**CAMBRIDGE INTERNATIONAL EXAMINATIONS**

**Cambridge International Advanced Level**

# MARK SCHEME for the October/November 2014 series

## 9701 CHEMISTRY

**9701/41** Paper 4 (A2 Structured Questions), maximum raw mark 100

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| Question | Marking point | Marks | Marks total |
|---|---|---|---|
| **1 (a) (i)** | [NO] $2^{nd}$ order **and** the concentration is ×2, rate × 4<br><br>$[O_2]$ $1^{st}$ order **and** evidence of using expt 1 & 2 when the concentration is ×2, rate doubles | **1**<br><br>**1** | |
| **(ii)** | (0.00408 × 27)<br>rate = **<u>0.11</u>** (mol $dm^{-3}$ $s^{-1}$) to **2sf** | **1** | |
| **(iii)** | (Rate =) $k$ $[O_2][NO]^2$ | **1** | |
| **(iv)** | k = 332(.03125)<br>$mol^{-2}$ $dm^6$ $s^{-1}$ | **1**<br>**1** | **[6]** |
| **(b) (i)** | labelled axes $x$-axis: energy (KE) and $y$-axis: molecules or particles<br>two curves: starts origin; not touching $x$-axis again; no levelling out; curves only intersecting once<br>curves labelled and T2 is to the right and lower max than T1 | **1**<br>**1**<br>**1** | |
| **(ii)** | rate increases **and** energy of the particles increases<br><br>more particles have $E_a$ | **1**<br><br>**1** | **[5]** |
| **(c)** | 1 mole of $F_2$ and 1 mole NO reacting in the **slow** step<br><br>a balanced mechanism consistent with overall equation<br><br>e.g. $F_2 + NO \rightarrow NOF + F$ **OR** $F_2 + NO \rightarrow NOF_2$<br>$NO + F \rightarrow NOF$ $NO + NOF_2 \rightarrow 2NOF$ | **1**<br><br>**1** | **[2]** |
| **Total** | | | **[13]** |

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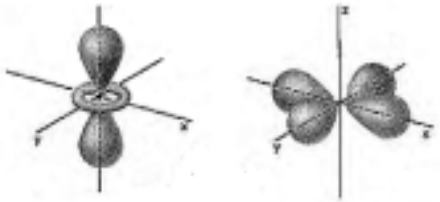
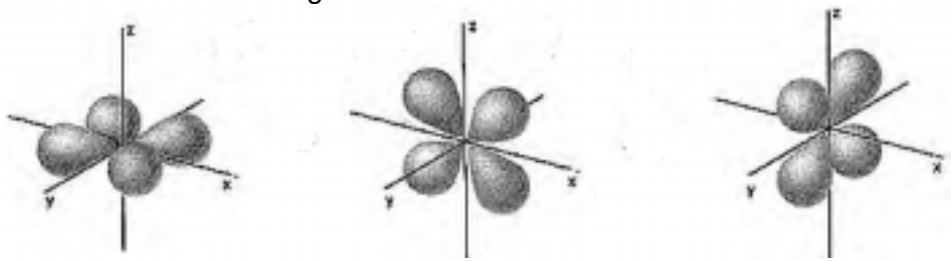
| | | | |
|---|---|---|---|
| **2 (a)** | 3d 4s<br>(Ni) ↑↓ ↑↓ ↑↓ ↑ ↑ ↑↓<br>($Ni^{2+}$) ↑↓ ↑↓ ↑↓ ↑ ↑ | **1**<br>**1** | **[2]** |
| **(b) (i)** | degenerate | **1** | |
| **(ii)** | 2 upper orbitals **and** 3 lower orbitals | **1** | |
| **(iii)** | **correct upper** orbital diagram<br><br>**correct lower** orbital diagram<br> | **1**<br>**1** | **[4]** |
| **(c)** | **electron(s)** move from lower to upper level<br>**absorb** (red/blue) light/photon<br>complementary colour (green) is seen<br>**OR** green light is transmitted | **1**<br>**1**<br>**1** | **[3]** |

