Mark Scheme for January 2013
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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

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<table>
<thead>
<tr>
<th>Annotation</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>BBD</td>
<td>Benefit of doubt given</td>
</tr>
<tr>
<td>CON</td>
<td>Contradiction</td>
</tr>
<tr>
<td>X</td>
<td>Incorrect response</td>
</tr>
<tr>
<td>ECF</td>
<td>Error carried forward</td>
</tr>
<tr>
<td>I</td>
<td>Ignore</td>
</tr>
<tr>
<td>NAD</td>
<td>Not answered question</td>
</tr>
<tr>
<td>NBD</td>
<td>Benefit of doubt not given</td>
</tr>
<tr>
<td>POT</td>
<td>Power of 10 error</td>
</tr>
<tr>
<td>O</td>
<td>Omission mark</td>
</tr>
<tr>
<td>R</td>
<td>Rounding error</td>
</tr>
<tr>
<td>OFE</td>
<td>Error in number of significant figures</td>
</tr>
<tr>
<td>✓</td>
<td>Correct response</td>
</tr>
</tbody>
</table>
Subject-specific Marking Instructions

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

<table>
<thead>
<tr>
<th>Annotation</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DO NOT ALLOW</strong></td>
<td>Answers which are not worthy of credit</td>
</tr>
<tr>
<td><strong>IGNORE</strong></td>
<td>Statements which are irrelevant</td>
</tr>
<tr>
<td><strong>ALLOW</strong></td>
<td>Answers that can be accepted</td>
</tr>
<tr>
<td>( )</td>
<td>Words which are not essential to gain credit</td>
</tr>
<tr>
<td>—</td>
<td>Underlined words must be present in answer to score a mark</td>
</tr>
<tr>
<td><strong>ECF</strong></td>
<td>Error carried forward</td>
</tr>
<tr>
<td><strong>AW</strong></td>
<td>Alternative wording</td>
</tr>
<tr>
<td><strong>ORA</strong></td>
<td>Or reverse argument</td>
</tr>
</tbody>
</table>

The following questions should be fully annotated with ticks, crosses, ecf etc to show where marks have been awarded in the body of the text:

