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**Cambridge International Advanced Subsidiary and Advanced Level**

# MARK SCHEME for the March 2016 series

## 9701 CHEMISTRY

**9701/42** Paper 4 (A Level Structured Questions), maximum raw mark 100

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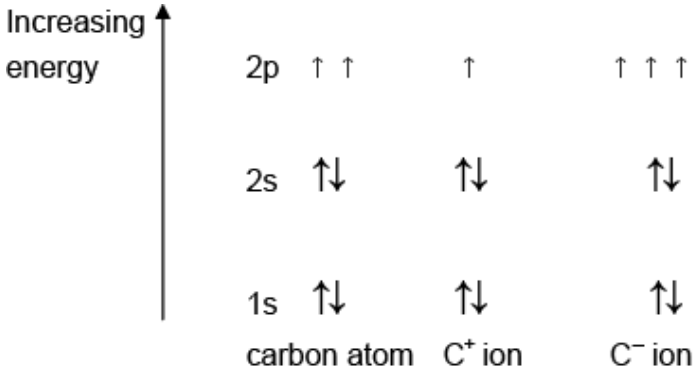
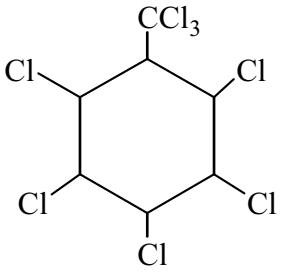
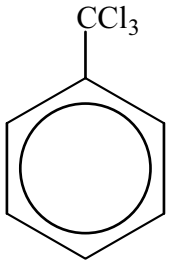
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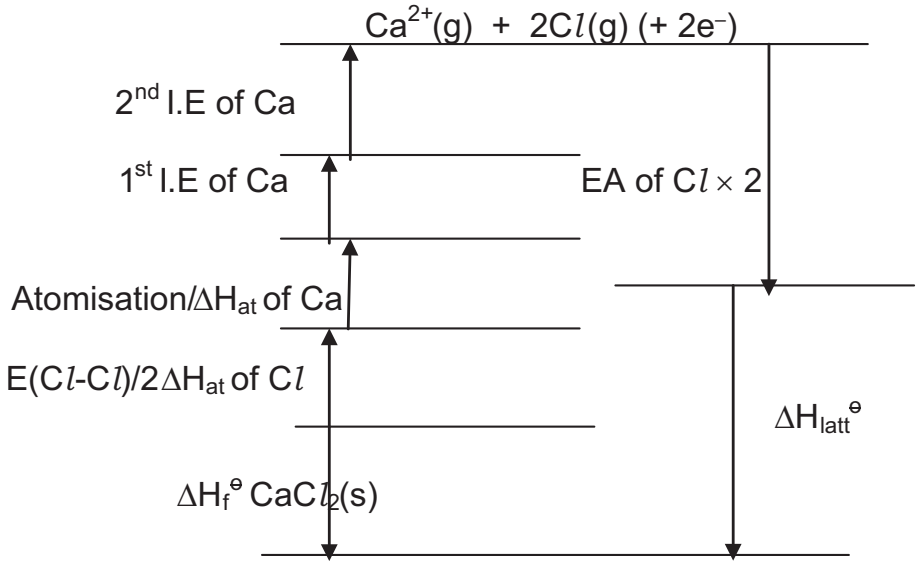
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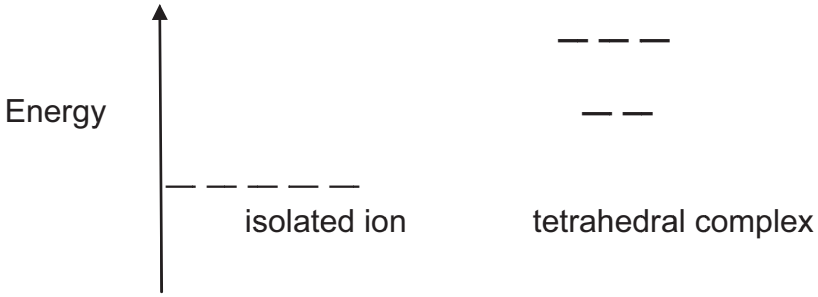
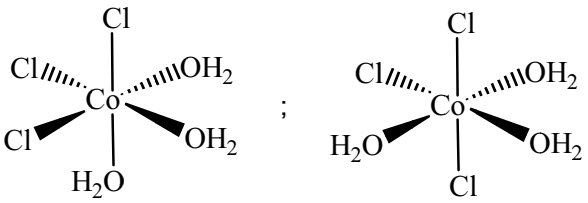
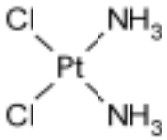
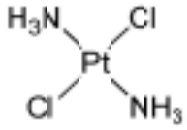
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| Question | Answer | Mark |
|---|---|---|
| 1 (a) |  | 2 |
| (b) (i) | $sp^2$ | 1 |
| (ii) | $x = 60$ / $C_{60}H_{60}$ | 1 |
| (c) (i) | reaction 1: $Cl_2$ and UV light;<br>reaction 2: $AlCl_3$, $Cl_2$ (NOT aqueous); | 1<br>1 |
| (ii) | (free) radical substitution | 1 |
| (iii) |  *or*  | 1 |

