



Pearson

# **Mark Scheme (Results)**

Summer 2017

Pearson Edexcel IAL  
In Chemistry (WCH01) Paper 01  
The Core Principles of Chemistry

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Summer 2017

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## General marking guidance

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- This mark scheme provides a list of acceptable answers for this paper. Candidates will receive credit for all correct responses but will be penalised if they give more than one answer where only one is required (e.g. putting an additional cross in a set of boxes). If a candidate produces more written answers than the required number (two instead of one, three instead of two etc), only the first answers will be accepted. Free responses are marked for the effective communication of the correct answer rather than for quality of language but it is possible that, on some occasions, the quality of English or poor presentation can impede communication and loose candidate marks. It is sometimes possible for a candidate to produce a written response that does not feature in the mark scheme but which is nevertheless correct. If this were to occur, an examiner would, of course, give full credit to that answer.
- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

### Section A (multiple choice)

| Question Number | Correct Answer                                                                                                                                                                                                                                                                                                                                                                               | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>1</b>        | <b>1. The only correct answer is C</b><br><br><i>A is not correct because <math>1\text{kg} = 10^6\text{mg}</math> so no conversion factor is needed.</i><br><br><i>B is not correct because <math>1\text{kg} = 10^6\text{mg}</math> so no conversion factor is needed.</i><br><br><i>D is not correct because <math>1\text{kg} = 10^6\text{mg}</math> so no conversion factor is needed.</i> | <b>(1)</b> |

| Question Number | Correct Answer                                                                                                                                                                                                                                                                                                                                                                                      | Mark       |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>2</b>        | <b>2. The only correct answer is C</b><br><br><i>A is not correct because this does not count the 3 ions per mol of <math>\text{Na}_2\text{SO}_4</math></i><br><br><i>B is not correct because this assumes there are 2 ions per mol of <math>\text{Na}_2\text{SO}_4</math></i><br><br><i>D is not correct because this assumes there are 7 ions per mol of <math>\text{Na}_2\text{SO}_4</math></i> | <b>(1)</b> |

| Question Number | Correct Answer                                                                                                                                                                                                                             | Mark       |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>3</b>        | <b>3. The only correct answer is D</b><br><br><i>A is not correct because this is based on mass, not mol</i><br><br><i>B is not correct because the Li:O ratio is wrong</i><br><br><i>C is not correct because the Li:P ratio is wrong</i> | <b>(1)</b> |

| Question Number | Correct Answer                                                                                                                                                                                                                                                                 | Mark       |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>4</b>        | <b>4. The only correct answer is C</b><br><br><i>A is not correct because the mol of O have not been calculated</i><br><br><i>B is not correct because the mol of O have not been calculated</i><br><br><i>D is not correct because the molar ratio Cr:O has been inverted</i> | <b>(1)</b> |

| Question Number | Correct Answer                                                                                                                                                                                                                                                                                                                                                                                                        | Mark       |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>5</b>        | <p><b>5. The only correct answer is A</b></p> <p><i>B is not correct because the ratio of <math>\text{SO}_2:\text{SO}_3</math> is 1:1 and oxygen is in excess</i></p> <p><i>C is not correct because the ratio of <math>\text{SO}_2:\text{SO}_3</math> is 1:1 and oxygen is in excess</i></p> <p><i>D is not correct because the ratio of <math>\text{SO}_2:\text{SO}_3</math> is 1:1 and oxygen is in excess</i></p> | <b>(1)</b> |

| Question Number | Correct Answer                                                                                                                                                                                                                                              | Mark       |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>6</b>        | <p><b>6. The only correct answer is B</b></p> <p><i>A is not correct because Be has no unpaired electrons</i></p> <p><i>C is not correct because Cl has one unpaired p electron</i></p> <p><i>D is not correct because Ca has no unpaired electrons</i></p> | <b>(1)</b> |

