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**CHEMISTRY**

**9701/41**

Paper 4 A Level Structured Questions

**May/June 2018**

MARK SCHEME

Maximum Mark: 100

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**Published**

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.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the May/June 2018 series for most Cambridge IGCSE™, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

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This document consists of **13** printed pages.

**PUBLISHED****Generic Marking Principles**

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

**GENERIC MARKING PRINCIPLE 1:**

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

**GENERIC MARKING PRINCIPLE 2:**

Marks awarded are always **whole marks** (not half marks, or other fractions).

**GENERIC MARKING PRINCIPLE 3:**

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

**GENERIC MARKING PRINCIPLE 4:**

Rules must be applied consistently e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

**GENERIC MARKING PRINCIPLE 5:**

Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

**GENERIC MARKING PRINCIPLE 6:**

Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

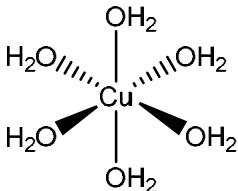
| Question | Answer  | Marks    |
|----------|---|----------|
| 1(a)     | $4\text{Na(s)} + \text{O}_2\text{(g)} \rightarrow 2\text{Na}_2\text{O(s)}$  |          |
|          | balanced with all formulae correct  | <b>1</b> |
|          | state symbols   | <b>1</b> |
| 1(b)     | giant ionic   | <b>1</b> |
|          | strong bond / attraction between<br><b>AND</b><br>positive and negative ions / anions and cations / $\text{Na}^+$ and $\text{O}^{2-}$ / oppositely charged ions   | <b>1</b> |
| 1(c)(i)  | the reaction produces sodium hydroxide / hydroxide ions / $\text{OH}^-$ ions  | <b>1</b> |
|          | the hydroxide ions can receive / accept $\text{H}^+$ ions / protons   | <b>1</b> |
| 1(c)(ii) | Calculation of $\text{Na}_2\text{O}$ moles $3.10 \text{ g} / 62$ <b>OR</b> 0.05   | <b>1</b> |
|          | Calculation of $[\text{OH}^-]$ $0.05 \times (2 / 0.400) = 0.25 \text{ mol dm}^{-3}$   | <b>1</b> |
|          | Calculation of pH $-\log 0.25 = 0.60$<br>$14 - 0.60 = 13.40$  | <b>1</b> |
| 1(d)     | use of $(2 \times 109)$ or 218 and $(2 \times 494)$ or 988  | <b>1</b> |
|          | use of $(0.5 \times 496)$ or 248  | <b>1</b> |
|          | use of 416, 142, 844  | <b>1</b> |
|          | evaluation of expression correctly<br>$\Delta H_{\text{lat}} = -416 - (2 \times 109) - (0.5 \times 496) - (2 \times 494) - (-142 + 844) = -2572$  | <b>1</b> |
| 1(e)     | the lattice energy of $\text{Na}_2\text{S}$ is less exothermic  | <b>1</b> |
|          | the sulfide ion is larger than the oxide ion / $\text{S}^{2-}$ larger than $\text{O}^{2-}$ / ionic radii quoted 0.184 nm and 0.140 nm<br><b>AND</b> less attraction (between the ions)/bonds are weaker | <b>1</b> |

| Question  | Answer  | Marks |
|-----------|---|-------|
| 2(a)      | change in amount / mass / concentration of reactant / product per time  | 1     |
| 2(b)      | decrease in volume or pressure  | 1     |
| 2(c)      | $8.13 \times 10^4 / 81280 / 81300$  | 1     |
|           | $\text{mol}^{-2} \text{dm}^6 \text{s}^{-1}$   | 1     |
| 2(d)      | $\sqrt{(0.00231 / (0.0046 \times 81280))} = 2.49 \times 10^{-3}$  | 1     |
| 2(e)      | 2, 1, 3   | 1     |
| 2(f)(i)   | 2   | 1     |
| 2(f)(ii)  | the total of steps 1 and 2 / the components of 2 are two NO and one H <sub>2</sub>  | 1     |
| 2(g)(i)   | time for amount or mass or concentration to halve   | 1     |
| 2(g)(ii)  | 0.02 at start and 0.01 after 2 seconds  | 1     |
|           | 0.005 after 4 seconds and 0.0025 after 6 seconds  | 1     |
| 2(h)(i)   | $\text{NO} + \frac{1}{2} \text{O}_2 \rightarrow \text{NO}_2$ <b>or</b> $\text{NO} + \text{O}_2 \rightarrow \text{NO}_2 + \frac{1}{2} \text{O}_2$<br><b>AND</b><br>$\text{NO}_2 + \text{SO}_2 \rightarrow \text{NO} + \text{SO}_3$ | 1     |
| 2(h)(ii)  | (NO is) regenerated / reformed  | 1     |
| 2(h)(iii) | $\text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4$ <b>AND</b> acid rain or consequence of this described  | 1     |

