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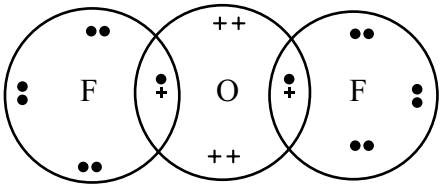
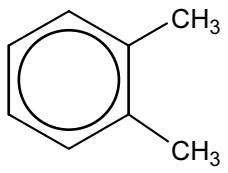
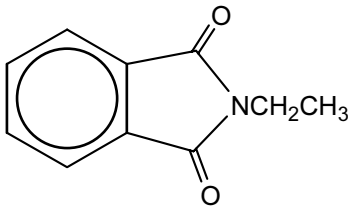
| Question | Marking point | Marks |
|---|---|---|
| 1 (a) | oxygen: $(1s^2)\ 2s^2 2p^4$<br>fluorine: $(1s^2)\ 2s^2 2p^5$ | 1 |
| (b) (i) | $F_2O$ / $OF_2$ | 1 |
| (ii) |  | 1 |
| (iii) | bent ***or*** non-linear | 1 |
| (c) (i) | $E^\ominus$ values: $F_2 / F^-$ = 2.87 V **and** $Cl_2 / Cl^-$ = 1.36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

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**3 (a) (i)**

| isotope | relative abundance |
|---|---|
| $^{24}Mg$ | **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**

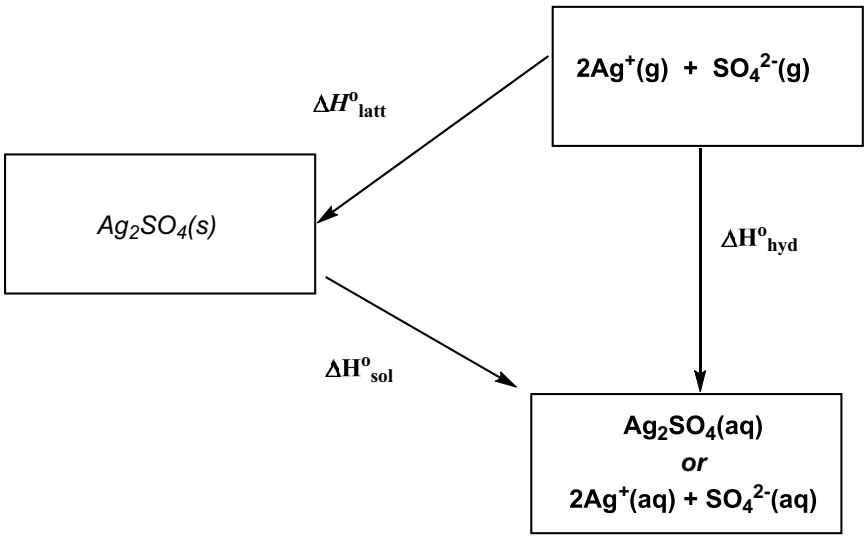
**(iii)** the **charge density** of the other cations are too small (to polarise the anion sufficiently so the anion is more stable) — **1**

**[Total: 7]**

**4 (a) (i)** $K_{sp} = [Ag^+(aq)]^2[SO_4^{2-}(aq)]$ **and** units: $mol^3dm^{-9}$ — **1**

**(ii)** $K_{sp} = (2 \times 0.025)^2 \times (0.025) =$ **$6.25 \times 10^{-5}$** — **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 — **1**

