

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the October/November 2015 series

9701 CHEMISTRY

9701/22

Paper 2 (AS Structured Questions), maximum raw mark 60

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|--------|--|----------|-------|
| Page 2 | Mark Scheme | Syllabus | Paper |
| | Cambridge International AS/A Level – October/November 2015 | 9701 | 22 |

| Question | Mark Scheme | | | | | Mark | Total | | | | | | | | | | | | | | | | | | | | | | | | | |
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| 1 (a) | <table><tr><td>name of isotope</td><td>type of particle</td><td>charge</td><td>symbol</td><td>electron configuration</td></tr><tr><td>carbon-13</td><td>atom</td><td>0</td><td>$^{13}_6\text{C}$</td><td>$1s^2 2s^2 2p^2$</td></tr><tr><td>chloride(-37)</td><td>anion</td><td>1-</td><td>Cl^-</td><td>$1s^2 2s^2 2p^6 3s^2 3p^6$</td></tr><tr><td>sulfur-34</td><td>atom</td><td>0</td><td>$^{34}_{16}\text{S}$</td><td>$1s^2 2s^2 2p^6 3s^2 3p^4$</td></tr><tr><td>iron-54</td><td>cation</td><td>2+</td><td>$^{54}_{26}\text{Fe}^{(2+)}$</td><td>$1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$</td></tr></table> | | | | | name of isotope | type of particle | charge | symbol | electron configuration | carbon-13 | atom | 0 | $^{13}_6\text{C}$ | $1s^2 2s^2 2p^2$ | chloride(-37) | anion | 1- | Cl^- | $1s^2 2s^2 2p^6 3s^2 3p^6$ | sulfur-34 | atom | 0 | $^{34}_{16}\text{S}$ | $1s^2 2s^2 2p^6 3s^2 3p^4$ | iron-54 | cation | 2+ | $^{54}_{26}\text{Fe}^{(2+)}$ | $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$ | [5] | [5] |
| | name of isotope | type of particle | charge | symbol | electron configuration | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | carbon-13 | atom | 0 | $^{13}_6\text{C}$ | $1s^2 2s^2 2p^2$ | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | chloride(-37) | anion | 1- | Cl^- | $1s^2 2s^2 2p^6 3s^2 3p^6$ | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | sulfur-34 | atom | 0 | $^{34}_{16}\text{S}$ | $1s^2 2s^2 2p^6 3s^2 3p^4$ | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| iron-54 | cation | 2+ | $^{54}_{26}\text{Fe}^{(2+)}$ | $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (b) (i) | ability / tendency / power of an atom / nucleus to attract / pull electron(s) | | | | | [1] | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | in a covalent bond / shared pair of electrons / bonding pair of electrons | | | | | [1] | [2] | | | | | | | | | | | | | | | | | | | | | | | | | |
| (ii) | Covalent overlap of orbitals OR shared <u>pair</u> (s) (of electrons) | | | | | [1] [1] | [2] | | | | | | | | | | | | | | | | | | | | | | | | | |
| | OR metallic positive ions / cations surrounded by delocalised electrons | | | | | [1] [1] | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (iii) | Ionic/electrovalent (electrostatic) Attraction between oppositely charged / +ve and -ve <u>ions</u> | | | | | [1] [1] | [2] | | | | | | | | | | | | | | | | | | | | | | | | | |
| (c) (i) | similar strength / amount / number of intermolecular forces / induced dipole / van der Waals' / VdW / London forces / LDF / dispersion forces | | | | | [1] | [2] | | | | | | | | | | | | | | | | | | | | | | | | | |
| | therefore similar energy needed | | | | | [1] | | | | | | | | | | | | | | | | | | | | | | | | | | |

