

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.

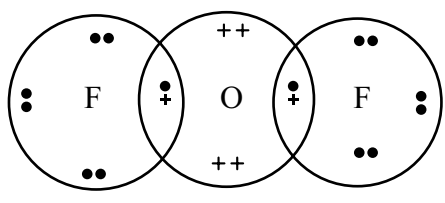
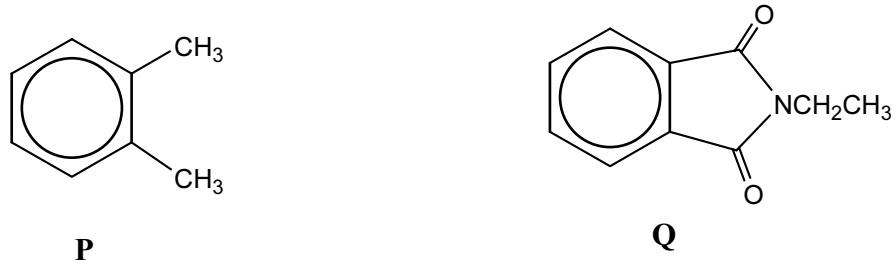
Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

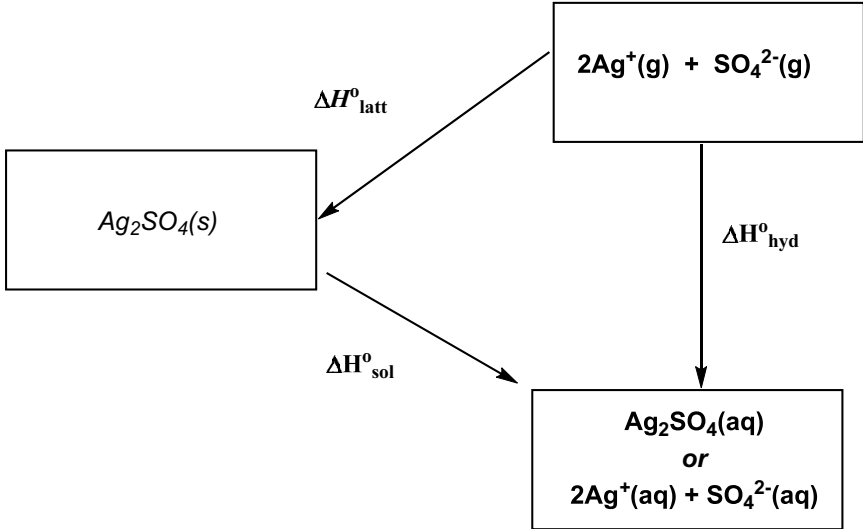
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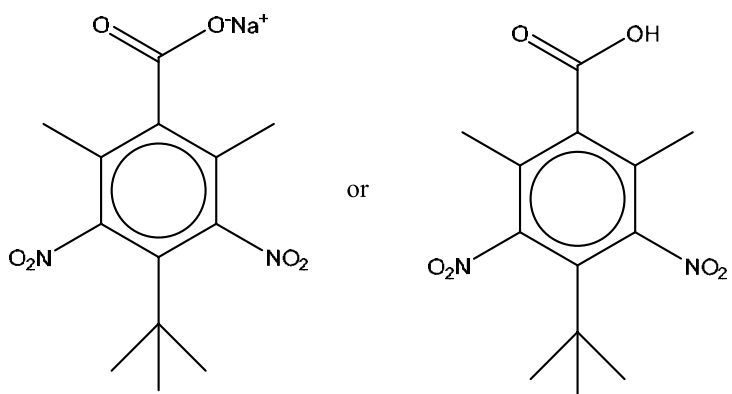
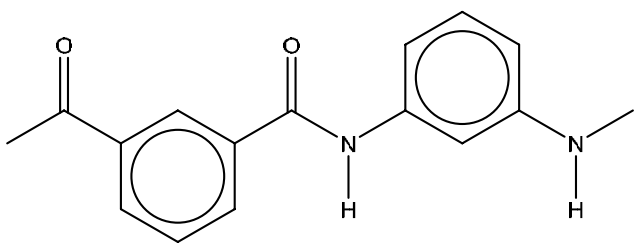
Question	Marking point	Marks
1 (a)	oxygen: $(1s^2) 2s^2 2p^4$ fluorine: $(1s^2) 2s^2 2p^5$	1
(b) (i)	F_2O / OF_2	1
(ii)		1
(iii)	bent <i>or</i> non-linear	1
(c) (i)	E^\ominus values: $F_2 / F^- = 2.87V$ and $Cl_2 / Cl^- = 1.36V$ fluorine (has the more positive E^\ominus so) is more oxidising	1 1
(ii)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