| Question Number | Correct Answer                                                                                                                                                                                                                                                                                                                                               | Mark       |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>7</b>        | <p><b>7. The only correct answer is D</b></p> <p><i>A is not correct because this ion has 20 protons and <math>\text{S}^{2-}</math> has 16</i></p> <p><i>B is not correct because this ion has 17 protons and <math>\text{S}^{2-}</math> has 16</i></p> <p><i>C is not correct because this ion has 19 protons and <math>\text{S}^{2-}</math> has 16</i></p> | <b>(1)</b> |

| Question Number | Correct Answer                                                                                                                                                                                                                                                                                                                                                                                                                       | Mark       |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>8</b>        | <p><b>8. The only correct answer is D</b></p> <p><i>A is not correct because <math>\text{Na}^+</math> has less polarising power than <math>\text{Al}^{3+}</math></i></p> <p><i>B is not correct because <math>\text{Na}^+</math> has less polarising power than <math>\text{Al}^{3+}</math></i></p> <p><i>C is not correct because <math>\text{F}^-</math> is smaller than <math>\text{I}^-</math> and less easily polarised</i></p> | <b>(1)</b> |

| Question Number | Correct Answer                                                                                                                                                                                                                                                                                       | Mark       |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>9</b>        | <p><b>9. The only correct answer is C</b></p> <p><i>A is not correct because electrons are removed from level 2 before level 1</i></p> <p><i>B is not correct because electrons are removed from 2p before 2s</i></p> <p><i>D is not correct because electrons are removed from 2s before 1s</i></p> | <b>(1)</b> |

| Question Number | Correct Answer                                                                                                                                                                                                                                                                                                                                                                                                                         | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>10(a)</b>    | <p><b>10(a). The only correct answer is B</b></p> <p><i>A is not correct because <math>\text{CaCO}_3(\text{s})</math> should not be shown as separated ions</i></p> <p><i>C is not correct because <math>\text{CaCO}_3(\text{s})</math> should not be shown as separated ions</i></p> <p><i>D is not correct because <math>\text{CaCl}_2(\text{aq})</math> should be shown as separated ions and spectators then cancelled out</i></p> | <b>(1)</b> |

| Question Number | Correct Answer                                                                                                                                                                                                                                                                                                                                     | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>10(b)</b>    | <p><b>10(b). The only correct answer is A</b></p> <p><i>B is not correct because calcium chloride cannot be removed by distillation</i></p> <p><i>C is not correct because calcium chloride cannot be removed by distillation</i></p> <p><i>D is not correct because the excess solid calcium carbonate must be removed before evaporating</i></p> | <b>(1)</b> |

| Question Number | Correct Answer                                                                                                                                                                                                                                                                                                                                                           | Mark       |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>10(c)</b>    | <p><b>10(c). The only correct answer is B</b></p> <p><b>A</b> is not correct because this does not use the molar masses and the value is based on 10.4/14.7</p> <p><b>C</b> is not correct because the 2:1 ratio of HCl:CaCl<sub>2</sub> is not used</p> <p><b>D</b> is not correct because it is not based on the theoretical yield of calcium chloride being 14.7g</p> | <b>(1)</b> |

| Question Number | Correct Answer                                                                                                                                                                                                                                                                                                    | Mark       |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>11</b>       | <p><b>11. The only correct answer is C</b></p> <p><b>A</b> is not correct because melting temperatures decrease down Group 1</p> <p><b>B</b> is not correct because the melting temperature of P is less than Si</p> <p><b>D</b> is not correct because the melting temperature of Ar is less than the others</p> | <b>(1)</b> |

| Question Number | Correct Answer                                                                                                                                                                                                                                                                                                                                | Mark       |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>12</b>       | <p><b>12. The only correct answer is C</b></p> <p><b>A</b> is not correct because it has used a wrong sign in the calculation and then divided the answer by 2</p> <p><b>B</b> is not correct because it has used a wrong sign in the calculation</p> <p><b>D</b> is not correct because the wrong sign for enthalpy change has been used</p> | <b>(1)</b> |

| Question Number | Correct Answer                                                                                                                                                                                                                                                                                                                                 | Mark       |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>13</b>       | <p><b>13. The only correct answer is D</b></p> <p><b>A</b> is not correct because there are 6 C atoms in the longest chain</p> <p><b>B</b> is not correct because there are 6 C atoms in the longest chain</p> <p><b>C</b> is not correct because the chain should be numbered from the end which gives lowest numbers for the side chains</p> | <b>(1)</b> |