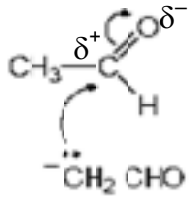
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| Question | Answer | Mark |
|---|---|---|
| 2 (a) (i) | $Ca^{2+}(g) + 2Cl^{-}(g) \rightarrow CaCl_2(s)$ (state symbols required) | 1 |
| (ii) |  | 2 |
| (iii) | $\Delta H_{latt}^{\ominus} = -796 - 242 - 178 - 590 - 1150 + (2 \times 349) = -2258\ kJ\ mol^{-1}$ | 3 |
| (b) | (higher temperature means that) particles have more energy;<br>entropy (of the gas / system) increases because of an increase in the amount of disorder / randomness; | 2 |
| (c) (i) | reaction / sign of $\Delta S^{\ominus}$:<br>$CO(g) + O_2(g) \rightarrow CO_2(g)$ — negative<br>$Mg(s) + ½O_2(g) \rightarrow MgO(s)$ — negative<br>$CuSO_4(s) + 5H_2O(l) \rightarrow CuSO_4.5H_sO(s)$ — negative<br>$NaHCO_3(s) + H^+(aq) \rightarrow Na^+(aq) + CO_2(g) + H_2O(l)$ — positive | 2 |
| (ii) | there is a reduction in the overall number of gaseous molecules | 1 |
| (d) | $\Delta S_f^{\ominus} = 386 - (192 + (3 \times 131))$<br>$= -199\ (J\,K^{-1}\,mol^{-1})$ | 2 |
| (e) (i) | $\Delta G^{\ominus} = \Delta H^{\ominus} - T\Delta S^{\ominus}$<br>$= 117 - ((298 \times 175) / 1000)$<br>$= (+)\ 64.85\ (kJ\,mol^{-1})$ | 2 |
| (ii) | $\Delta G^{\ominus}$ is positive and so the reaction is not spontaneous (at 298 K) | 1 |

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| Question | Answer | Mark |
|---|---|---|
| 3 (a) | Co [Ar] $3d^7 4s^2$<br>$Co^{2+}$ [Ar] $3d^7$ | 1<br>1 |
| (b) |  | 1 |
| (c) (i) | $[Co(Cl)_3(H_2O)_3]^-$ | 1 |
| (ii) |  ;  | 2 |
| (d) (i) | $[Pt(Cl)_2(NH_3)_2]$ | 1 |
| (ii) | **M1, M2**: diagrams<br>**M3**: names<br> <br>cis-platin / cis-diamminedichloroplatinum(II) trans-platin / trans-diamminedichloroplatinum(II) | 2<br>1 |
| (iii) | (*cis* isomer)<br>this can react / bond / bind with DNA;<br>which prevents replication of the strand / prevents cell division; | <br>1<br>1 |
| (e) (i) | **M1**: formula<br>**M2**: units (ecf from formula)<br>$K_{stab} = \frac{[Cu(NH_3)_4(H_2O)_2^{2+}]}{[Cu(H_2O)_6^{2+}][NH_3]^4}$ $mol^{-4}\,dm^{12}$ | 1<br>1 |
| (ii) | (large value of $K_{stab}$ shows that) the tetrammine complex is more stable | 1 |

