

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

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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: $F_2 / F^- = 2.87V$ and $Cl_2 / Cl^- = 1.36V$ 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 $(RCOCl)$ has two electron-withdrawing groups/atoms, making the more δ^+ /electron deficient or $(RCOCl)$ has an oxygen, making the carbon more δ^+ /electron deficient or $(RCOCl)$ has two electron-withdrawing groups, weakening the C–Cl 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]		

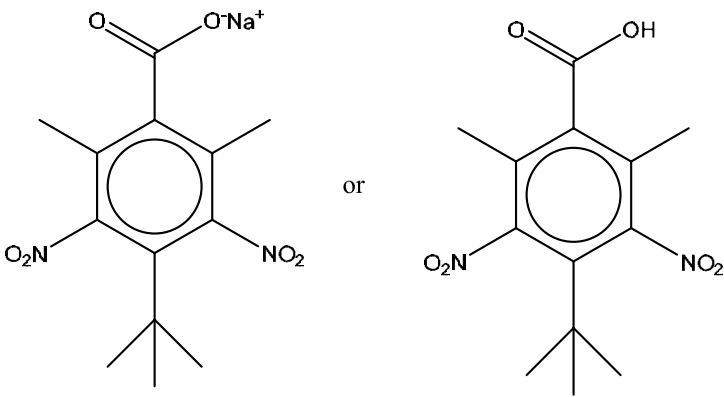
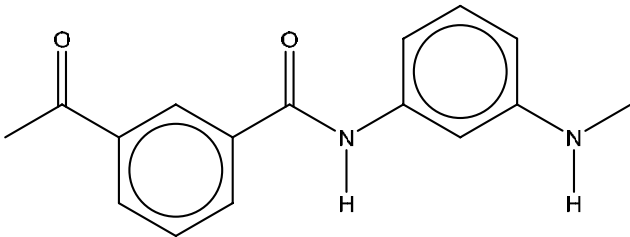
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3	(a)	(i)	<table><tr><td>isotope</td><td>relative abundance</td></tr><tr><td>^{24}Mg</td><td>78–79</td></tr><tr><td>^{25}Mg</td><td>10</td></tr><tr><td>^{26}Mg</td><td>12–11</td></tr></table> (total must add up to 100 %)	isotope	relative abundance	^{24}Mg	78–79	^{25}Mg	10	^{26}Mg	12–11	1
		isotope	relative abundance									
		^{24}Mg	78–79									
		^{25}Mg	10									
		^{26}Mg	12–11									
(ii)	e.g. $0.78 \times 24 + 0.10 \times 25 + 0.12 \times 26 = 24.34$	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)	$4\text{LiNO}_3 \longrightarrow 2\text{Li}_2\text{O} + 4\text{NO}_2 + \text{O}_2$	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)	$K_{\text{sp}} = [\text{Ag}^+(\text{aq})]^2[\text{SO}_4^{2-}(\text{aq})]$ and units: $\text{mol}^3\text{dm}^{-9}$	1								
		(ii)	$K_{\text{sp}} = (2 \times 0.025)^2 \times (0.025) = 6.25 \times 10^{-5}$	1								
	(b)	$2\text{Ag}^+(\text{g}) + \text{SO}_4^{2-}(\text{g})$ $\Delta H^\circ_{\text{latt}}$ $\text{Ag}_2\text{SO}_4(\text{s})$ $\Delta H^\circ_{\text{sol}}$ $\text{Ag}_2\text{SO}_4(\text{aq})$ or $2\text{Ag}^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq})$ $\Delta H^\circ_{\text{hyd}}$	1 1 1 1									
(c)	(i)	$E^\ominus_{\text{cell}} (= 0.80 - 0.77 =) (+)0.03\text{V}$ and Ag^+/Ag or Ag/silver or right	1									
	(ii)	E_{cell} would be less positive/more negative because the $[\text{Ag}^+(\text{aq})]$ (in the Ag electrode) is less than 1.0 mol dm^{-3}	1									
	(iii)	• no change	1									