| Question Number | Correct Answer                                                                                                                                                                                                                                                                                                                          | Mark       |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>14</b>       | <p><b>14. The only correct answer is B</b></p> <p><b>A</b> is not correct because in the double bond the first C atom has 2H attached</p> <p><b>C</b> is not correct because in the double bond the first C atom has 2Cl attached</p> <p><b>D</b> is not correct because in the double bond one C atom has 2CH<sub>3</sub> attached</p> | <b>(1)</b> |

| Question Number | Correct Answer                                                                                                                                                                                                                                                                                                                                                                          | Mark       |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>15</b>       | <p><b>15. The only correct answer is A</b></p> <p><b>B</b> is not correct because the molecular formula C<sub>5</sub>H<sub>8</sub> cannot be simplified</p> <p><b>C</b> is not correct because the molecular formula C<sub>5</sub>H<sub>12</sub> cannot be simplified</p> <p><b>D</b> is not correct because the molecular formula C<sub>5</sub>H<sub>12</sub> cannot be simplified</p> | <b>(1)</b> |

| Question Number | Correct Answer                                                                                                                                                                                                                                                                                                                                                 | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>16</b>       | <p><b>16. The only correct answer is D</b></p> <p><b>A</b> is not correct because hydrogen peroxide does not react with propene to give a diol</p> <p><b>B</b> is not correct because oxygen and water do not react with propene to give a diol</p> <p><b>C</b> is not correct because aqueous sodium hydroxide does not react with propene to give a diol</p> | <b>(1)</b> |

| Question Number | Correct Answer                                                                                                                                                                                                                                                                                                                            | Mark       |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>17</b>       | <p><b>17. The only correct answer is A</b></p> <p><b>B</b> is not correct because bromine, not HBr, is needed to produce dibromopropane</p> <p><b>C</b> is not correct because bromine, not HBr, is needed to produce bromopropanol</p> <p><b>D</b> is not correct because bromine water, not HBr, is needed to produce bromopropanol</p> | <b>(1)</b> |

| Question Number | Correct Answer                                                                                                                                                                                                                                                                                                               | Mark       |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>18</b>       | <p><b>18. The only correct answer is B</b></p> <p><b>A</b> is not correct because another alkene is required to react with ethene</p> <p><b>C</b> is not correct because another alkene is required to react with ethene</p> <p><b>D</b> is not correct because an alkene with 3C atoms is required to react with ethene</p> | <b>(1)</b> |

**TOTAL FOR SECTION A = 20 MARKS**

**Section B**

| Question Number | Acceptable Answers                                                                                                                                                                                                                                | Reject       | Mark       |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|------------|
| <b>19a(i)</b>   | $\frac{(6.10 \times 54 + 92.0 \times 56 + 1.90 \times 57)}{100}$ <p><b>(1)</b></p> $= (5589.7 / 100)$ <p><b>=55.9</b><br/>Final answer must be to 3 SF<br/>IGNORE<br/>Units <b>(1)</b></p> <p>Correct answer with no working shown scores (2)</p> | 55.89/ 55.90 | <b>(2)</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                         | Reject   | Mark      |          |    |    |    |                         |            |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-----------|----------|----|----|----|-------------------------|------------|
| <b>19a(ii)</b>  | <p>X = Fe / iron.</p> <p>ALLOW Fe<sup>+</sup></p> <table border="1"><tr><td>protons</td><td>electrons</td><td>neutrons</td></tr><tr><td>26</td><td>25</td><td>30</td></tr></table> <p><b>MP1</b><br/>Identity of X <b>and</b> proton number <b>(1)</b></p> <p><b>MP2</b><br/>number of electrons <b>and</b> neutrons</p> <p>No TE for MP2 for wrong element <b>(1)</b></p> | protons  | electrons | neutrons | 26 | 25 | 30 | Fe with negative charge | <b>(2)</b> |
| protons         | electrons                                                                                                                                                                                                                                                                                                                                                                  | neutrons |           |          |    |    |    |                         |            |
| 26              | 25                                                                                                                                                                                                                                                                                                                                                                         | 30       |           |          |    |    |    |                         |            |