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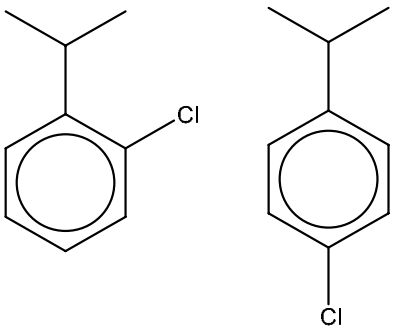
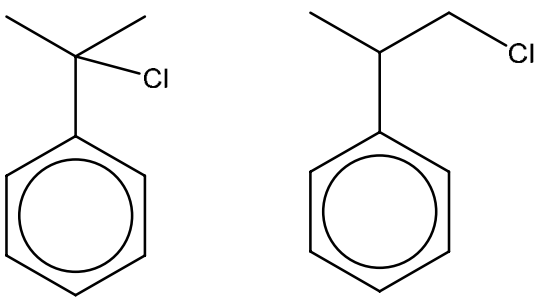
| Question               | Answer  | Marks                           |       |         |                        |                               |                    |                     |                                  |                                 |                        |                               |                    |          |
|------------------------|---|---------------------------------|-------|---------|------------------------|-------------------------------|--------------------|---------------------|----------------------------------|---------------------------------|------------------------|-------------------------------|--------------------|----------|
| 3(a)                   | <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%;"></td> <td style="width: 33%; text-align: center;">anode</td> <td style="width: 33%; text-align: center;">cathode</td> </tr> <tr> <td style="text-align: center;">AgNO<sub>3</sub> (aq)</td> <td style="text-align: center;"><b>oxygen / O<sub>2</sub></b></td> <td style="text-align: center;"><b>silver / Ag</b></td> </tr> <tr> <td style="text-align: center;">saturated NaCl (aq)</td> <td style="text-align: center;"><b>chlorine / Cl<sub>2</sub></b></td> <td style="text-align: center;"><b>hydrogen / H<sub>2</sub></b></td> </tr> <tr> <td style="text-align: center;">CuSO<sub>4</sub> (aq)</td> <td style="text-align: center;"><b>oxygen / O<sub>2</sub></b></td> <td style="text-align: center;"><b>copper / Cu</b></td> </tr> </table> |                                 | anode | cathode | AgNO <sub>3</sub> (aq) | <b>oxygen / O<sub>2</sub></b> | <b>silver / Ag</b> | saturated NaCl (aq) | <b>chlorine / Cl<sub>2</sub></b> | <b>hydrogen / H<sub>2</sub></b> | CuSO <sub>4</sub> (aq) | <b>oxygen / O<sub>2</sub></b> | <b>copper / Cu</b> | <b>3</b> |
|                        | anode   | cathode                         |       |         |                        |                               |                    |                     |                                  |                                 |                        |                               |                    |          |
| AgNO <sub>3</sub> (aq) | <b>oxygen / O<sub>2</sub></b>   | <b>silver / Ag</b>              |       |         |                        |                               |                    |                     |                                  |                                 |                        |                               |                    |          |
| saturated NaCl (aq)    | <b>chlorine / Cl<sub>2</sub></b>  | <b>hydrogen / H<sub>2</sub></b> |       |         |                        |                               |                    |                     |                                  |                                 |                        |                               |                    |          |
| CuSO <sub>4</sub> (aq) | <b>oxygen / O<sub>2</sub></b>   | <b>copper / Cu</b>              |       |         |                        |                               |                    |                     |                                  |                                 |                        |                               |                    |          |
| 3(b)(i)                | $2\text{I}^- \rightarrow \text{I}_2 + 2\text{e}^-$  | <b>1</b>                        |       |         |                        |                               |                    |                     |                                  |                                 |                        |                               |                    |          |
|                        | $\text{Ca}^{2+} + 2\text{e}^- \rightarrow \text{Ca}$  | <b>1</b>                        |       |         |                        |                               |                    |                     |                                  |                                 |                        |                               |                    |          |
| 3(b)(ii)               | <ul style="list-style-type: none"> <li>• Ca / Calcium reduced and I / iodine oxidised</li> <li>• Oxidation number of calcium decreases from 2 to 0</li> <li>• Oxidation number of iodine increases from -1 to 0</li> </ul> <p>2 points = 1 mark<br/>3 points = 2 marks</p>  | <b>2</b>                        |       |         |                        |                               |                    |                     |                                  |                                 |                        |                               |                    |          |
| 3(b)(iii)              | <ul style="list-style-type: none"> <li>• metal / grey / silvery</li> <li>• purple AND vapour / gas / fumes</li> <li>• amount of melt decreases</li> </ul> <p>any 2 points for 1 mark</p>  | <b>1</b>                        |       |         |                        |                               |                    |                     |                                  |                                 |                        |                               |                    |          |
| 3(c)                   | $2 \times 60 \times 60 \times 0.8 = 5760 \text{ C}$<br><b>AND</b><br>$5760 / 96500 = 0.060 \text{ (0.0597) F}$  | <b>1</b>                        |       |         |                        |                               |                    |                     |                                  |                                 |                        |                               |                    |          |
|                        | $1.11 / 55.8 = 0.020 \text{ (0.0199) mol of Fe}$  | <b>1</b>                        |       |         |                        |                               |                    |                     |                                  |                                 |                        |                               |                    |          |
|                        | $0.06 / 0.02 = 3 \therefore \text{Fe}^{3+} \text{ or } +3 \text{ or } 3$  | <b>1</b>                        |       |         |                        |                               |                    |                     |                                  |                                 |                        |                               |                    |          |