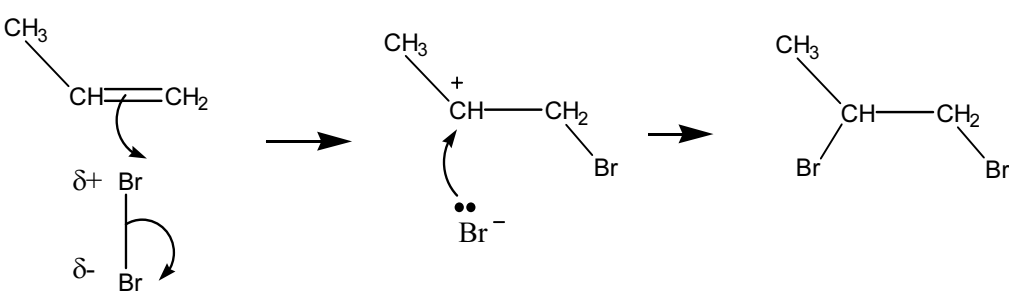
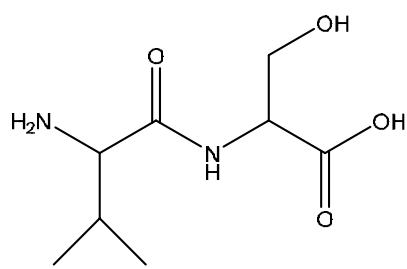
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	more negative/less positive	1								
(iv)	the $[\text{Ag}^+(\text{aq})]$ will decrease $E_{\text{electrode}}$ becomes less positive or due to the common ion effect	1								
(d)	$[\text{Fe}^{3+}(\text{aq})] = 0.2 \text{ mol dm}^{-3}$ $[\text{H}^+] = \sqrt{(c.K_a)} = \sqrt{(0.2 \times 8.9 \times 10^{-4})}$ or $1.33 \times 10^{-2} \text{ (mol dm}^{-3}\text{)}$ $\text{pH} = -\log([\text{H}^+]) = \mathbf{1.9}$ (or 1.87–1.89)	1 1								
[Total: 13]										
5 (a)	<table><tr><td></td><td>protons</td><td>electrons</td><td>neutrons</td></tr><tr><td>$^{14}\text{C}^{2-}$</td><td>6</td><td>8</td><td>8</td></tr></table>		protons	electrons	neutrons	$^{14}\text{C}^{2-}$	6	8	8	1 1
	protons	electrons	neutrons							
$^{14}\text{C}^{2-}$	6	8	8							
(b)	CCl_4 : no reaction GeCl_4 and SnCl_4 : for each steamy fumes evolved <i>or</i> white solid produced $\text{GeCl}_4 + 2\text{H}_2\text{O} \longrightarrow \text{GeO}_2 + 4\text{HCl}$ $\text{SnCl}_4 + 2\text{H}_2\text{O} \rightarrow \text{SnO}_2 + 4\text{HCl}$	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)	$\text{Sn}^{4+}/\text{Sn}^{2+} = +0.15\text{V}$ and $\text{Pb}^{4+}/\text{Pb}^{2+} = +1.69\text{V}$ and $\text{Cl}_2/\text{Cl}^- = +1.36\text{V}$ Sn^{2+} is oxidised by Cl_2 because its $E^\ominus$ 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 $\text{SnCl}_2 + \text{Cl}_2 \longrightarrow \text{SnCl}_4$ or $\text{Sn}^{2+} + \text{Cl}_2 \longrightarrow \text{Sn}^{4+} + 2\text{Cl}^-$ or $\text{SnCl}_2 + \text{Cl}_2 + 2\text{H}_2\text{O} \longrightarrow \text{SnO}_2 + 4\text{HCl}$	1 1 1								
(e) (i)	F = Le	1								
(ii)	moles of $\text{O}_2(\text{g}) = 130/24000 = 5.417 \times 10^{-3} \text{ mol}$ moles of electrons needed = $4 \times 5.417 \times 10^{-3}$ or $2.17 \times 10^{-2} \text{ mol}$ no. of coulombs passed = $1.2 \times 30 \times 60$ 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]										