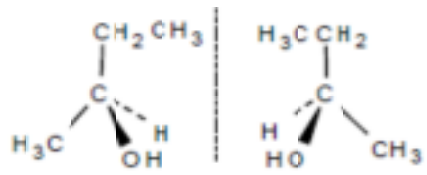
| Page 3 | Mark Scheme | Syllabus | Paper |
|--------|--|----------|-------|
| | Cambridge International AS/A Level – October/November 2015 | 9701 | 22 |

| Question | Mark Scheme | Mark | Total |
|----------|---|------|-------|
| (ii) | M1 HCl polar / has a dipole AND F ₂ non-polar / has no dipole OR (permanent) dipole (-dipole) attractions / forces between HCl (molecules) AND induced dipole (-induced dipole) attractions / forces / LDFs between F ₂ (molecules) | [1] | [2] |
| | M2 more energy needed for HCl than F ₂ OR pd-pd forces stronger than id-id forces OR IMFs / VdWs in HCl stronger than in F ₂ | [1] | |
| (iii) | Hydrogen bonding (between methanol molecules) | [1] | [2] |
| | Stronger than IMFs / van der Waals' in other three / is the strongest intermolecular force | [1] | |
| | | | [17] |
| 2 (a) | M1 <u>Heat</u> (energy) change (or H _{prod} – H _{react}) measured at constant pressure OR enthalpy change when the amount / moles of reactants as shown in a (reaction) <u>equation</u> react together to give products | [1] | [2] |
| | M2 measured at standard conditions | [1] | |
| (b) (i) | q = 2125.53 | [1] | [1] |
| (ii) | amount = 0.025(0) | [1] | [1] |
| (iii) | –85.(0) | [1] | [1] |

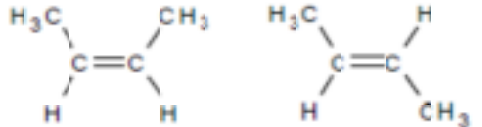
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|--------|--|----------|-------|
| Page 4 | Mark Scheme | Syllabus | Paper |
| | Cambridge International AS/A Level – October/November 2015 | 9701 | 22 |

| Question | Mark Scheme | Mark | Total |
|-----------|---|------------------------------|-------|
| (iv) | $\begin{array}{ccc} & \text{(MgSO}_4\text{(s)} + 7\text{H}_2\text{O(l)} \rightarrow \text{MgSO}_4 \cdot 7\text{H}_2\text{O(s)}) & \\ & \swarrow \quad \searrow & \\ -85.0 \text{ (kJ mol}^{-1}\text{)} & & (+)9.60 \text{ (kJ mol}^{-1}\text{)} \\ & \searrow \quad \swarrow & \\ & \text{MgSO}_4\text{(aq)} & \end{array}$ | [1] | [1] |
| (v) | $\Delta H + 9.6 = -85.0$ $\Delta H = -85.0 - 9.6 = -94.6 \text{ (kJ mol}^{-1}\text{)}$ | [1] | [1] |
| | | | [7] |
| 3 (a) (i) | Na ₂ O or Na ₂ O ₂ ; MgO; P ₄ O ₁₀ or P ₄ O ₆ ; SO ₂ | [1] [1] | [2] |
| (ii) | Na: Yellow / orange / gold flame / white solid / powder / smoke $4\text{Na} + \text{O}_2 \rightarrow 2\text{Na}_2\text{O}$ or $2\text{Na} + \text{O}_2 \rightarrow \text{Na}_2\text{O}_2$ S: Blue flame / (yellow) solid melts / turns red / amber / white fumes $\text{S} + \text{O}_2 \rightarrow \text{SO}_2$ | [1] [1] [1] [1] | [4] |
| (b) (i) | acidic P and S amphoteric Al and basic Na and Mg | [1] [1] | [2] |
| (ii) | acidic: covalent (bonding) basic: ionic (bonding) | [1] [1] | [2] |

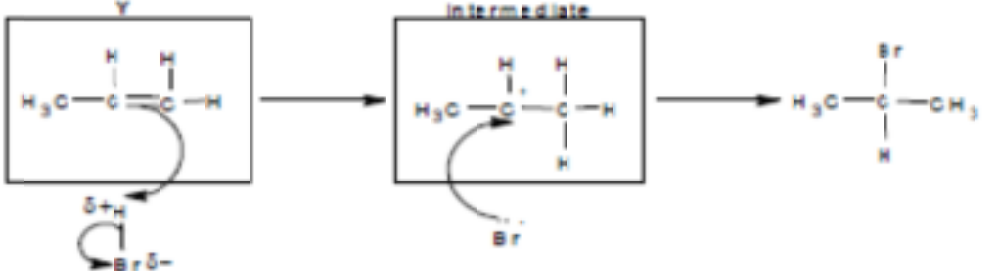
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|--------|--|----------|-------|
| Page 5 | Mark Scheme | Syllabus | Paper |
| | Cambridge International AS/A Level – October/November 2015 | 9701 | 22 |