| Question Number | Acceptable Answers                                                                            | Reject                                                                                       | Mark       |
|-----------------|-----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|------------|
| <b>19a(iii)</b> | <p>X<sup>2+</sup>/ Fe<sup>2+</sup> forms</p> <p>IGNORE any atomic numbers or mass numbers</p> | <p>Fe<sup>2-</sup></p> <p>Silicon, Si,<br/>Ni, Si<sup>+</sup>, N<sub>2</sub><sup>+</sup></p> | <b>(1)</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                               | Reject | Mark       |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------------|
| <b>19a(iv)</b>  | <p>The isotopes have the same number of electrons <b>(1)</b></p> <p>(therefore)</p> <p>same number of electrons in outer shell / valence electrons</p> <p>(so the same chemical properties) <b>(1)</b></p> <p>Isotopes have the same electronic configuration/structure scores (2)</p> <p>IGNORE</p> <p>Same number of protons/ different number of neutrons</p> |        | <b>(2)</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                         | Reject                   | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|------------|
| <b>19b(i)</b>   | <p>Sample is vaporised / converted to a gas / atomised</p> <p>ALLOW</p> <p>sample is sublimed <b>(1)</b></p> <p>(Atoms are) bombarded with (high energy) electrons /</p> <p>electron removed with electron gun /</p> <p>electron removed with electron beam <b>(1)</b></p> | 'vaporised to form ions' | <b>(2)</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                     | Reject                                                                                        | Mark       |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|------------|
| <b>19b(ii)</b>  | <p><b>MP1</b><br/>Reference to acceleration, deflection, detection in correct order<br/>IGNORE<br/>Additional comments on vaporisation and ionisation <b>(1)</b></p> <p><b>MP2 and 3</b><br/>Acceleration: (ions pass through slit in negatively) charged plate / electric field / electronic field <b>(1)</b></p> <p>Deflection: (ions pass through) a magnetic field<br/>ALLOW magnet / electromagnet <b>(1)</b></p> | <p>Incorrect order</p> <p>Analysing</p> <p>Just positively charged plate 'electron field'</p> | <b>(3)</b> |

**(Total for Question 19 =12 marks)**

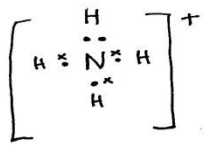
| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                       | Reject                                                                                    | Mark       |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|------------|
| <b>20a(i)</b>   | <p><b>MP1</b><br/>Metallic (bonding)</p> <p><b>and</b></p> <p>Na has delocalised / mobile electrons / free electrons<br/>ALLOW<br/>Sea of electrons <b>(1)</b></p> <p><b>MP2</b><br/>attracting the positive ions / attracting the metal ions / attracting the nuclei <b>(1)</b></p> <p>Second mark depends on first</p> | <p>Intermolecular forces</p> <p>Attraction in any sort of bonding other than metallic</p> | <b>(2)</b> |