because the $[Ag^+(aq)]$ (in the Ag electrode) is less than 1.0 mol $dm^{-3}$

**(iii)**
- no change — **1**

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| | | |
|---|---|---|
| | • more negative/less positive | **1** |
| **(iv)** | the $[Ag^+(aq)]$ will decrease<br><br>$E_{electrode}$ becomes less positive ***or*** due to the common ion effect | <br><br>**1** |
| **(d)** | $[Fe^{3+}(aq)] = 0.2$ mol dm$^{-3}$<br><br>$[H^+] = \sqrt{(c.K_a)} = \sqrt{(0.2 \times 8.9 \times 10^{-4})}$ or $1.33 \times 10^{-2}$ (mol dm$^{-3}$)<br>pH = –log($[H^+]$) = **1.9** *(or 1.87–1.89)* | **1**<br><br>**1** |
| | | **[Total: 13]** |
| **5 (a)** | <br>protons: **6**; electrons: **8**; neutrons: **8** for $^{14}C^{2-}$ | **1**<br><br>**1** |
| **(b)** | $CCl_4$: no reaction<br>$GeCl_4$ and $SnCl_4$: for **each** steamy fumes evolved *or* white solid produced<br>$GeCl_4 + 2H_2O \longrightarrow GeO_2 + 4HCl$<br>$SnCl_4 + 2H_2O \rightarrow SnO_2 + 4HCl$ | **1**<br>**1**<br>**1**<br>**1** |
| **(c)** | Ge/Sn **use** d–orbitals<br>***or*** Ge/Sn have low lying d orbitals<br>***or*** carbon cannot expand its octet<br>***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<br><br>$Sn^{2+}$ is oxidised by $Cl_2$ because its $E^{\ominus}$ is less positive/more negative<br>**or** $Sn^{2+}$ is a good reducing agent due to its smaller $E$ value than $Cl_2$ **ora**<br>**or** $Pb^{4+}$ is a stronger oxidising agent than $Cl_2$ so $Pb^{2+}$ with $Cl_2$ reaction is not feasible<br>**or** $Sn^{4+}$ is a weaker oxidising agent than $Cl_2$ so $Sn^{2+}$ with $Cl_2$ reaction is feasible<br><br>$SnCl_2 + Cl_2 \longrightarrow SnCl_4$<br>***or*** $Sn^{2+} + Cl_2 \longrightarrow Sn^{4+} + 2Cl^-$<br>***or*** $SnCl_2 + Cl_2 + 2H_2O \longrightarrow SnO_2 + 4HCl$ | **1**<br><br>**1**<br><br><br><br><br><br>**1** |
| **(e) (i)** | F = Le | **1** |
| **(ii)** | moles of $O_2(g) = 130/24000 = 5.417 \times 10^{-3}$ mol<br><br>moles of electrons needed = $4 \times 5.417 \times 10^{-3}$ ***or*** $2.17 \times 10^{-2}$ mol<br><br>no. of coulombs passed = $1.2 \times 30 \times 60$ ***or*** 2160 C<br><br>no. of electrons passed = $2160/1.6 \times 10^{-19}$ ***or*** $1.35 \times 10^{22}$<br><br>no. of electrons per mole = $1.35 \times 10^{22}/2.17 \times 10^{-2}$ = **$6.2 \times 10^{23}$** (mol$^{-1}$) | **1**<br><br><br>**1**<br><br>**1**<br><br>**1** |
| | | **[Total: 15]** |

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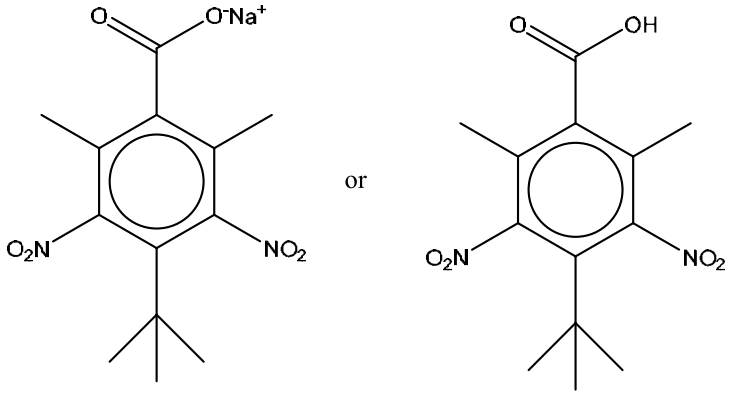
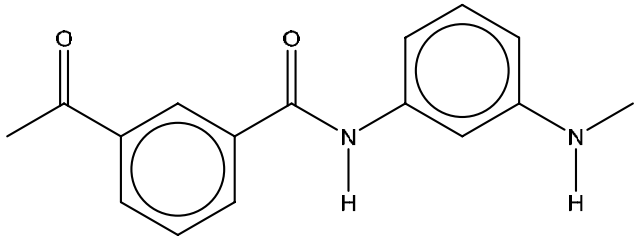
| | | |
|---|---|---|
| **6 (a) (i)** | $CH_3COCl$ ***or*** ethanoyl chloride | **1** |
| **(ii)** | electrophilic substitution | **1** |
| **(iii)** | conc $HNO_3$ **and** conc $H_2SO_4$ | **1** |
| **(iv)** | $CHI_3$<br><br> | **1**<br><br><br><br>**1** |
| **(b) (i)** | <br> | **1** |
| **(ii)** | 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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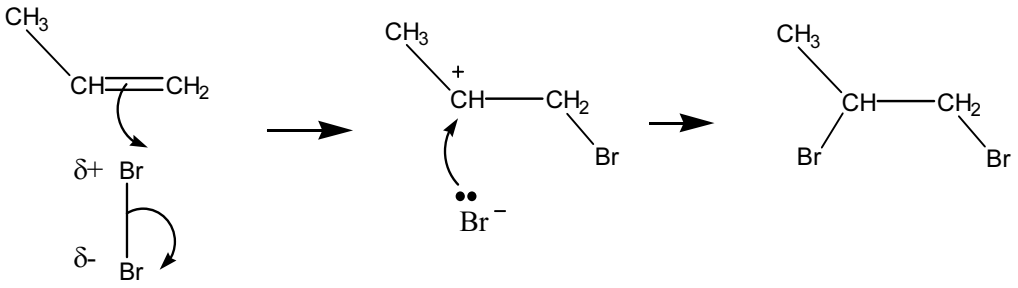
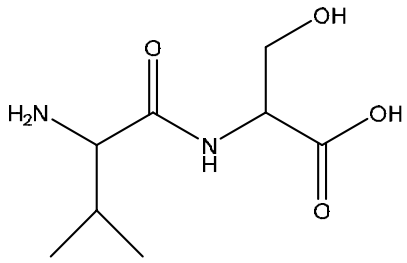
| | | |
|---|---|---|
| **7 (a) (i)** | heat with catalyst ***or*** heat with $Al_2O_3$ / $SiO_2$ | **1** |
| **(ii)** | **B** is $CH_3CH_2CH_3$ | **1** |
| **(iii)** | **C** is $CH_2{=}CHCH_2CH_2CH_3$ | **1** |
| | **D** and **E** are $CH_3CH{=}CHCH_2CH_3$ (one shown as cis, the other as trans) | **1** |
| | **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 |