3(c), 4(e)(iii) and 5(a)
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>Guidance</th>
</tr>
</thead>
</table>
| 1        | **(a) (i)** Atom(s) of an element                                        | 1     | **ALLOW** for ‘atoms of an element’:  
Atoms of the same element  
OR atoms with the same number of protons  
OR atoms with the same atomic number  
**IGNORE** ‘different relative atomic masses’  
**IGNORE** different mass number  
**IGNORE** same number of electrons  
DO NOT ALLOW different numbers of electrons  
DO NOT ALLOW ‘atoms of elements’ for ‘atoms of an element’  
DO NOT ALLOW ‘an element with different numbers of neutrons’ (ie atom(s) is essential) |
|          | **AND**                                                                |       | **ALLOW** for ‘atoms of an element’:  
Atoms of the same element  
OR atoms with the same number of protons  
OR atoms with the same atomic number  
**IGNORE** ‘different relative atomic masses’  
**IGNORE** different mass number  
**IGNORE** same number of electrons  
DO NOT ALLOW different numbers of electrons  
DO NOT ALLOW ‘atoms of elements’ for ‘atoms of an element’  
DO NOT ALLOW ‘an element with different numbers of neutrons’ (ie atom(s) is essential) |
|          | with different numbers of neutrons (and with different masses) ✔        |       | **ALLOW** for ‘atoms of an element’:  
Atoms of the same element  
OR atoms with the same number of protons  
OR atoms with the same atomic number  
**IGNORE** ‘different relative atomic masses’  
**IGNORE** different mass number  
**IGNORE** same number of electrons  
DO NOT ALLOW different numbers of electrons  
DO NOT ALLOW ‘atoms of elements’ for ‘atoms of an element’  
DO NOT ALLOW ‘an element with different numbers of neutrons’ (ie atom(s) is essential) |
|          | **(ii)** Protons            | 1     | **ALLOW** for ‘atoms of an element’:  
Atoms of the same element  
OR atoms with the same number of protons  
OR atoms with the same atomic number  
**IGNORE** ‘different relative atomic masses’  
**IGNORE** different mass number  
**IGNORE** same number of electrons  
DO NOT ALLOW different numbers of electrons  
DO NOT ALLOW ‘atoms of elements’ for ‘atoms of an element’  
DO NOT ALLOW ‘an element with different numbers of neutrons’ (ie atom(s) is essential) |
|          | Neutrons           |       | **ALLOW** for ‘atoms of an element’:  
Atoms of the same element  
OR atoms with the same number of protons  
OR atoms with the same atomic number  
**IGNORE** ‘different relative atomic masses’  
**IGNORE** different mass number  
**IGNORE** same number of electrons  
DO NOT ALLOW different numbers of electrons  
DO NOT ALLOW ‘atoms of elements’ for ‘atoms of an element’  
DO NOT ALLOW ‘an element with different numbers of neutrons’ (ie atom(s) is essential) |
|          | Electrons |       | **ALLOW** for ‘atoms of an element’:  
Atoms of the same element  
OR atoms with the same number of protons  
OR atoms with the same atomic number  
**IGNORE** ‘different relative atomic masses’  
**IGNORE** different mass number  
**IGNORE** same number of electrons  
DO NOT ALLOW different numbers of electrons  
DO NOT ALLOW ‘atoms of elements’ for ‘atoms of an element’  
DO NOT ALLOW ‘an element with different numbers of neutrons’ (ie atom(s) is essential) |
|          | **Protons Neutrons Electrons** |       | **ALLOW** for ‘atoms of an element’:  
Atoms of the same element  
OR atoms with the same number of protons  
OR atoms with the same atomic number  
**IGNORE** ‘different relative atomic masses’  
**IGNORE** different mass number  
**IGNORE** same number of electrons  
DO NOT ALLOW different numbers of electrons  
DO NOT ALLOW ‘atoms of elements’ for ‘atoms of an element’  
DO NOT ALLOW ‘an element with different numbers of neutrons’ (ie atom(s) is essential) |
|          | 74 110 74 ✔ | | **ALLOW** for ‘atoms of an element’:  
Atoms of the same element  
OR atoms with the same number of protons  
OR atoms with the same atomic number  
**IGNORE** ‘different relative atomic masses’  
**IGNORE** different mass number  
**IGNORE** same number of electrons  
DO NOT ALLOW different numbers of electrons  
DO NOT ALLOW ‘atoms of elements’ for ‘atoms of an element’  
DO NOT ALLOW ‘an element with different numbers of neutrons’ (ie atom(s) is essential) |
|          | **(iii)** | 1     | **ALLOW** for ‘atoms of an element’:  
Atoms of the same element  
OR atoms with the same number of protons  
OR atoms with the same atomic number  
**IGNORE** ‘different relative atomic masses’  
**IGNORE** different mass number  
**IGNORE** same number of electrons  
DO NOT ALLOW different numbers of electrons  
DO NOT ALLOW ‘atoms of elements’ for ‘atoms of an element’  
DO NOT ALLOW ‘an element with different numbers of neutrons’ (ie atom(s) is essential) |
|          | ¹²C OR C-12 OR carbon 12 OR carbon-12 ✔ | | **ALLOW** for ‘atoms of an element’:  
Atoms of the same element  
OR atoms with the same number of protons  
OR atoms with the same atomic number  
**IGNORE** ‘different relative atomic masses’  
**IGNORE** different mass number  
**IGNORE** same number of electrons  
DO NOT ALLOW different numbers of electrons  
DO NOT ALLOW ‘atoms of elements’ for ‘atoms of an element’  
DO NOT ALLOW ‘an element with different numbers of neutrons’ (ie atom(s) is essential) |
|          | **(b) (i)** | 2     | **ALLOW** 6+ OR 6 OR 1+ OR 1  
ALLOW one mark for correct oxidation number changes  
H = 0 to H = +1 ✔  
(Reduced):  
W (oxidation number has decreased) from W = +6 to W = 0 ✔  
ALLOW oxidation states written above the equation if not seen in the text BUT **IGNORE** oxidation states written above the equation if seen in the text  
ALLOW for one mark: (Oxidised) H has increased by 1 AND (Reduced) W has decreased by 6  
**IGNORE** WO₃ is reduced  
**IGNORE** references to electron loss / gain if correct  
DO NOT ALLOW incorrect references to electron loss / gain  
DO NOT ALLOW ‘H oxidised and W reduced’ without reference to oxidation number changes  
**ALLOW** for ‘atoms of an element’:  
Atoms of the same element  