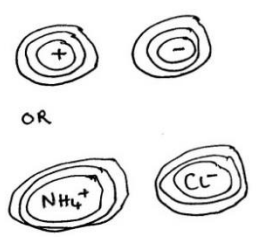
| Question Number | Acceptable Answers                                                                                                                                                                                        | Reject                                                                                                         | Mark       |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|------------|
| <b>20a(ii)</b>  | <p>Ionic bonding <b>and</b> (electrostatic) force /attraction between oppositely charged ions<br/>OR<br/>+ and – ions<br/>OR<br/>Na<sup>+</sup> and Br<sup>-</sup> ions<br/>OR<br/>cations and anions</p> | <p>Intermolecular forces between ions<br/>Attraction of differently charged ions</p> <p>Sodium and bromine</p> | <b>(1)</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                       | Reject                                      | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|------------|
| <b>20a(iii)</b> | <p>Ionic (bonding) is stronger than metallic (bonding) (in this case)<br/>OR<br/>Bonding in NaBr is stronger (than in Na)</p> <p>ALLOW</p> <p>Attraction in NaBr is stronger</p> <p>Reverse argument</p> | Any reference to incorrect types of bonding | <b>(1)</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Reject                                                                                     | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|------------|
| <b>20a(iv)</b>  | <p><b>Electrical conductivity:</b></p> <p>Sodium conducts (in solid or liquid state)<br/>NaBr does not conduct when solid/ only conducts when molten / in (aqueous) solution</p> <p>OR</p> <p><b>Thermal conductivity :</b><br/>Na good, NaBr poor<br/>Sodium conducts heat is insufficient</p> <p>OR</p> <p><b>Malleability/ Ductility:</b><br/>Na malleable/ ductile, NaBr brittle</p> <p>ALLOW</p> <p><b>Hardness</b><br/>Na soft; NaBr harder</p> <p><b>Density</b><br/>Na low ; NaBr higher</p> <p>Name of property and correct for Na or NaBr <b>(1)</b></p> <p>Correct for the second substance <b>(1)</b></p> <p>IGNORE<br/>Explanations for differences</p> | <p>NaBr cannot conduct heat</p> <p>Chemical properties</p> <p>Colour</p> <p>Solubility</p> | <b>(2)</b> |

| Question Number | Acceptable Answers                                                                                                                                               | Reject | Mark       |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------------|
| <b>20b(i)</b>   | <p>Covalent: The (bonding) electrons come (equally) from both atoms <b>(1)</b></p> <p>Dative covalent: The (bonding) electrons come from one atom <b>(1)</b></p> |        | <b>(2)</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Reject                   | Mark       |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|------------|
| <b>20b(ii)</b>  |  <p>N joined to four H with three correct N-H single bonds, i.e. with a dot and a cross <b>(1)</b></p> <p>Datively covalently bonded H (lone pair on N shared with fourth H) <b>and</b> a + charge on this H / on the whole ion / on the N</p> <p>ALLOW 2 crosses for dative bond <b>(1)</b></p> <p>IGNORE<br/>Arrow from N to H indicating dative covalent<br/>Lack of square brackets</p> | Just diagram for ammonia | <b>(2)</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                          | Reject | Mark       |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------------|
| <b>20b(iii)</b> | <p>(Electron density contour) lines go round ion and not around other nuclei/<br/>do not overlap/<br/>do not fuse/<br/>do not intercept/<br/>OR<br/>There is a gap between particles/ ions with no electron density lines</p> <p>IGNORE<br/>Number of circles<br/>ALLOW<br/>Diagram</p>  |        | <b>(1)</b> |

**(Total for Question 20 = 11 marks)**

| Question Number | Acceptable Answers                                                             | Reject | Mark       |
|-----------------|--------------------------------------------------------------------------------|--------|------------|
| <b>21a(i)</b>   | Answers between 7000 and 8500, including 7000 and 8500 (kJ mol <sup>-1</sup> ) |        | <b>(1)</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                        | Reject | Mark       |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------------|
| <b>21a(ii)</b>  | $\text{Mg}^{2+}(\text{g}) \rightarrow \text{Mg}^{3+}(\text{g}) + \text{e}^{(-)}(\text{g})$ <p>ALLOW<br/> <math display="block">\text{Mg}^{2+}(\text{g}) - \text{e}^{(-)}(\text{g}) \rightarrow \text{Mg}^{3+}(\text{g})</math></p> <p>Gaseous states for both magnesium species <b>(1)</b></p> <p>Rest of equation correct <b>(1)</b></p> |        | <b>(2)</b> |