| Question | Mark Scheme | Mark | Total |
|-----------|---|----------------|-------|
| (iii) | $\text{Al}_2\text{O}_3 + 6\text{HCl} \rightarrow 2\text{AlCl}_3 + 3\text{H}_2\text{O}$ OR $\text{Al}_2\text{O}_3 + 6\text{H}^+ \rightarrow 2\text{Al}^{3+} + 3\text{H}_2\text{O}$ $\text{Al}_2\text{O}_3 + 2\text{NaOH} + 7\text{H}_2\text{O} \rightarrow 2\text{NaAl}(\text{OH})_4(\text{H}_2\text{O})_2$ OR $\text{Al}_2\text{O}_3 + 2\text{NaOH} + 3\text{H}_2\text{O} \rightarrow 2\text{NaAl}(\text{OH})_4$ OR $\text{Al}_2\text{O}_3 + 2\text{NaOH} \rightarrow 2\text{NaAlO}_2 + \text{H}_2\text{O}$ OR $\text{Al}_2\text{O}_3 + 2\text{OH}^- + 7\text{H}_2\text{O} \rightarrow 2[\text{Al}(\text{OH})_4(\text{H}_2\text{O})_2]^-$ OR $\text{Al}_2\text{O}_3 + 2\text{OH}^- + 3\text{H}_2\text{O} \rightarrow 2[\text{Al}(\text{OH})_4]^-$ OR $\text{Al}_2\text{O}_3 + 2\text{OH}^- \rightarrow 2\text{AlO}_2^- + \text{H}_2\text{O}$ | [1] [1] | [2] |
| (c) | sulfur forms $\text{SO}_2/\text{SO}_2 + / \text{mixes } \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3$ or in words OR $\text{SO}_2 + / \text{mixes } \text{H}_2\text{O} (\rightarrow \text{acid}) /$ or in words OR $\text{SO}_2 + / \text{mixes } \text{H}_2\text{O} + (1/2\text{O}_2) \rightarrow \text{H}_2\text{SO}_4$ / or in words | [1] [1] | [2] |
| | | | [14] |
| 4 (a) (i) | Nucleophilic Substitution | [1] | [1] |
| (ii) | Has a chiral centre / carbon OR has a <u>carbon / C</u> attached to 4 different groups / atoms / chains OR has no plane / line of symmetry | [1] | [1] |
| (iii) |  | [1+1] | [2] |
| (iv) | Elimination | [1] | [1] |

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|--------|--|----------|-------|
| Page 6 | Mark Scheme | Syllabus | Paper |
| | Cambridge International AS/A Level – October/November 2015 | 9701 | 22 |

| Question | Mark Scheme | Mark | Total |
|----------|---|-------------------|-------|
| (v) |  <p><i>cis-but-2-ene</i> <i>trans-but-2-ene</i></p> | [1] [1] | [2] |
| (vi) | But-1-ene 2 Hs on one of the double-bonded Cs OR does not have 2 different groups on both atoms / each atom in C=C | [1] [1] | [2] |
| (b) (i) | ammonia / NH ₃ | [1] | [1] |
| (ii) | propanoyl chloride / C ₂ H ₅ COCl | [1] | [1] |
| (iii) | CH ₃ CH(NHCOC ₂ H ₅)CH ₃ | [1] | [1] |
| (iv) | Reduction LiAlH ₄ / lithium aluminium hydride / lithium tetrahydridoaluminate | (1) [1] [1] | [2] |
| (v) | aluminium oxide | [1] | [1] |

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|--------|--|----------|-------|
| Page 7 | Mark Scheme | Syllabus | Paper |
| | Cambridge International AS/A Level – October/November 2015 | 9701 | 22 |

| Question | Mark Scheme | Mark | Total |
|----------|---|--------------------------------------|-------|
| (vi) |  <p>M1 = correct structure of Y and curly arrow from double bond to H M2 = dipole and curly arrow from H-Br bond to Br M3 = correct intermediate M4 = Br⁻ with lone pair and curly arrow from lone pair to C(+)</p> | [1] [1] [1] [1] | [4] |
| (vii) | electrophilic addition | [1] | [1] |
| (viii) | secondary carbocation more stable than primary due to electron releasing character / (positive) inductive effect of alkyl groups | [1] [1] | [2] |
| | | | [22] |