OR atoms with the same number of protons  
OR atoms with the same atomic number  
**IGNORE** ‘different relative atomic masses’  
**IGNORE** different mass number  
**IGNORE** same number of electrons  
DO NOT ALLOW different numbers of electrons  
DO NOT ALLOW ‘atoms of elements’ for ‘atoms of an element’  
DO NOT ALLOW ‘an element with different numbers of neutrons’ (ie atom(s) is essential) |
|          | (Oxidised): H (oxidation number has increased) from H = 0 to H = +1 ✔  | | **ALLOW** for ‘atoms of an element’:  
Atoms of the same element  
OR atoms with the same number of protons  
OR atoms with the same atomic number  
**IGNORE** ‘different relative atomic masses’  
**IGNORE** different mass number  
**IGNORE** same number of electrons  
DO NOT ALLOW different numbers of electrons  
DO NOT ALLOW ‘atoms of elements’ for ‘atoms of an element’  
DO NOT ALLOW ‘an element with different numbers of neutrons’ (ie atom(s) is essential) |
|          | (Reduced): W (oxidation number has decreased) from W = +6 to W = 0 ✔  | | **ALLOW** for ‘atoms of an element’:  
Atoms of the same element  
OR atoms with the same number of protons  
OR atoms with the same atomic number  
**IGNORE** ‘different relative atomic masses’  
**IGNORE** different mass number  
**IGNORE** same number of electrons  
DO NOT ALLOW different numbers of electrons  
DO NOT ALLOW ‘atoms of elements’ for ‘atoms of an element’  
DO NOT ALLOW ‘an element with different numbers of neutrons’ (ie atom(s) is essential) |
|          | WO₃ is reduced  
**IGNORE** references to electron loss / gain if correct  
DO NOT ALLOW incorrect references to electron loss / gain  
DO NOT ALLOW ‘H oxidised and W reduced’ without reference to oxidation number changes  
**ALLOW** for ‘atoms of an element’:  
Atoms of the same element  
OR atoms with the same number of protons  
OR atoms with the same atomic number  
**IGNORE** ‘different relative atomic masses’  
**IGNORE** different mass number  
**IGNORE** same number of electrons  
DO NOT ALLOW different numbers of electrons  
DO NOT ALLOW ‘atoms of elements’ for ‘atoms of an element’  
DO NOT ALLOW ‘an element with different numbers of neutrons’ (ie atom(s) is essential) |
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<th>Marks</th>
<th>Guidance</th>
</tr>
</thead>
</table>
| 1 (b) (ii) | **FIRST CHECK THE ANSWER ON ANSWER LINE**  
IF answer = 3.6(0) (dm³) award 3 marks | 3 | If there is an alternative answer, check to see if there is any ECF credit possible using working below  
ALLOW calculator value or rounding to 2 significant figures or more BUT **IGNORE** ‘trailing’ zeroes, eg 0.200 allowed as 0.2 if wrong M, produces such numbers throughout.  
**IF** answer = 1.2(0) dm³ award 2 marks (not multiplying by 3)  
ALLOW use of inexact Mₐ (eg 232) – if it still gives 0.05  
ALLOW amount of WO₃ x 3 correctly calculated for 2nd mark  
ALLOW amount of H₂ x 24.0 correctly calculated for 3rd mark  
ALLOW 1 mark for incorrect amount of WO₃ x 24.0 (not multiplied by 3 ie scores third mark only) |
<p>|       | Amount of WO₃ = (11.59 / 231.8 = ) 0.05(00) (mol) ✓ |       |       |
|       | Amount of H₂ = 0.0500 x 3 = 0.15(0) (mol) ✓ |       |       |
|       | Volume of H₂ = 0.150 x 24.0 = 3.6(0) (dm³) ✓ |       |       |
| Total  | 8 | | |</p>
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 (a)</td>
<td>A shared pair of electrons √</td>
<td>1</td>
<td>DO NOT ALLOW ‘shared electrons’</td>
</tr>
<tr>
<td>(b) (i)</td>
<td><strong>Pairs</strong> of (electrons surrounding a central atom) repel √</td>
<td>2</td>
<td>ALLOW alternative phrases/words to repel eg ‘push apart’</td>
</tr>
<tr>
<td></td>
<td>The shape is determined by the number of bond pairs AND the number of lone pairs (of electrons) √</td>
<td></td>
<td>ALLOW lone pairs repel OR bond(ing) pairs repel</td>
</tr>
<tr>
<td></td>
<td><strong>ALLOW</strong> ‘the number of bonding pairs and number of lone pairs decides the orientation of the surrounding atoms’</td>
<td></td>
<td>ALLOW ‘how many’ for ‘number of’</td>
</tr>
<tr>
<td></td>
<td><strong>ALLOW</strong> the second mark for a response which has 2 of the following including at least one shape involving lone pairs (of electrons) BUT mark incorrect responses first</td>
<td></td>
<td><strong>ALLOW</strong> the second mark for a response which has 2 of the following including at least one shape involving lone pairs (of electrons) BUT mark incorrect responses first</td>
</tr>
<tr>
<td></td>
<td>2 bonding pairs = linear</td>
<td></td>
<td>2 bonding pairs = linear</td>
</tr>
<tr>
<td></td>
<td>3 bonding pairs = trigonal planar</td>
<td></td>
<td>3 bonding pairs = trigonal planar</td>
</tr>
<tr>
<td></td>
<td>4 bonding pairs = tetrahedral</td>
<td></td>
<td>4 bonding pairs = tetrahedral</td>
</tr>
<tr>
<td></td>
<td>6 bonding pairs = hexagonal</td>
<td></td>
<td>6 bonding pairs = hexagonal</td>
</tr>
<tr>
<td></td>
<td>3 bonding pairs and 1 lone pair = pyramidal</td>
<td></td>
<td>3 bonding pairs and 1 lone pair = pyramidal</td>
</tr>
<tr>
<td></td>
<td>2 bonding pairs and 2 lone pairs = non-linear</td>
<td></td>
<td>2 bonding pairs and 2 lone pairs = non-linear</td>
</tr>
<tr>
<td></td>
<td><strong>IGNORE</strong> ‘number of electron pairs decides shape of molecule’ as this is in the question</td>
<td></td>
<td><strong>IGNORE</strong> ‘number of electron pairs decides shape of molecule’ as this is in the question</td>
</tr>
<tr>
<td>(ii)</td>
<td>O–B–O = 120° √</td>
<td>2</td>
<td>ALLOW 104–105°</td>
</tr>
<tr>
<td></td>
<td>B–O–H = 104.5° √</td>
<td></td>
<td>ALLOW 104–105°</td>
</tr>
<tr>
<td>(c)</td>
<td><strong>SF₆</strong> OR sulfur hexafluoride OR sulfur(VI) fluoride √</td>
<td>1</td>
<td>ALLOW XeF₄</td>
</tr>
<tr>
<td></td>
<td><strong>DO NOT ALLOW</strong> SCl₆</td>
<td></td>
<td><strong>DO NOT ALLOW</strong> stated complexes (simple molecule is asked for)</td>
</tr>
<tr>
<td></td>
<td><strong>DO NOT ALLOW</strong> stated complexes (simple molecule is asked for)</td>
<td></td>
<td><strong>DO NOT ALLOW</strong> stated complexes (simple molecule is asked for)</td>
</tr>
</tbody>
</table>