| Question Number | Acceptable Answers   |                                                                                                                                                                                                                                                                        | Reject                | Mark       |            |
|-----------------|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|------------|------------|
| <b>21b(i)</b>   | (Enthalpy change of) |                                                                                                                                                                                                                                                                        | EA of Cl <sub>2</sub> | <b>(3)</b> |            |
|                 | $\Delta H_1$         | Atomisation of Mg and (2x) atomisation of $\frac{1}{2}$ Cl <sub>2</sub> / Cl / chlorine / Cl <sub>2</sub><br><br>ALLOW<br>$\Delta H_{\text{at}}$ for (enthalpy change of) atomisation<br>OR Bond enthalpy Cl-Cl for $\Delta H_{\text{at}}$<br><br>Ignore state symbols |                       |            | <b>(1)</b> |
|                 | $\Delta H_3$         | (2x) (first) electron affinity of Cl / chlorine (2x) EA of Cl<br><br>ALLOW<br>Electron affinity of 2 Cl                                                                                                                                                                |                       |            | <b>(1)</b> |
|                 | $\Delta H_5$         | Formation (of MgCl <sub>2</sub> )<br>$\Delta H_{\text{f}}$ (of MgCl <sub>2</sub> )                                                                                                                                                                                     |                       |            | <b>(1)</b> |

| Question Number | Acceptable Answers              | Reject                        | Mark       |
|-----------------|---------------------------------|-------------------------------|------------|
| <b>21b(ii)</b>  | (+)2189 (kJ mol <sup>-1</sup> ) | -2189 (kJ mol <sup>-1</sup> ) | <b>(1)</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Reject                                                          | Mark       |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|------------|
| <b>21b(iii)</b> | $\Delta H_4 =$<br>$-641.3 - (391.1 + 2189 - 697.6)$<br><b>(1)</b><br>$= - 2523.8 / -2524$ (kJ mol <sup>-1</sup> )<br><b>(1)</b><br>Final answer without working scores 2<br>Correct value with + sign scores 1<br>TE on incorrect value in (b)(ii) for 2 marks:<br>(b)(ii) = +1451, (b)(iii) = <b>-1785.8</b><br>(b)(ii) = -2189, (b)(iii) = <b>(+)1854.2</b><br>If no value has been calculated in (b)(ii), $\Delta H_4 = -334.8 - \Delta H_2$<br>This scores <b>(1)</b> | incorrect unit, but allow the minor slip eg kJ mol <sup>-</sup> | <b>(2)</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                      | Reject                                                                      | Mark       |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|------------|
| <b>*21c(i)</b>  | Ca atom has a larger radius (than Mg)/<br>has more electron shells (than Mg) /<br>has (outer) electrons which are further from nucleus<br>OR<br>The (outer shell) electrons in Ca are more shielded <b>(1)</b><br>(Outer shell) electrons experience less attraction from the nucleus<br>OR<br>require less energy/ are easier to remove <b>(1)</b><br>ALLOW reverse argument<br>IGNORE<br>References to charge density | Ca ions larger<br>Just "Ca is larger (than Mg)"<br>The molecules are larger | <b>(2)</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Reject                                                                                                    | Mark       |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|------------|
| <b>*21c(ii)</b> | <p><b>MP1</b><br/> <math>\text{Mg}^{2+}</math> has higher charge density / same charge but smaller (radius) than <math>\text{Ca}^{2+}</math> / distance between ions is smaller</p> <p>IGNORE<br/> <math>\text{Mg}^{2+}</math> has higher polarising power than <math>\text{Ca}^{2+}</math> <b>(1)</b></p> <p><b>MP2</b><br/>           So attracts <math>\text{Cl}^-</math> more strongly (in <math>\text{MgCl}_2</math>) / so more energy is released when bond forms <b>(1)</b></p> <p>MP2 depends on MP1</p> <p>ALLOW reverse argument</p> | <p>Atomic radius</p> <p>'attracts chlorine'<br/>           References to incorrect type of bond/force</p> | <b>(2)</b> |

**(Total for Question 21 = 13 marks)**

| Question Number | Acceptable Answers                                                                                                                                                                                                                                 | Reject                                                        | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|------------|
| <b>22(a)</b>    | Difficult to measure energy supplied/<br>take measurements while heating (the sample)/<br>to decide when reaction is complete<br><br>ALLOW<br>Difficult to measure the temperature of a solid<br>Difficult to measure heat supplied/ heat absorbed | Just "because requires heating"<br><br>Because of heat losses | <b>(1)</b> |