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|---|---|---|---|
| **(d)** | **A** $Ni(OH)_2$ **OR** $Ni(OH)_2(H_2O)_4$<br>**B** $[Ni(NH_3)_6]^{2+}$ **OR** $[Ni(NH_3)_n(H_2O)_{6-n}]^{2+}$ **OR** $[Ni(NH_3)_n(H_2O)_{4-n}]^{2+}$<br><br>$Ni^{2+} + 2OH^- \rightarrow Ni(OH)_2$<br>**OR** $[Ni(H_2O)_6]^{2+} + 2OH^- \rightarrow Ni(OH)_2 + 6H_2O$<br>**OR** $[Ni(H_2O)_6]^{2+} + 2NH_3 \rightarrow Ni(OH)_2 + 4H_2O + 2NH_4^+$<br>**OR** $[Ni(H_2O)_6]^{2+} + 2OH^- \rightarrow Ni(OH)_2(H_2O)_4 + 2H_2O$<br><br>$Ni(OH)_2 + 6NH_3 \rightarrow [Ni(NH_3)_6]^{2+-} + 2OH^-$<br>**OR** $Ni(H_2O)_6]^{2+} + 6NH_3 \rightarrow [Ni(NH_3)_6]^{2+-} + 6H_2O$ | **1**<br>**1**<br><br>**1**<br><br><br><br><br><br>**1** | **[4]** |
| **Total** | | | **[13]** |

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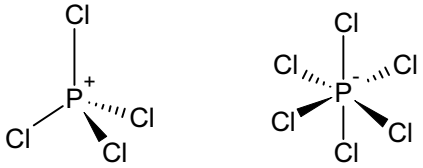
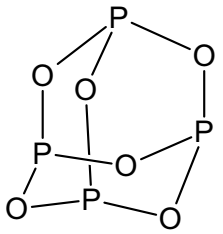
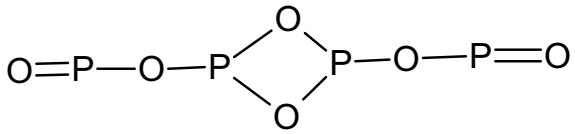
| | | | | |
|---|---|---|---|---|
| **3** | **(a) (i)** | 101 = $P^{35}Cl^{35}Cl$<br>103 = $P^{35}Cl^{37}Cl$<br>105 = $P^{37}Cl^{37}Cl$ | **1**<br>**1**<br>**1** | |
| | **(ii)** | 9:6:1 | **1** | **[4]** |
| | **(b) (i)** | $PCl_5$ 5 bonding pairs around P | **1** | |
| | **(ii)** |  | **1**<br>**1** | **[3]** |
| | **(c) (i)** | <br>$P_4O_6$ structure where each P has three P-O bonds and each O has two P-O bonds e.g.<br> | **1** | |
| | **(ii)** | (molecule/ion/species) that **donates** a lone pair of electrons (to a central transition metal atom or ion) | **1** | **[2]** |
| | **(d) (i)** | $K_{sp} = [Ca^{2+}]^3[PO_4^{3-}]^2$ | **1** | |

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|---|---|---|---|
| **(ii)** | $[Ca^{2+}] = 3 \times 2.50 \times 10^{-6} = 7.50 \times 10^{-6}$ mol dm$^{-3}$<br>$[PO_4^{3-}] = 2 \times 2.50 \times 10^{-6} = 5.00 \times 10^{-6}$ mol dm$^{-3}$<br><br>$= (7.50 \times 10^{-6})^3(5.00 \times 10^{-6})^2$<br>$=$ **1.05(1.1)** $\times$ **10$^{-26}$**<br>mol$^5$dm$^{-15}$ | **1**<br><br><br>**1**<br>**1** | **[4]** |
| **(e) (i)** | (enthalpy change) when **1 mole** of an **ionic compound**<br>is **formed** from its **gaseous ions** | **1**<br>**1** | |
| **(ii)** | $Mg^{2+}$ has a smaller (ionic) radii than $Ca^{2+}$<br>**OR** $Mg^{2+}$ is smaller than $Ca^{2+}$ | **1** | **[3]** |
| **Total** | | | **[16]** |
| | | | |
| **4 (a) (i)** | $2H_2SO_4 + HNO_3 \rightarrow 2HSO_4^- + NO_2^+ + H_3O^+$<br>**OR** $H_2SO_4 + HNO_3 \rightarrow HSO_4^- + NO_2^+ + H_2O$ | **1** | |