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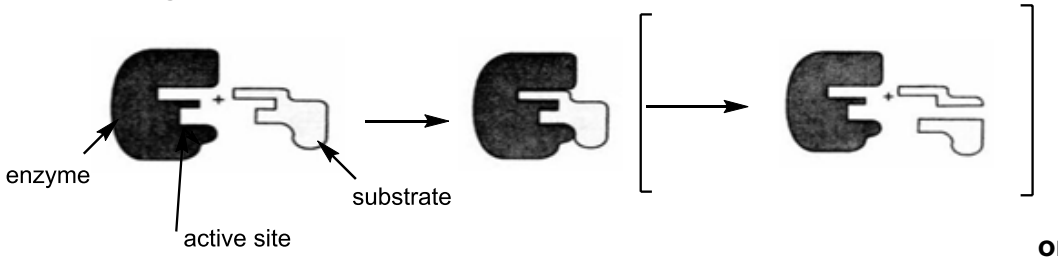
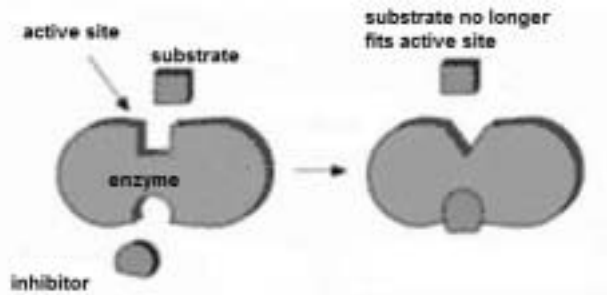
| | | |
|---|---|---|
| **(b) (i)** | **labelled diagrams**<br><br><br>**or**<br>**in words**<br>• the enzyme has a specific shape **or** substrate shape is complementary to active site<br>• the substrate bonds / binds / fits to the active site ***or*** other substrates do not fit into active site | **1**<br>**1** |
| **(ii)** | **labelled diagrams**<br><br><br>**or in words**<br>• inhibitor binds to enzyme away from the active site ***or*** inhibitor binds to allosteric site<br>• this changes the **shape (or structure)** of the **active site**<br>• substrate no longer fits the active site | **1**<br>**1**<br>**1** |
| | | **[Total: 10]** |
| **9 (a) (i)** | use restriction enzymes<br>***or*** using an enzyme to break (the DNA) down into smaller fragments | **1** |
| **(ii)** | use the polymerase chain reaction<br>***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<br>• DNA fragments have negatively-charge phosphates(or $PO_4$)<br>***or*** DNA has $PO_4^{3-}$ groups | **1**<br>**1** |

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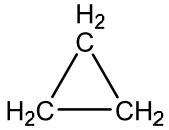
| | | |
|---|---|---|
| **(iv)** | <table><tr><td>A piece of leather from an Egyptian tomb</td><td></td></tr><tr><td>A sample of skin from a mummified body</td><td></td></tr><tr><td>A fragment of ancient pottery</td><td>**X**</td></tr><tr><td>A piece of wood from a Roman chariot</td><td></td></tr></table>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

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

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