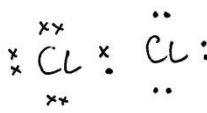
| Question Number | Acceptable Answers                                                                                                                                                                                                          | Reject          | Mark       |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|------------|
| <b>22b(i)</b>   | To protect from or prevent (the acid/ reaction mixture)<br>spraying/<br>spitting/<br>splashing out/<br>bubbling over/<br>spilling with reason eg due to excessive frothing / stirring<br><br>IGNORE<br>Reaction is vigorous | Just "spilling" | <b>(1)</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                    | Reject | Mark       |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------------|
| <b>22b(ii)</b>  | Mol HCl = $(100 \times 1.25 / 1000)$<br>= $1.25 \times 10^{-1}$ / <b>0.125</b> <b>(1)</b><br><br>Mol NaHCO <sub>3</sub> = $(8.0/84)$<br>= 0.095238/ <b>0.0952</b><br>Ignore SF except 1 SF <b>(1)</b> |        | <b>(2)</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Reject | Mark       |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------------|
| <b>22b(iii)</b> | <p>Energy transferred =<br/> <math>(100 \times 4.18 \times 7.3)</math><br/> <b>= 3051.4 (J) / 3.0514 kJ</b><br/>                     Ignore sign<br/>                     Ignore SF except 1 or 2 SF <b>(1)</b></p> <p><math>\Delta H = + 3051.4 \div 0.095238</math></p> <p>Allow TE from incorrect <math>\text{NaHCO}_3</math> from<br/>                     (b) (ii) <b>(1)</b></p> <p><b>= + 32040 J mol<sup>-1</sup> /</b><br/> <b>+32.040/ +32.0 kJ mol<sup>-1</sup></b></p> <p>ALLOW answers using rounded values<br/>                     of 0.095238 e.g.<br/> <b>+32.120 kJ mol<sup>-1</sup></b> if based on 0.095<br/> <b>(1)</b></p> <p>IGNORE SF</p> <p>Use of 0.125 mol does NOT score MP2,<br/>                     but will score MP3 for +24.41 kJ mol<sup>-1</sup></p> |        | <b>(3)</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Reject                    | Mark       |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|------------|
| <b>22b(iv)</b>  | <div style="text-align: center;"> </div> <p>2NaCl + 2H<sub>2</sub>O + 2CO<sub>2</sub> in bottom box<br/>IGNORE<br/>State symbols <b>(1)</b></p> <p>Two arrows pointing downwards each with 2HCl<br/>OR<br/>Two arrows pointing downwards with 2HCl on each side of the equation in both top boxes <b>(1)</b></p> <p>ALLOW<br/>Right hand arrow pointing upwards and 2HCl<br/>if (2x) (b)(iii) + 36.3 used correctly in calculation</p> <p><math>\Delta H</math> for Reaction 1 =<br/>2x answer to (b)(iii) -(-36.3) <b>(1)</b><br/>= (+)100.3 (kJ mol<sup>-1</sup>) <b>(1)</b></p> <p>If factor of 2 missing in MP3 allow TE in MP4<br/>= (+)68.3 (kJ mol<sup>-1</sup>)</p> <p>TE on incorrect answer to (b)(iii)<br/>Answer of +3.05 in (b)(iii) gives (2x 3.05 +36.3) = (+)42.4 (kJ mol<sup>-1</sup>)<br/>Answer of +24.41 in (b)(iii) gives (2x 24.41 +36.3) = (+)85.12 (kJ mol<sup>-1</sup>)</p> | Cycles using $\Delta H_f$ | <b>(4)</b> |

( Total for question 22 = 11 marks)