Total 6
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Marks</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 (a)</td>
<td>Energy (needed) to remove an electron ✓ from each atom in one mole ✓ of gaseous atoms ✓</td>
<td>3</td>
<td>ALLOW 'energy to remove one mole of electrons from one mole of gaseous atoms' for three marks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IGNORE 'element'</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ALLOW 'energy needed to remove an electron from one mole of gaseous atoms to form one mole of gaseous 1+ ions' for two marks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>For third mark:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ALLOW ECF if wrong particle is used in second marking point but is described as being gaseous eg 'molecule' instead of 'atom'</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IGNORE equations</td>
</tr>
<tr>
<td>(b) (i)</td>
<td>O⁺(g) → O²⁺(g) + e⁻ ✓</td>
<td>1</td>
<td>ALLOW O⁺(g) – e⁻ → O²⁺(g)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ALLOW e for electron (ie charge omitted)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IGNORE states on the electron</td>
</tr>
<tr>
<td>(b) (ii)</td>
<td><img src="image" alt="Graph showing ionisation energies" /></td>
<td>2</td>
<td>IGNORE the 2p/2s true jump</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IGNORE line if seen</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IGNORE 0, if included by candidate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IGNORE missing 1st IE point BUT</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DO NOT ALLOW first ionisation energy higher than second</td>
</tr>
<tr>
<td></td>
<td>All eight ionisation energies showing an increase ✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The biggest increase between the sixth and seventh ionisation energy AND 8th ionisation energy is higher than 7th ✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><img src="image" alt="Graph showing ionisation energies" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Place tick for second mark on the x-axis between 6 and 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
<td>Marks</td>
<td>Guidance</td>
</tr>
<tr>
<td>----------</td>
<td>--------</td>
<td>-------</td>
<td>----------</td>
</tr>
<tr>
<td>3 (c)</td>
<td></td>
<td>3</td>
<td><strong>Use annotations ie ticks crosses ECF ^ etc for this part</strong></td>
</tr>
</tbody>
</table>

