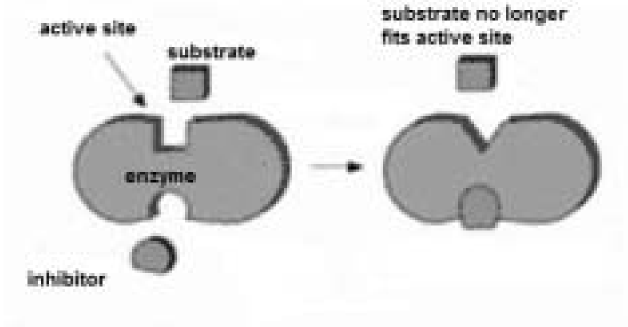
Table for 5 (a):

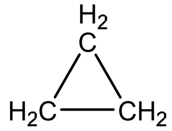
	protons	electrons	neutrons
$^{14}C^{2-}$	**6**	**8**	**8**

6 (a) (i)	CH_3COCl ***or*** ethanoyl chloride	**1**
(ii)	electrophilic substitution	**1**
(iii)	conc HNO_3 **and** conc H_2SO_4	**1**
(iv)	CHI_3 	**1** **1**
(b) (i)		**1**
(ii)	polyamide ***or*** condensation	**1**
(iii)	H_2O / water	**1**
(iv)	Sn / Fe + HC*l* + conc / aq / heat/warm	**1**
(v)	harder ***or*** more dense ***or*** stronger ***or*** higher m.pt ***or*** tougher ***or*** more rigid due to cross-linking **or** more H-bonding between the chains	**1**
		[Total: 10]

7 (a)	(i)	heat with catalyst ***or*** heat with Al_2O_3 / SiO_2	1
	(ii)	**B** is $CH_3CH_2CH_3$	1
	(iii)	**C** is $CH_2{=}CHCH_2CH_2CH_3$ **D** and **E** are $CH_3CH{=}CHCH_2CH_3$ (one shown as cis, the other as trans) **F** is $CH_3CH_2CH_2CO_2H$ **G** is CH_3CO_2H **H** is $CH_3CH_2CO_2H$	1 1 1
	(iv)	geometrical *or* cis-trans *or* *E*–*Z*	1
(b)	(i)	No particular conditions ***or*** in the dark	1
	(ii)	electrophilic addition	1
	(iii)		1 1
			[Total: 10]
8 (a)	(i)	condensation	1
	(ii)		2
	(iii)	any **two** side-chain interactions mentioned with group	2

Ionic attractions / bonds	between $–CO_2^-$ and $–NH_3^+$
van der Waals	between alkyl / aryl / non-polar groups ***or*** valine
hydrogen(H) bonding	between –OH, $–NH_2$, COOH, –NH ***or*** serine
–S–S– ***or*** disulfide bonds ***or*** disulfur bond / bridge	between –SH groups or cysteine

	(b)	(i)	**labelled diagrams**  **or** **in words** • the enzyme has a specific shape **or** substrate shape is complementary to active site • the substrate bonds / binds / fits to the active site ***or*** other substrates do not fit into active site	 1 1
		(ii)	**labelled diagrams**  **or in words** • inhibitor binds to enzyme away from the active site ***or*** inhibitor binds to allosteric site • this changes the **shape (or structure)** of the **active site** • substrate no longer fits the active site	 1 1 1
			[Total: 10]	
9	(a)	(i)	use restriction enzymes ***or*** using an enzyme to break (the DNA) down into smaller fragments	1
		(ii)	use the polymerase chain reaction ***or*** use DNA polymerase to replicate / copy (the sample of DNA)	1
		(iii)	• amino acids have different charges due to their side-chain / R group / pH / CO_2^- **and** NH_3^+ groups • DNA fragments have negatively-charge phosphates(or PO_4) ***or*** DNA has PO_4^{3-} groups	1 1

(iv)	A piece of leather from an Egyptian tomb | A sample of skin from a mummified body | A fragment of ancient pottery | **X** A piece of wood from a Roman chariot |	1
(b) (i)	the electron density in the molecule ***or*** positions of atoms ***or*** interatomic distance / spacing between the atoms	1
(ii)	phosphorus has the most electrons ***or*** phosphorus has the highest electron density	1
(c) (i)	equilibrium constant (for the solution) of a solute between two (immiscible) solvents ***or*** ratio of the concentration of the solute in (each of the) two solvents ***or*** ratio of the solubility of the solute in (each of the) two solvents	1
(ii)	$\frac{x/(25/1000)}{(0.0042-x)/(25/1000)}$ x = 0.0252 – 6x x = **0.0036g**	1 1
	[Total: 10]	
10 (a) (i)	any **three** of the following structures $CH_3CH_2CH_3$ $CH_3CH{=}CH_2$ $CH_3C{\equiv}CH$ $CH_2{=}C{=}CH_2$ 	2
(ii)	**K** since it has the greatest % of hydrocarbons / carbon-containing compounds ***or*** 99.6 % of it is burnt for energy	1
(iii)	any **two** from • reacted with lime / CaO / soda lime / $Ca(OH)_2$ / KOH / NaOH / • liquefied under pressure / ≥5 atm • dissolved in water under pressure / ≥5 atm	2
(b) (i)	have a shorter carbon / hydrocarbon chain ***or*** shorter hydrocarbon ***or*** fewer carbon atoms in its chain ***or*** have high H / C ratio	1
(ii)	Coal	1

	produces the largest amount of SO_2 ***or*** largest combined amount of SO_2 and NO_2	
(iii)	they burn at higher temperatures ***or*** release more heat on burning	**1**
(iv)	CO – the gas is toxic/poisonous ***or*** references to Hb **and** ability to carry oxygen CO_2 – the gas contributes to global warming	**1** **1**
		[Total: 10]