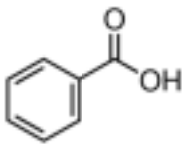
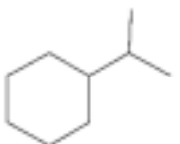
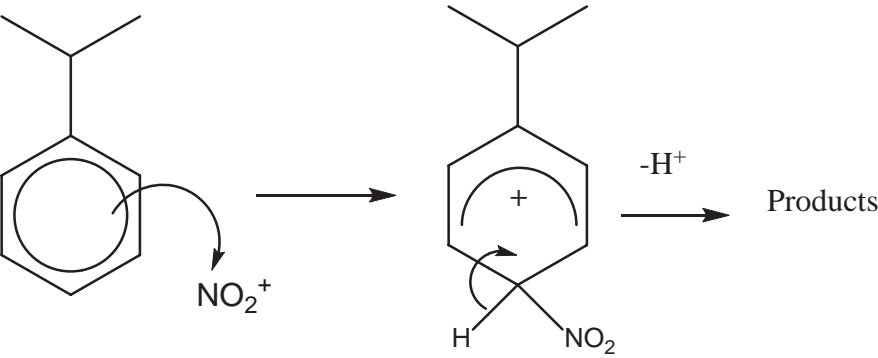
| Question | Answer  | Marks |
|----------|---|-------|
| 4(a)     | calcium – red flame   | 1     |
|          | barium – green flame  | 1     |
| 4(b)     | <ul style="list-style-type: none"> <li>the temperature increases down the group</li> <li>ionic radius increases / charge density decreases down the group</li> <li>decreasing distortion / polarisation <b>or</b> decreasing weakening of bonds</li> <li>of the anion / the <math>\text{CO}_3^{2-}</math> ion</li> </ul> <p>2 points = 1 mark<br/>3 points = 2 marks<br/>4 points = 3 marks</p> | 3     |
| 4(c)     | the gas is colourless / looks like air / cannot be seen   | 1     |
|          | appearance of solid doesn't change / white solid becomes white solid  | 1     |