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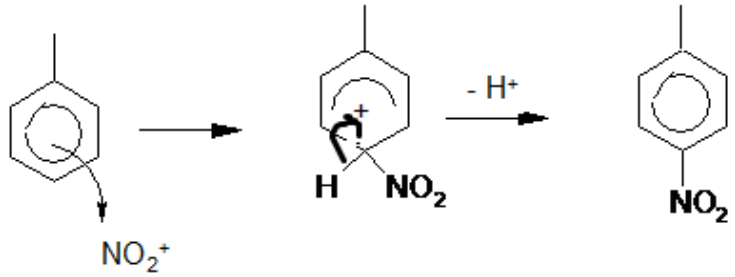
| **(ii)** | **any three** of<br>• curly arrow from inside the benzene ring to $NO_2^+$ group<br>• intermediate – **penalise** $NO_2$ connectivity ***or*** missing methyl group (once)<br>• curly arrow from C-H bond into ring<br>• product + $H^+$ (or as diagram $–H^+$)<br>**allow** 2- and 3-substituted nitromethylbenzene)<br><br> | **3** | **[4]** |
| **(b) (i)** | acidity of $ClCH_2CO_2H > CH_3CO_2H$ **AND** ($ClCH_2CO_2H$) as an electronegative/electron withdrawing Cl | **1** | |
| **(ii)** | acidity of phenol > $CH_3CH_2OH$ **AND** electrons on oxygen (on phenol) delocalised into ring | **1** | |
| | **OR** benzene ring withdraws electrons from oxygen<br>stronger acid linked to weakening O-H bond/anion being stabilised | **1** | **[3]** |

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**(c)**

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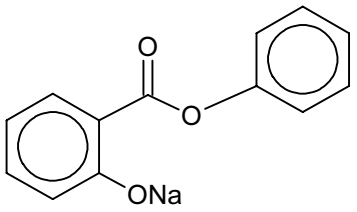
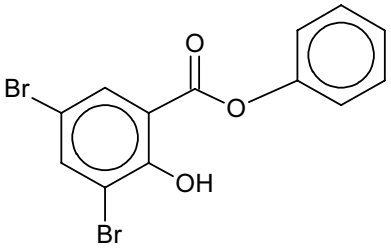
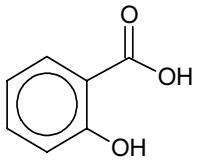
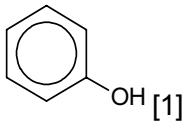
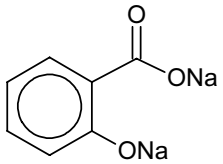
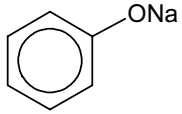
|---|---|---|
| Na |  (or ionic) | redox/reduction |
| $Br_2$ |  | (electrophilic) substitution |
| NaOH |  and  [1] or ionic   | hydrolysis/ acid-base/ |

1 mark for each correct structure **4**
for reaction types, 2 correct = 1 mark, 3 correct = 2 marks **2** **[6]**

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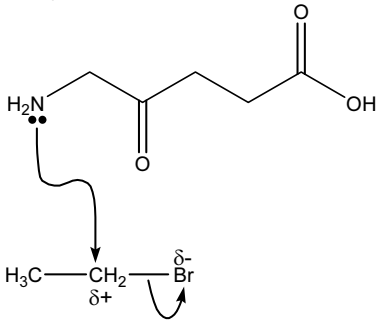
|---|---|---|---|
| **Total** | | | **13** |
| **5 (a)** | $CH_3CH_2COCl$ > $CH_3CH_2CH_2Cl$ > $C_6H_5Cl$<br><br>**any two** *of:*<br>• C-C$l$ bond strength is weakest in $CH_3CH_2COCl$ ora<br>• In $C_6H_5Cl$ (no hydrolysis) C-C$l$ bond is part of delocalised system **OR** p-orbital on C$l$ overlaps with $\pi$ system **OR** electrons from C$l$ overlap with $\pi$ system<br>• $CH_3CH_2COCl$ carbon in C-C$l$ bond is more electron deficient since it is also attached to an oxygen atom ora | **1**<br><br>**1+1** | **[3]** |
| **(b)** | ketone, amine, carboxylic acid<br>two correct 1 mark, all three 2 | **2** | **[2]** |
| **(c) (i)** | dipole on C-Br<br>curly arrow breaking C-Br bond<br>curly arrow from **lone pair** on N to carbon in C-Br bond<br> | **1**<br>**1**<br>**1** | |
| **(ii)** | nucleophilic substitution | **1** | |
| **(iii)** | HBr or hydrogen bromide | **1** | **[5]** |

