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Cambridge International Advanced Level

MARK SCHEME for the May/June 2015 series

9701 CHEMISTRY

9701/43 Paper 4 (Structured Questions), maximum raw mark 100

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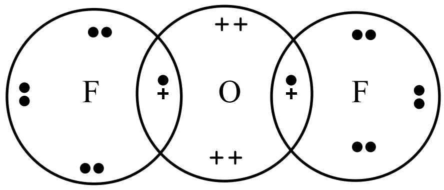
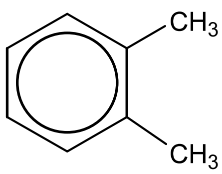
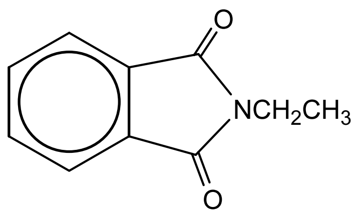
Question	Marking point	Marks
1 (a)	oxygen: $(1s^2)\ 2s^22p^4$ fluorine: $(1s^2)\ 2s^22p^5$	**1**
(b) (i)	F_2O / OF_2	**1**
(ii)		**1**
(iii)	bent ***or*** non-linear	**1**
(c) (i)	$E^{\ominus}$ values: F_2 / F^- = 2.87 V **and** Cl_2 / Cl^- = 1.36 V fluorine (has the more positive $E^{\ominus}$ so) is more oxidising	**1** **1**
(ii)	redox	**1**
(iii)	$ClF + 2KBr \longrightarrow KCl + KF + Br_2$	**1**
		[Total: 8]
2 (a) (i)	hydrogen chloride ***or*** HC*l*	**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]

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3 (a) (i)		isotope	relative abundance
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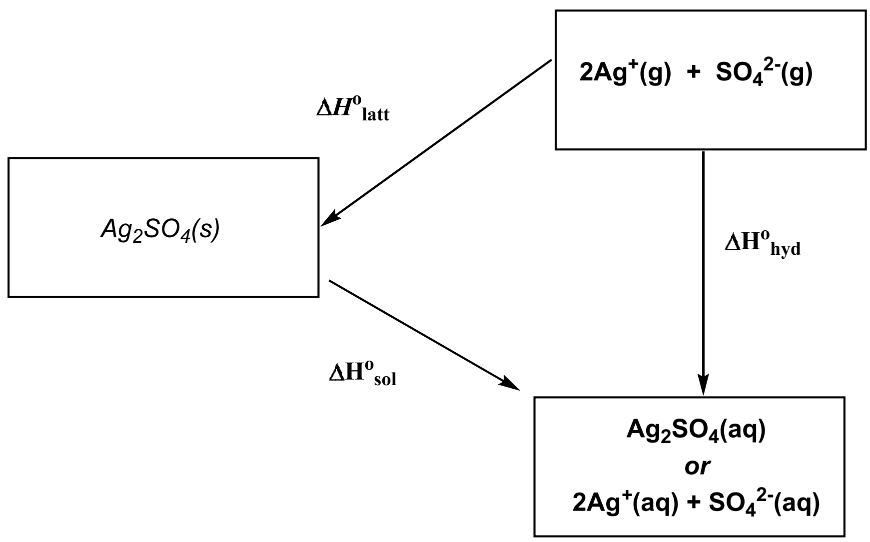
^{24}Mg	**78–79**
^{25}Mg	**10**
^{26}Mg	**12–11** | (**total must add up to 100 %**)	1
(ii)	e.g. 0.78x24 + 0.10x25 + 0.12x26 = **24.34**	1
(b) (i)	nitrates become more stable (down the group)	1
	as the ionic radius increases ***or*** charge density on cation/ion decreases	1
	decreasing its ability to distort/polarise the NO_3^-/nitrate ion	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)	$K_{sp} = (2 \times 0.025)^2 \times (0.025) =$ $\mathbf{6.25 \times 10^{-5}}$	1
(b)	(diagram below)	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	1
	because the $[Ag^+(aq)]$ (in the Ag electrode) is less than 1.0 mol dm^{-3}	
(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)	$Sn^{4+}/Sn^{2+} = +0.15$ V **and** $Pb^{4+}/Pb^{2+} = +1.69$ V **and** $Cl_2/Cl^- = + 1.36$ 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 $SnCl_2 + Cl_2 \longrightarrow SnCl_4$ ***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 / 24 000 = 5.417×10^{-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 / 1.6×10^{-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**