3	(a) (i)	isotope	relative abundance	1
		^{24}Mg	78–79	
		^{25}Mg	10	
		^{26}Mg	12–11	
(total must add up to 100 %)				
	(ii)	e.g. $0.78 \times 24 + 0.10 \times 25 + 0.12 \times 26 = \mathbf{24.34}$		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)	$K_{\text{sp}} = (2 \times 0.025)^2 \times (0.025) = \mathbf{6.25 \times 10^{-5}}$		1
	(b)			1 1 1 1
	(c) (i)	$E^\ominus_{\text{cell}} (= 0.80 - 0.77 =) (+)\mathbf{0.03V}$ 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)	<ul style="list-style-type: none"> • no change 		1

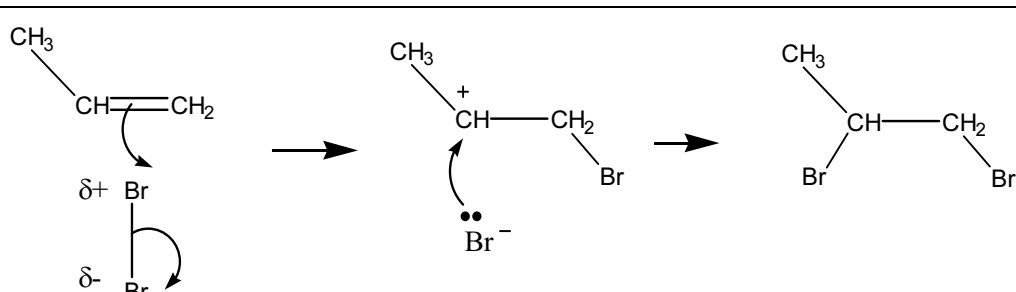
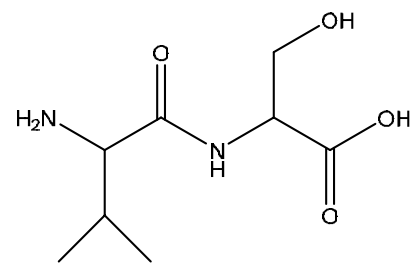
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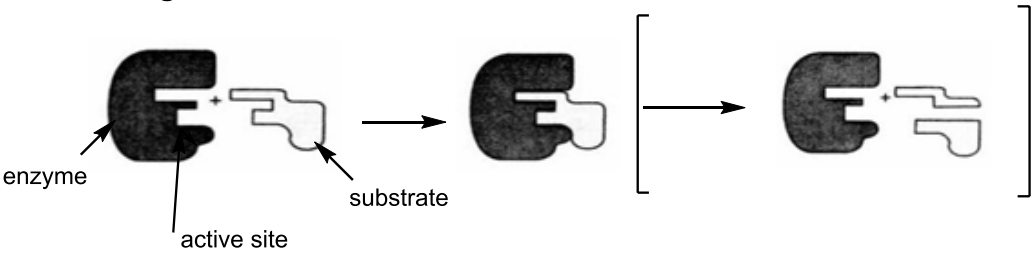
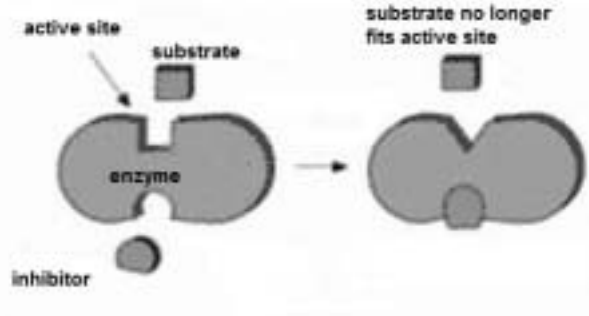
	<ul style="list-style-type: none"> more negative/less positive 	1								
(iv)	<p>the $[Ag^+(aq)]$ will decrease</p> <p>$E_{\text{electrode}}$ becomes less positive or due to the common ion effect</p>	1								
(d)	$[Fe^{3+}(aq)] = 0.2 \text{ mol dm}^{-3}$	1								
	<p>$[H^+] = \sqrt{c \cdot K_a} = \sqrt{(0.2 \times 8.9 \times 10^{-4})}$ or $1.33 \times 10^{-2} \text{ (mol dm}^{-3}\text{)}$</p> <p>$pH = -\log([H^+]) = 1.9$ (or 1.87–1.89)</p>	1								
[Total: 13]										
5 (a)	<table border="1"> <thead> <tr> <th></th> <th>protons</th> <th>electrons</th> <th>neutrons</th> </tr> </thead> <tbody> <tr> <td>$^{14}C^{2-}$</td> <td>6</td> <td>8</td> <td>8</td> </tr> </tbody> </table>		protons	electrons	neutrons	$^{14}C^{2-}$	6	8	8	1
		protons	electrons	neutrons						