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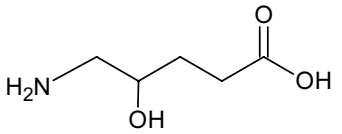
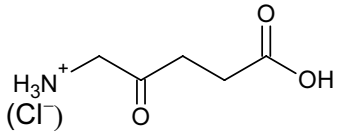
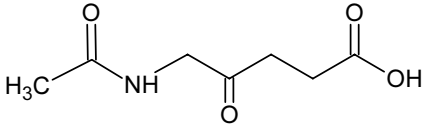
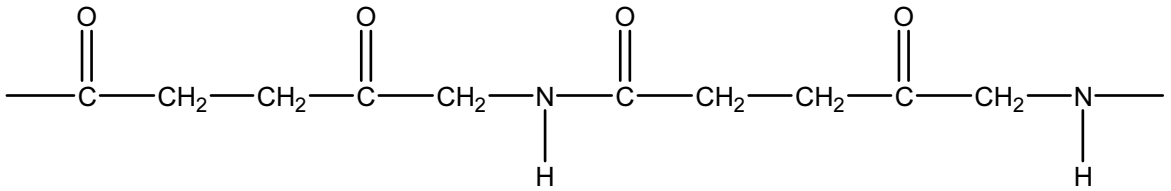
|---|---|---|---|
| **(d)** | **Y =**  <br> **W =**  **X =**  <br> each structure 1 mark | **3** | **[3]** |
| **(e)** |  <br> correct displayed amide formula <br> correct polyamide with two repeat units | **1** <br> **1** | **[2]** |
| **Total** | | | **15** |
| | | | |
| **6 (a)** | • (move in different directions) some amino acids have a different charge <br> • (move at different speeds) some amino acids have a different size/different charge <br> • (some amino acids do not move at all) some amino acids exist as a zwitterions/have no net(overall) charge/neutral/both $NH_2$/COOH are charged in amino acids | **1** <br> **1** <br> **1** | **[3]** |
| **(b) (i)** | mobile – solvent ***or*** water <br> stationary – alumina/silica (supported on glass/plastic/Al) | **1** <br> **1** | |
| **(ii)** | by adsorption | **1** | **[3]** |

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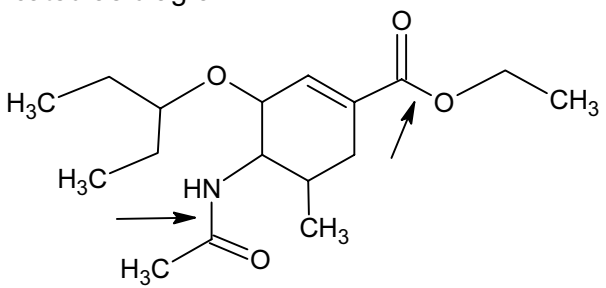
| **(c)** | **any three** of: (all can be awarded from a clear, labelled diagram)<br><br>• (base pairing) A to T **OR** C to G<br>• H-bonds between bases<br>• two/double stranded/chains<br>• anti-parallel strands<br>• (general structure) sugar-phosphate backbone **OR** BASE-SUGAR-PHOSPHATE bonded in a diagram | **3** | **[3]** |
| **(d)** | van der Waals' forces lost (in val)<br>H-bonding gained (in ser) | **1**<br>**1** | **[2]** |
| **Total** | | | **11** |
| | | | |
| **7 (a)** | amide group circled **OR** indicated as diagram<br>ester group circled **OR** indicated as diagram<br> | **1**<br>**1** | **[2]** |
| **(b)** | lower doses of the drug required<br>**OR** improved activity of the drug<br>**OR** reduced side effects | **1** | **[1]** |

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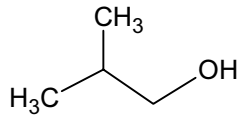
| **(c)** | decreases enzyme activity **OR** decreases rate at which product is formed<br><br>binds with the enzyme's active site **OR** has a complementary shape to active site **OR** similar shape to substrate<br><br>(competitive inhibition can be overcome by)<br>increasing [substrate] **OR** increasing substrate concentration | **1**<br><br>**1**<br><br><br><br>**1** | **[3]** |
| **(d)** | **energy** source/carrier **OR** releases energy when hydrolysed | **1** | **[1]** |
| **Total** | | | **7** |
| | | | |
| **8 (a)** | M:M+1 = 100/(1.1 x n)<br>20.4/0.9 = 100/(1.1 x n)<br>x =4 | **1**<br><br>**1** | |
| **(ii)** | $C_4H_{10}O$ | **1** | **[3]** |
| **(b) (i)** | 2-methylpropan-1-ol **OR** correct structure<br> | **1** | |
| **(ii)** | 0.9-1.0 is (2 x)$CH_3R/CH_3/RCH$<br>multiplet/1.8 is $CHR/R_3CH$<br>singlet/2.5 is OH<br>3.4 is $CH_2O/CH_3O$ | **1**<br>**1**<br>**1**<br>**1** | |
| **(iii)** | doublet<br>1H/one proton on adjacent carbon | **1**<br>**1** | |

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| **(iv)** | OH peak or one peak disappears<br><br>OH proton is labile ***or*** exchanges for D of $D_2O$<br>***or*** as an equation e.g. $D_2O$ + OH → DOH + OD as a minimum | **1**<br><br>**1** | **[9]** |
| **Total** | | | **12** |
| | | | **100** |

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