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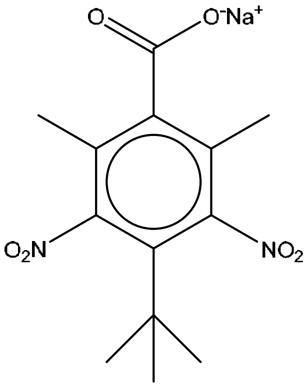
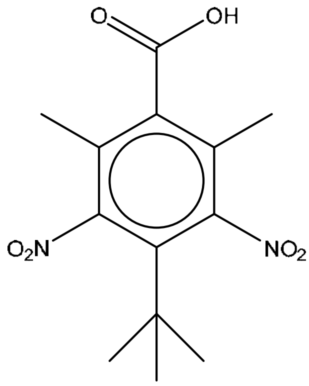
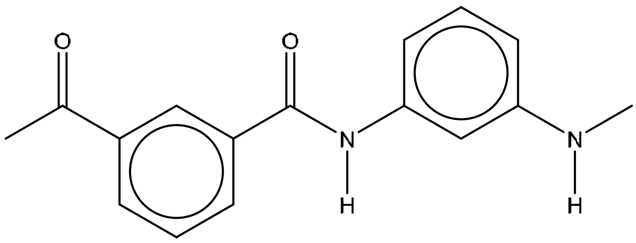
6 (a) (i)	CH_3COCl ***or*** ethanoyl chloride	**1**
(ii)	electrophilic substitution	**1**
(iii)	conc HNO_3 **and** conc H_2SO_4	**1**
(iv)	CHI_3  or 	**1** **1**
(b) (i)		**1**
(ii)	polyamide ***or*** condensation	**1**
(iii)	H_2O / water	**1**
(iv)	Sn / Fe + HCl + conc / aq / heat/warm	**1**
(v)	harder ***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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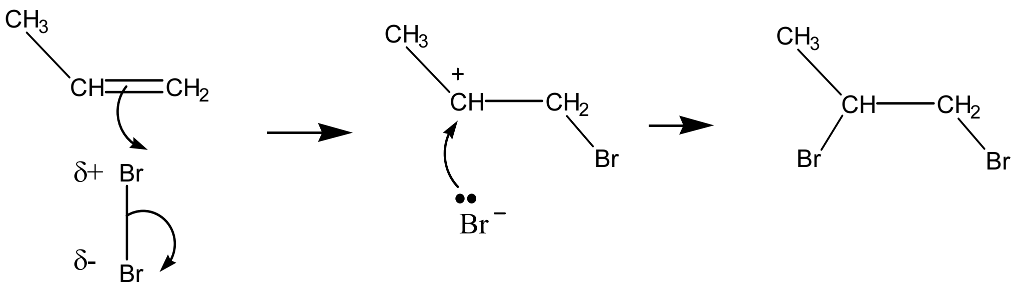
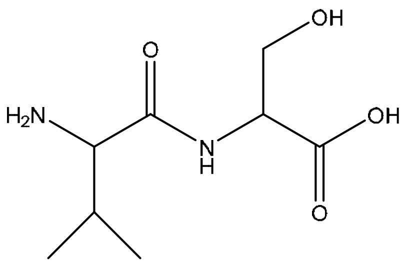
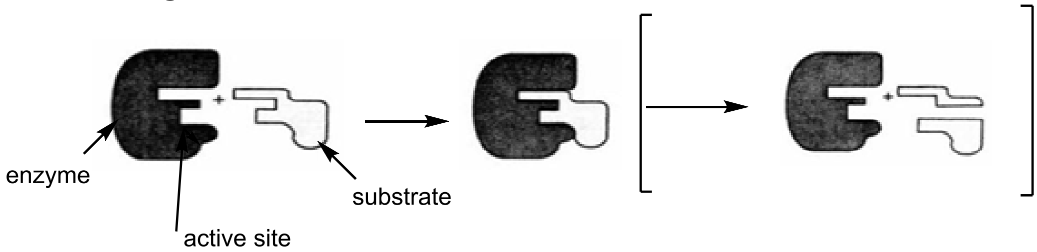
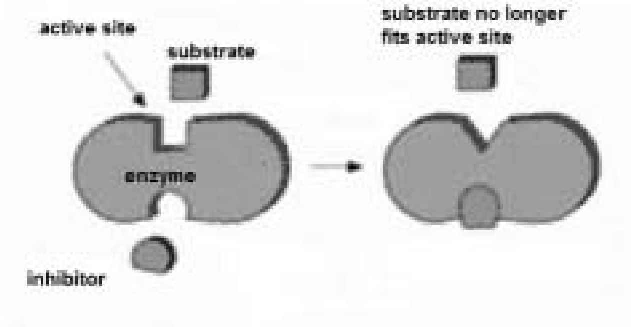
7 (a) (i)	heat with catalyst ***or*** heat with Al_2O_3 / SiO_2	**1**
(ii)	**B** is $CH_3CH_2CH_3$	**1**
(iii)	**C** is $CH_2{=}CHCH_2CH_2CH_3$	**1**
	D and **E** are $CH_3CH{=}CHCH_2CH_3$ (one shown as cis, the other as trans)	**1**
	F is $CH_3CH_2CH_2CO_2H$	**1**
	G is CH_3CO_2H	
	H is $CH_3CH_2CO_2H$	
(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

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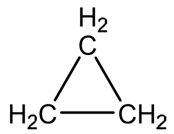
(iv)	A piece of leather from an Egyptian tomb | A sample of skin from a mummified body | A fragment of ancient pottery | **X** A piece of wood from a Roman chariot |	**1**
(b) (i)	the electron density in the molecule ***or*** positions of atoms ***or*** interatomic distance / spacing between the atoms	**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]