$^{14}C^{2-}$	6	8	8							
		1								
(b)	CCl_4 : no reaction	1								
	$GeCl_4$ and $SnCl_4$: for each steamy fumes evolved or white solid produced	1								
	$GeCl_4 + 2H_2O \longrightarrow GeO_2 + 4HCl$	1								
	$SnCl_4 + 2H_2O \rightarrow SnO_2 + 4HCl$	1								
(c)	<p>Ge/Sn use d-orbitals</p> <p>or Ge/Sn have low lying d orbitals</p> <p>or carbon cannot expand its octet</p> <p>or carbon cannot accommodate more than 4 bonded pairs</p>	1								
(d)	<p>$Sn^{4+}/Sn^{2+} = +0.15V$ and $Pb^{4+}/Pb^{2+} = +1.69V$ and $Cl_2/Cl^- = +1.36V$</p> <p>Sn^{2+} is oxidised by Cl_2 because its E^\ominus is less positive / more negative</p> <p>or Sn^{2+} is a good reducing agent due to its smaller E value than Cl_2 ora</p> <p>or Pb^{4+} is a stronger oxidising agent than Cl_2 so Pb^{2+} with Cl_2 reaction is not feasible</p> <p>or Sn^{4+} is a weaker oxidising agent than Cl_2 so Sn^{2+} with Cl_2 reaction is feasible</p>	1								
	<p>$SnCl_2 + Cl_2 \longrightarrow SnCl_4$</p> <p>or $Sn^{2+} + Cl_2 \longrightarrow Sn^{4+} + 2Cl^-$</p> <p>or $SnCl_2 + Cl_2 + 2H_2O \longrightarrow SnO_2 + 4HCl$</p>	1								
			1							
(e) (i)	$F = Le$	1								
(ii)	moles of $O_2(g) = 130/24000 = 5.417 \times 10^{-3} \text{ mol}$	1								
	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	1								
	no. of electrons passed = $2160/1.6 \times 10^{-19}$ or 1.35×10^{22}	1								
	no. of electrons per mole = $1.35 \times 10^{22}/2.17 \times 10^{-2} = 6.2 \times 10^{23} \text{ (mol}^{-1}\text{)}$	1								
[Total: 15]										