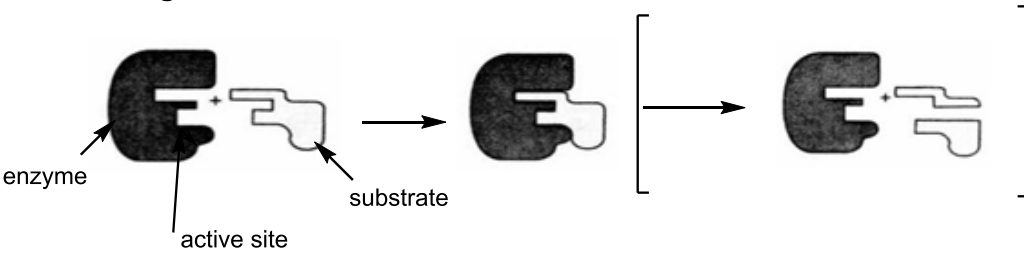
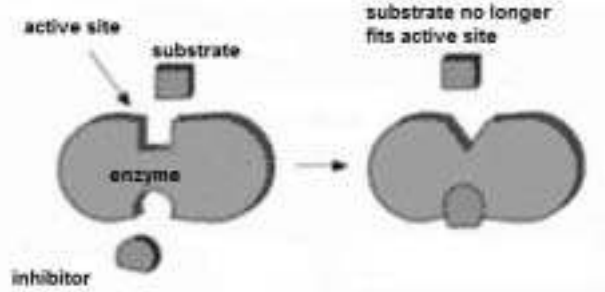
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6	(a) (i)	CH_3COCl or ethanoyl chloride	1
	(ii)	electrophilic substitution	1
	(iii)	conc HNO_3 and conc H_2SO_4	1
	(iv)	CHI_3 	1 1
	(b) (i)		1
	(ii)	polyamide or condensation	1
	(iii)	H_2O /water	1
	(iv)	$\text{Sn/Fe} + \text{HCl} + \text{conc/aq/heat/warm}$	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]			

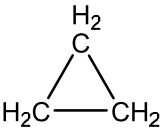
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7	(a) (i)	heat with catalyst or heat with $\text{Al}_2\text{O}_3/\text{SiO}_2$	1								
	(ii)	B is $\text{CH}_3\text{CH}_2\text{CH}_3$	1								
	(iii)	C is $\text{CH}_2=\text{CHCH}_2\text{CH}_2\text{CH}_3$	1								
		D and E are $\text{CH}_3\text{CH}=\text{CHCH}_2\text{CH}_3$ (one shown as cis, the other as trans)	1								
		F is $\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$	1								
		G is $\text{CH}_3\text{CO}_2\text{H}$									
		H is $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$									
	(iv)	geometrical <i>or</i> cis-trans <i>or</i> 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 <table border="1" data-bbox="293 1733 1307 2013"><tr><td>ionic attractions / bonds</td><td>between CO_2^- and NH_3^+</td></tr><tr><td>van der Waals</td><td>between alkyl / aryl / non-polar groups or valine</td></tr><tr><td>hydrogen(H) bonding</td><td>between OH, NH_2, COOH, NH or serine</td></tr><tr><td>S-S or disulfide bonds or disulfur bond / bridge</td><td>between SH groups or cysteine</td></tr></table>	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	2
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(b) (i)	labelled diagrams  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/CO₂⁻ and NH₃⁺ groups - DNA fragments have negatively-charge phosphates(or PO₄) or DNA has PO₄³⁻ groups	1 1

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(iv)	A piece of leather from an Egyptian tomb		1
	A sample of skin from a mummified body		
	A fragment of ancient pottery	X	
	A piece of wood from a Roman chariot		
(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)	$\frac{x}{(25/1000)}$ $\frac{(0.0042-x)}{(25/1000)}$ $x = 0.0252 - 6x$ $x = \mathbf{0.0036g}$		1 1
[Total: 10]			
10 (a) (i)	any three of the following structures CH ₃ CH ₂ CH ₃ CH ₃ CH=CH ₂ CH ₃ C≡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

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	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	1
	CO ₂ – the gas contributes to global warming	1
[Total: 10]		