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| Question | Answer | Mark |
|---|---|---|
| **4 (a) (i)** | 1st order | **1** |
| **(ii)** | 1st order | **1** |
| **(iii)** | rate = $k[CH_3CHO][OH^-]$ | **1** |
| **(iv)** | $mol^{-1}\,dm^3\,s^{-1}$ (or per any suitable time unit) | **1** |
| **(v)** | calculation from candidate's answer to **(iii)** (expected answer = 6) | **1** |
| **(b) (i)** | rate-determining step: step 1<br>explanation: both reactant species are in step 1 / rate-determining step | **1**<br>**1** |
| **(ii)** | acid / proton donor / acidic behaviour | **1** |
| **(c)** | nucleophilic addition | **1** |
| **(d)** | **M1**: both curly arrows<br>**M2**: dipole correctly shown<br> | **1**<br>**1** |

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| Question | Answer | Mark |
|---|---|---|
| 5 (a) (i) | any metal with an $E^{\ominus}$ value more negative than –0.41 V,<br>e.g. Fe, Mn, Zn, Mg, Cr, A*l*<br>**R:** Li / Na / K / Ca / Ba | **1** |
| (ii) | **M1**: value of $E_{cell}$ correctly calculated (with correct sign) for metal named in **(i)**<br>**M2**: $E^{\ominus}_{cell}$ is positive **and** so reaction is feasible | **1**<br>**1** |
| (b) | **M1**:<br>$(Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O)$ $E^{\ominus} = +1.33\,V$<br>$(H_2O_2 + 2H^+ + 2e^- \rightleftharpoons 2H_2O)$ $E^{\ominus} = +1.77\,V$<br>$E^{\ominus}_{cell} = 0.44\,(V)$<br><br>**M2**:<br>$E^{\ominus}_{cell}$ (0.44 V) is positive (so the reaction is feasible) / $E^{\ominus}(Cr_2O_7^{2-}/Cr^{3+})$ is less positive than $E^{\ominus}(H_2O_2/H_2O)$ | **1**<br><br><br><br><br>**1** |
| (c) | **M1**:<br>$Cr_2O_7^{2-}$: ox.no Cr = +6 because –2 = 2 × ox.no(Cr) + (7 × –2)<br>$CrO_4^{2-}$: ox.no Cr = +6 because –2 = ox.no(Cr) + (4 × –2)<br><br>**M2**: no change in oxidation number, so reaction is not redox | **1**<br><br><br><br>**1** |
| (d) | **M1**: no. moles Cr deposited = 0.0312 / 52 = $6.0 \times 10^{-4}$ moles<br>**M2**: deduction that 6 moles of $e^-$ needed per mole of Cr /<br>reaction is $Cr_2O_7^{2-} + 14H^+ + 12e^- \rightarrow 2Cr + 7H_2O$<br>**M3**: no. moles of $e^- = 6 \times 6.0 \times 10^{-4} = (0.125 \times t) / 96\,500$<br>so t = $(6 \times 6.0 \times 10^{-4} \times 96\,500) / (0.125 \times 60)$ = 46.3 min / 0.772 h / 2780 s | **1**<br>**1**<br><br>**1** |

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| Question | Answer | Mark |
|---|---|---|

**6 (a)**

| | identity or value | |
|---|---|---|
| **V** | nitrogen or | chlorine |
| **X** | $NO / NO_2$ | $ClO_2 / ClO_3$ |
| **m** | 2, 3 | 1,2,3, or 4 |
| **W** | sulfur | |
| **Y** | $SO_2$ or $SO_3$ | |
| **n** | 4, 3 | |

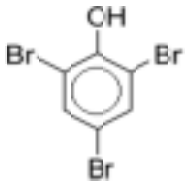
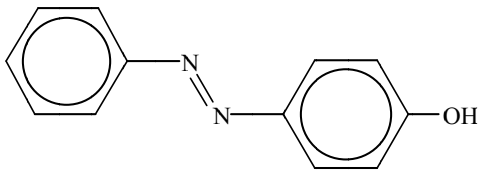
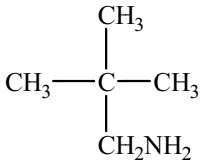
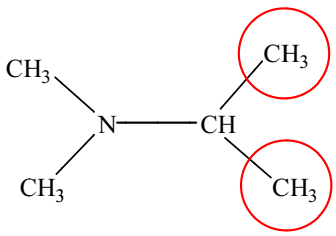
**3**