**Nuclear charge mark**  
O has (one) less proton(s)  
OR  
O has smaller nuclear charge  
OR  
F has (one) more proton(s)  
OR  
F has greater nuclear charge ✓

**Atomic radius/shielding mark**  
(Outermost) electrons are in the same shell OR energy level  
OR  
(Outermost) electrons experience the same shielding  
OR  
Atomic radius of O is larger  
OR  
Atomic radius of F is smaller ✓

**Nuclear attraction mark**  
Less nuclear attraction (on outermost electrons) in O  
OR  
(outer) electrons are attracted less strongly (to the nucleus) in O  
OR  
More nuclear attraction (on outermost electrons) in F  
OR  
(outer) electrons are attracted more strongly (to the nucleus) in F ✓

Comparison should be used for each mark.  
Look for ORA from perspective of F throughout.  
ALLOW all three marks applied to ‘as you go across the period’ BUT assume the response refers to ‘as you go across the period’ if not stated  
ALLOW O has lower proton number BUT IGNORE O has lower atomic number  
IGNORE O has a smaller nucleus  
IGNORE ‘O has a smaller charge’ ie must be nuclear charge  
IGNORE ‘O has smaller effective nuclear charge’

ALLOW sub-shell for shell but IGNORE orbitals  
ALLOW shielding is similar  
ALLOW outermost electrons of O are further  
DO NOT ALLOW ‘distance is the same’ for second mark

ALLOW ‘less nuclear pull’ for ‘less nuclear attraction’  
DO NOT ALLOW ‘less nuclear charge’ instead of ‘less nuclear attraction’ for the third mark  
IGNORE ‘not pulled as close’ for ‘pulled less strongly’
<table>
<thead>
<tr>
<th>Question</th>
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<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>3(d)</td>
<td>$1s^2\ 2s^2\ 2p^4$ <strong>AND</strong> $1s^2\ 2s^2\ 2p^6$ ✔</td>
<td>2</td>
<td><strong>ALLOW</strong> subscripts, capitals <strong>ALLOW</strong> oxidation number of oxygen has decreased <strong>ALLOW</strong> non metals form negative ions <strong>IGNORE</strong> oxygen has gained electrons (this is shown in the electron configurations)</td>
</tr>
<tr>
<td>(e)(i)</td>
<td>$\text{SO}_3^{2-}$ ✔</td>
<td>2</td>
<td><strong>ALLOW</strong> subscripts, capitals <strong>ALLOW</strong> oxidation number of oxygen has decreased <strong>ALLOW</strong> non metals form negative ions <strong>IGNORE</strong> oxygen has gained electrons (this is shown in the electron configurations)</td>
</tr>
<tr>
<td></td>
<td>$\text{ClO}_2^-$ ✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(ii)</td>
<td>$\text{Al(NO}_3)_3$ ✔</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>(iii)</td>
<td>Aluminium oxide <strong>OR</strong> aluminium hydroxide ✔</td>
<td>2</td>
<td><strong>IGNORE</strong> correct formula (ie Al$_2$O$_3$ or Al(OH)$_3$) <strong>DO NOT ALLOW</strong> correct name with incorrect formula <strong>IGNORE</strong> correct name (ie nitric acid or nitric(V) acid) <strong>DO NOT ALLOW</strong> correct formula with incorrect name <strong>ALLOW</strong> one mark for Al$_2$O$_3$ or Al(OH)$_3$ <strong>AND</strong> nitric acid or nitric(V) acid (ie name answer and formulae answer has been transposed)</td>
</tr>
<tr>
<td>HNO$_3$ ✔</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
<td>Marks</td>
<td>Guidance</td>
</tr>
<tr>
<td>----------</td>
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</tr>
</tbody>
</table>
| 4 (a)    | ![Diagram](image) | 3     | Diagram showing a regular arrangement of **labelled `Ba^{2+}` ions or `2+ ions`** and some attempt to show electrons ✓