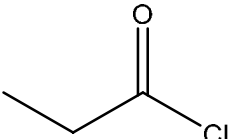
| Question | Answer   | Marks |
|----------|--|-------|
| 5(a)     | $3s^23p^63d^{10}4s^1$  | 1     |
|          | $3s^23p^63d^{10}$  | 1     |
| 5(b)     | $\text{Cl-Cu-Cl}$  | 1     |
|          | one minus charge   | 1     |
| 5(c)     |           | 1     |
|          | octahedral <b>and</b> $90^\circ$ or $180^\circ$ labelled correctly on diagram as appropriate | 1     |

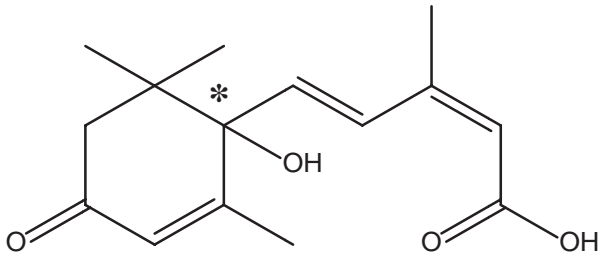
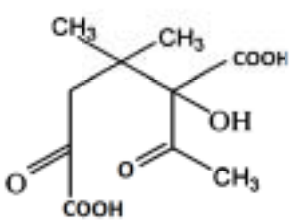
| Question  | Answer   | Marks    |
|-----------|--|----------|
| 5(d)      | reaction 1: blue ppt / blue <b>solid</b>   | <b>1</b> |
|           | [Cu(H <sub>2</sub> O) <sub>6</sub> ] <sup>2+</sup> + 2OH <sup>-</sup> → Cu(OH) <sub>2</sub> + 6H <sub>2</sub> O<br>or [Cu(H <sub>2</sub> O) <sub>6</sub> ] <sup>2+</sup> + 2OH <sup>-</sup> → Cu(OH) <sub>2</sub> (H <sub>2</sub> O) <sub>4</sub> + 2H <sub>2</sub> O<br>or [Cu(H <sub>2</sub> O) <sub>6</sub> ] <sup>2+</sup> + 2NH <sub>3</sub> → Cu(OH) <sub>2</sub> (H <sub>2</sub> O) <sub>4</sub> + 2NH <sub>4</sub> <sup>+</sup>  | <b>1</b> |
|           | reaction 2: deep / dark / royal blue solution  | <b>1</b> |
|           | Cu(OH) <sub>2</sub> + 4NH <sub>3</sub> + 2H <sub>2</sub> O → [Cu(NH <sub>3</sub> ) <sub>4</sub> (H <sub>2</sub> O) <sub>2</sub> ] <sup>2+</sup> + 2OH <sup>-</sup><br>or Cu(OH) <sub>2</sub> + 4NH <sub>3</sub> → [Cu(NH <sub>3</sub> ) <sub>4</sub> ] <sup>2+</sup> + 2OH <sup>-</sup><br>or Cu(OH) <sub>2</sub> (H <sub>2</sub> O) <sub>4</sub> + 4NH <sub>3</sub> → [Cu(NH <sub>3</sub> ) <sub>4</sub> (H <sub>2</sub> O) <sub>2</sub> ] <sup>2+</sup> + 2OH <sup>-</sup> + 2H <sub>2</sub> O | <b>1</b> |
| 5(e)(i)   | ligand exchange / displacement / replacement / substitution  | <b>1</b> |
| 5(e)(ii)  | $K_{\text{stab}} = \frac{[\text{CuEDTA}]^{2-}}{[\text{Cu}(\text{H}_2\text{O})_6]^{2+} [\text{EDTA}]^{4-}}$   | <b>1</b> |
| 5(e)(iii) | stable / more stable than [Cu(H <sub>2</sub> O) <sub>6</sub> ] <sup>2+</sup>   | <b>1</b> |
| 5(f)(i)   | donates lone pairs / forms dative / co-ordinate bonds to (central) metal atom / metal ion  | <b>1</b> |
|           | donates two lone pairs / forms two (dative or coordinate) bonds  | <b>1</b> |
| 5(f)(ii)  | [Zr(C <sub>2</sub> O <sub>4</sub> ) <sub>4</sub> ] <sup>4-</sup>   | <b>1</b> |
|           | not octahedral because 8 dative bonds to Zr<br><b>or</b> not octahedral because not 6 dative bonds to Zr<br><b>or</b> not octahedral because co-ordination number is 8 / is not 6  | <b>1</b> |