**(b)**

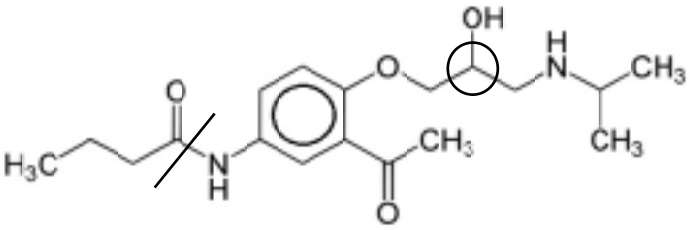
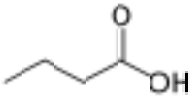
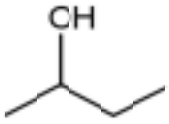
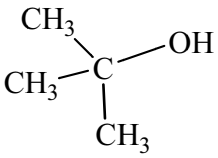
**M1**: (white precipitate is $BaSO_4$)
descending the group $\Delta H_{sol}$ becomes more endothermic / positive; **1**

**M2, M3** any **two** from: **2**
$\Delta H_{latt}$ decreases / becomes more endothermic / becomes less exothermic
$\Delta H_{hyd}$ decreases / becomes more endothermic / becomes less exothermic
$\Delta H_{hyd}$ decreases more than $\Delta H_{latt}$

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| Question | Answer | Mark |
|---|---|---|
| 7 (a) (i) | **M1**: phenol is **more acidic** than ethanol because the O–H bond in phenol is weakened / the phenoxide anion is stabilised / ethanol has an electron donating group<br>**M2**: p orbital / lone pair of electrons on O can be delocalised over / overlaps with ring | 1<br>1 |
| (ii) | <table><tr><th>reagent</th><th>conditions</th><th>Structure</th></tr><tr><td>$HNO_3$</td><td>dilute, 5 °C</td><td></td></tr><tr><td>$Br_2$</td><td>aqueous<br>(**I**: temperature)</td><td></td></tr></table> | 3 |
| (iii) | electrophilic substitution | 1 |
| (b) (i) | white precipitate / solid | 1 |
| (ii) | between 0° C and 10 °C | 1 |
| (iii) | **M1**: double bond between nitrogen atoms<br>**M2**: rest of molecule<br> | 1<br>1 |
| (c) (i) |  | 1 |
| (ii) | <br>either one or both $CH_3$ groups circled | 1 |

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| Question | Answer | Mark |
|---|---|---|
| 8 (a) | **P** amide<br>**Q** ketone<br>**R** **secondary** alcohol<br><br>**Q** = carbonyl and **R** = alcohol scores [1] | **1**<br>**1**<br>**1** |
| (b) |  | **1** |
| (c) (i) | see line on diagram in **(b)** | **1** |
| (ii) |  | **1** |
| (d) | reagent / observation<br>alkaline iodine solution / yellow ppt. formed<br>universal indicator / blue / purple colour formed<br>2,4-dinitrophenylhydrazine / yellow / orange ppt formed<br>Tollens' reagent / no reaction | **3** |
| (e) (i) | $LiAlH_4$ | **1** |
| (ii) | <br>(must be skeletal) | **1** |
| (iii) |  | **1** |

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<table>
<tr><th>Question</th><th>Answer</th><th>Mark</th></tr>
<tr><td>9 (a) (i)</td><td>polyester : Terylene / polylactic acid (PLA) /<br>polyamide : nylon / Kevlar / Nomex</td><td>1</td></tr>
<tr><td>(ii)</td><td>water or hydrochloric acid / hydrogen chloride</td><td>1</td></tr>
<tr><td>(b) (i)</td><td><table><tr><th>polymer</th><th>biodegradable</th></tr><tr><td>A</td><td>yes</td></tr><tr><td>B</td><td>yes</td></tr><tr><td>C</td><td>no</td></tr><tr><td>D</td><td>yes</td></tr></table></td><td>2</td></tr>
<tr><td>(ii)</td><td>$HOCH_2CH_2OH$ and <br>or equivalent 1,4-diacyl chloride<br>or equivalent 1,4-diester</td><td>2</td></tr>
<tr><td>(c) (i)</td><td>V:<br>it has two amine / $NH_2$ groups (which can be protonated) or<br>it has an amine / $NH_2$ group on its side chain / R group</td><td>1</td></tr>
<tr><td>(ii)</td><td>four (TT, TU, UT, UU)</td><td>1</td></tr>
<tr><td>(iii)</td><td>hydrogen bonds;<br>between the O / N atoms or named group (in the polypeptide) and water;<br>or<br>ion-dipole attractions;<br>between $NH_3^+$ / $CO_2^-$ and water;</td><td>2</td></tr>
</table>

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