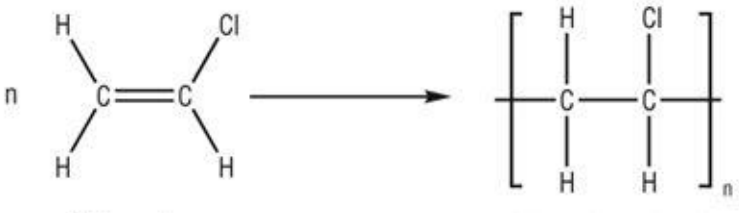
| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                       | Reject                      | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|------------|
| <b>23a(i)</b>   |  <p><b>MP1</b><br/>Diagram with 3 lone pairs of electrons per atom and one shared pair<br/>ALLOW<br/>All dots or all crosses <b>(1)</b></p> <p><b>MP2</b><br/>One electron from the Cl-Cl bond goes to each atom to produce a (free) <b>radical</b><br/>/ the bonding electrons are divided equally between the atoms to produce a (free) <b>radical</b> <b>(1)</b></p> | Just Cl-Cl with half arrows | <b>(2)</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Reject | Mark       |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------------|
| <b>23a (ii)</b> | <p>Penalise omission of dots in correct equations only once in (ii) and (iii)</p> <p><math>\text{C}_2\text{H}_6 + \text{Cl}\bullet \rightarrow \text{HCl} + \text{C}_2\text{H}_5\bullet</math> <b>(1)</b></p> <p><math>\text{C}_2\text{H}_5\bullet + \text{Cl}_2 \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{Cl}\bullet</math> <b>(1)</b></p> <p>ALLOW<br/>• before or after the formula.</p> <p>TE in equation 2 if the wrong hydrocarbon is used (eg methane giving <math>\text{CH}_3\bullet</math>)</p> <p>TE in equation 2 for formation of further substituted chloroalkane</p> <p>IGNORE any curly arrows</p> |        | <b>(2)</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                             | Reject                                                                                               | Mark       |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|------------|
| * <b>23b(i)</b> | <p><b>MP1</b><br/>pi bond forms by overlap of <b>p</b> orbitals.<br/>ALLOW<br/>Correct labelled diagram <b>(1)</b></p> <p><b>MP2</b><br/>Orbital overlap is poor so bond breaks easily<br/>OR<br/>Orbital overlap is poor as orbitals are parallel / sideways<br/><br/>(Poor overlap must be described, not just drawn)<br/>OR<br/>Region of high electron density makes bond reactive / susceptible to attack by electrophiles <b>(1)</b></p> | <p>p sub shells / pi orbital</p> <p>Just "it is weaker than the sigma bond" without a reason why</p> | <b>(2)</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Reject                                                                                         | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|------------|
| <b>*23b(ii)</b> | <div> </div> <p><b>MP1</b><br/>           Arrow from C=C to Cl<sup>δ+</sup> <b>and</b> from Cl-Cl bond to Cl<sup>δ-</sup> <b>(1)</b></p> <p><b>MP2</b><br/>           Intermediate with + charge, <b>and</b> Cl<sup>-</sup> <b>(1)</b></p> <p><b>MP3</b><br/>           Arrow from anywhere on Cl<sup>-</sup> to + on C and product (lone pair on Cl<sup>-</sup> not required)</p> <p><b>ALLOW</b><br/>           TE if partial charges are shown in MP2 (do not penalise these twice) <b>(1)</b></p> <p>Correct mechanism shown with bromine or HX or an incorrect alkene scores a maximum of 2 marks.</p> | <p>Partial charges on intermediate and chloride</p> <p>No TE from a free radical mechanism</p> | <b>(3)</b> |

| Question Number | Acceptable Answers | Reject                        | Mark       |
|-----------------|--------------------|-------------------------------|------------|
| <b>23b(iii)</b> | 1,2-dichloroethane | ethene for ethane in the name | <b>(1)</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Reject | Mark       |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------------|
| <b>23c</b>      |  <p>MP1 is for correct structure of monomer <b>and</b> single repeat unit of polymer with continuation bonds <b>(1)</b></p> <p>MP2 is for n in correct place of both sides of the equation and brackets round repeat unit</p> <p>ALLOW<br/>Multiples if balancing is correct in equation</p> <p>Polymer with more than one repeat unit if balanced</p> <p>Continuation bonds which do not go right through the bracket</p> <p>IGNORE<br/>Bracket round monomer<br/>Shape of brackets <b>(1)</b></p> |        | <b>(2)</b> |

**(Total for Question 23 = 13 marks)**

**TOTAL FOR PAPER = 80 MARKS**

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