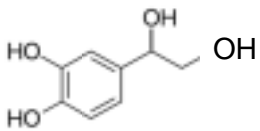


| Question  | Answer   | Marks    |
|-----------|--|----------|
| 6(a)(i)   | <b>D</b> 2-chloropropane   | <b>1</b> |
|           | <b>E</b> hydrogen chloride   | <b>1</b> |
| 6(a)(ii)  | (Friedel-Crafts) alkylation  | <b>1</b> |
| 6(b)(i)   | $AlCl_3$ or $FeCl_3$   | <b>1</b> |
| 6(b)(ii)  |   | <b>1</b> |
| 6(b)(iii) | sunlight or UV <b>OR</b> $T > 100\text{ }^\circ\text{C}$                           | <b>1</b> |
| 6(b)(iv)  |  | <b>1</b> |

| Question | Answer  | Marks |
|----------|---|-------|
| 6(c)     | reaction with hot $\text{KMnO}_4(\text{aq})$<br>           | 1     |
|          | reaction with $\text{H}_2 + \text{Ni}$ , high pressure<br> | 1     |
| 6(d)     |    |       |
|          | attacking species is $\text{NO}_2^+$  | 1     |
|          | curly arrow starting within hexagon and going to $\text{NO}_2^+$  | 1     |
|          | correct intermediate  | 1     |
|          | 2nd curly arrow from C-H bond into ring   | 1     |

| Question | Answer   | Marks |
|----------|--|-------|
| 7(a)     | $2\text{C}_3\text{H}_7\text{OH} + 2\text{Na} \rightarrow 2\text{C}_3\text{H}_7\text{ONa} + \text{H}_2$   | 1     |
| 7(b)(i)  | propanoic acid, phenol, propan-1-ol  | 1     |
| 7(b)(ii) | <ul style="list-style-type: none"> <li>propan-1-ol: O-H bond strengthened by positive inductive effect of alkyl group <b>OR</b> propoxide ion is destabilised by positive inductive effect of alkyl group</li> <li>phenol: O-H bond weakened by negative inductive effect of ring <b>OR</b> phenoxide ion is stabilised by delocalisation of oxygen lone pair into ring</li> <li>propanoic acid: O-H bond weakened by negative inductive effect of C=O <b>OR</b> propanoate ion is stabilised by delocalisation of minus charge by C=O</li> </ul> <p>1 mark for a correct explanation, max 2 marks</p> | 2     |
| 7(c)     | Tollens' reagent <b>or</b> Fehling's reagent   | 1     |
|          | methanoic acid gives a silver mirror/solid with Tollen's reagent <b>OR</b> red / orange ppt / solid with Fehlings' reagent   | 1     |
| 7(d)     | $\text{PCl}_5$ or $\text{PCl}_3$ (+heat) or $\text{SOCl}_2$ (added to propanoic acid)  | 1     |
|          | <p>product of first step:</p>    | 1     |
|          | add product of first step to phenol in NaOH  | 1     |
| 7(e)(i)  | propanoic acid   | 1     |
| 7(e)(ii) | propan-1-ol would have peak at 0.5–6.0 because of OH group   | 1     |
|          | propanal would have peak at 9.3–10.5 because of CHO / aldehyde   | 1     |

| Question  | Answer  | Marks    |
|-----------|---|----------|
| 8(a)      | <p style="text-align: center;">correct chiral centre labelled <b>only</b></p>  <p style="text-align: center;"><math>C_{15}H_{22}O_4</math></p> | <b>1</b> |
| 8(b)      | $C_{15}H_{22}O_4$   | <b>1</b> |
| 8(c)(i)   |    | <b>1</b> |
| 8(c)(ii)  | $CO_2$  | <b>1</b> |
|           | oxidation / oxidative cleavage  | <b>1</b> |
| 8(c)(iii) | $CH_3COCO_2H$   | <b>1</b> |

| Question | Answer   | Marks |
|----------|--|-------|
| 9(a)     | $C_8H_{11}O_3N$  | 1     |
| 9(b)     | yes, as it has a chiral C atom   | 1     |
| 9(c)(i)  | (phenyldiazonium ion is stabilised because) positive charge is delocalised by ring / positive charge is spread over ring | 1     |
| 9(c)(ii) |   | 1     |
|          | $N_2$  | 1     |