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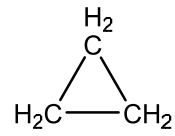
6	(a)	(i)	CH_3COCl <i>or</i> ethanoyl chloride	1
		(ii)	electrophilic substitution	1
		(iii)	conc HNO_3 and conc H_2SO_4	1
		(iv)	CHI_3 <div style="text-align: center;">  <p>The image shows two chemical structures of 2,4,6-trinitrotoluene (TNT) separated by the word 'or'. The structure on the left is the sodium salt form, where the carboxyl group is represented as COO^-Na^+. The structure on the right is the carboxylic acid form, where the carboxyl group is represented as COOH. Both structures feature a central benzene ring with a methyl group (CH_3) at the 1-position and three nitro groups (NO_2) at the 2, 4, and 6 positions.</p> </div>	1
	(b)	(i)	 <p>The image shows the chemical structure of a polyamide chain. It consists of two benzene rings connected by amide bonds. The left benzene ring has an acetyl group (CH_3CO) at the 1-position and an amide group (CONH) at the 3-position. The right benzene ring has an amide group (NH) at the 1-position and a methylamino group (NHCH_3) at the 3-position.</p>	1
		(ii)	polyamide <i>or</i> condensation	1
		(iii)	H_2O /water	1
		(iv)	$\text{Sn/Fe} + \text{HCl} + \text{conc/aq/heat/warm}$	1
		(v)	harder <i>or</i> more dense <i>or</i> stronger <i>or</i> higher m.pt <i>or</i> tougher <i>or</i> more rigid due to cross-linking <i>or</i> 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 $\text{CH}_2=\text{CHCH}_2\text{CH}_2\text{CH}_3$ D and E are $\text{CH}_3\text{CH}=\text{CHCH}_2\text{CH}_3$ (one shown as cis, the other as trans) F is $\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$ G is $\text{CH}_3\text{CO}_2\text{H}$ H is $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$	1 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								
		<table border="1"> <tr> <td>Ionic attractions / bonds</td> <td>between $-\text{CO}_2^-$ and $-\text{NH}_3^+$</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 $-\text{OH}$, $-\text{NH}_2$, COOH, $-\text{NH}$ or serine</td> </tr> <tr> <td>$-\text{S}-\text{S}-$ or disulfide bonds or disulfur bond / bridge</td> <td>between $-\text{SH}$ groups or cysteine</td> </tr> </table>		Ionic attractions / bonds	between $-\text{CO}_2^-$ and $-\text{NH}_3^+$	van der Waals	between alkyl / aryl / non-polar groups or valine	hydrogen(H) bonding	between $-\text{OH}$, $-\text{NH}_2$, COOH , $-\text{NH}$ or serine	$-\text{S}-\text{S}-$ or disulfide bonds or disulfur bond / bridge	between $-\text{SH}$ groups or cysteine
Ionic attractions / bonds	between $-\text{CO}_2^-$ and $-\text{NH}_3^+$										
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$-\text{S}-\text{S}-$ or disulfide bonds or disulfur bond / bridge	between $-\text{SH}$ groups or cysteine										

<p>(b) (i)</p>	<p>labelled diagrams</p>  <p>in words</p> <ul style="list-style-type: none"> 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 	<p>1</p> <p>1</p>
<p>(ii)</p>	<p>labelled diagrams</p>  <p>or in words</p> <ul style="list-style-type: none"> 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 	<p>1</p> <p>1</p> <p>1</p>
<p>[Total: 10]</p>		
<p>9 (a) (i)</p>	<p>use restriction enzymes or using an enzyme to break (the DNA) down into smaller fragments</p>	<p>1</p>
<p>(ii)</p>	<p>use the polymerase chain reaction or use DNA polymerase to replicate/copy (the sample of DNA)</p>	<p>1</p>
<p>(iii)</p>	<ul style="list-style-type: none"> 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 	<p>1</p> <p>1</p>

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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)	$\frac{x/(25/1000)}{(0.0042-x)/(25/1000)}$ $x = 0.0252 - 6x$ $x = \mathbf{0.0036g}$		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 <ul style="list-style-type: none"> 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]