Scattering of labelled electrons between other species **AND** statement anywhere of **delocalised** electrons (can be in text or in diagram) ✓

The attraction between (positive) ions and (delocalised) electrons is strong ✓

Regular arrangement must have at least two rows of correctly charged ions and a minimum of two ions per row

**ALLOW** as label: positive ions, cations if correct charge is seen within circle
**ALLOW** for labelled Ba$^{2+}$ ions: circles with Ba$^{2+}$ inside
**DO NOT ALLOW** incorrect charge for ions eg +, 3+ etc
**DO NOT ALLOW** for label of ions: nuclei OR positive atom OR protons
**ALLOW** e⁻ or 'e' or – as symbol for electron within the lattice for first marking point if not labelled as 'electrons'.

**ALLOW** mobile or 'sea of' for delocalised

**Quality of written communication:** 'electron(s)' spelled correctly and used in context for the third marking point
**ALLOW** a lot of energy is needed to break OR overcome the attraction between (positive) ions and (delocalised) electrons
**IGNORE** 'heat' but **ALLOW** 'heat energy'
**DO NOT ALLOW** references to incorrect particles or incorrect attractions eg 'intermolecular attraction' OR 'nuclear attraction'

**IGNORE** 'strong metallic bonds' without seeing correct description of metallic bonding
<table>
<thead>
<tr>
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<th>Guidance</th>
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<tbody>
<tr>
<td>4 (b) (i)</td>
<td>Ba(s) + 2H₂O(l) → Ba(OH)₂(aq) + H₂(g)</td>
<td>2</td>
<td>ALLOW multiples</td>
</tr>
<tr>
<td></td>
<td>Ba(OH)₂ as product ✓ Rest of equation + state symbols ✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(ii)</td>
<td>Any value or the range 7 &lt; pH ≤ 14 ✓</td>
<td>1</td>
<td>DO NOT ALLOW if pH 7 is in a quoted range</td>
</tr>
</tbody>
</table>
| (iii)    | OH⁻ OR HO⁻ ✓                                                           | 1     | DO NOT ALLOW Ba²⁺
|          | DO NOT ALLOW any reference to electrons                                 |       |          |
| (c)      | Magnesium hydroxide OR magnesium oxide ✓                               | 1     | ALLOW magnesium carbonate
|          | ALLOW correct formulae: Mg(OH)₂, MgO, MgCO₃
|          | IGNORE 'milk of magnesia'                                              |       |          |
| (d) (i)  | Effervescence OR fizzing OR bubbling OR gas produced AND                | 2     | DO NOT ALLOW 'carbon dioxide produced' without 'gas'
|          | Strontium carbonate OR solid dissolves OR disappears OR a colourless solution is formed ✓ |       | DO NOT ALLOW 'hydrogen gas produced' OR any other named gas
|          | SrCO₃ + 2HCl → SrCl₂ + H₂O + CO₂ ✓                                    |       | ALLOW 'it' for strontium carbonate
|          | ALLOW strontium for strontium carbonate if SrCO₃ seen in equation     |       | IGNORE 'reacts'
|          | IGNORE references to temperature change                                |       | IGNORE 'steam produced'
<p>|          | IGNORE state symbols                                                  |       |          |</p>
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<tr>
<td>4 (d) (ii)</td>
<td><img src="image" alt="Strontium ion with eight (or no) outermost electrons AND 2 x chloride (ions) with 'dot-and-cross' outermost octet" /></td>
<td>2</td>
<td>For first mark, if eight electrons are shown in the cation then the ‘extra’ electron in the anion must match symbol chosen for electrons in the cation. <strong>IGNORE</strong> inner shell electrons. Circles <strong>not</strong> essential. <strong>ALLOW</strong> One mark if both electron arrangement and charges are correct but only one Cl is drawn. <strong>ALLOW</strong> 2[Cl(^-)](^-) 2[Cl(^-)](^-) [Cl(^-)](^-) (brackets not required). <strong>DO NOT ALLOW</strong> [Cl(_2)](^-) [Cl(_2)](^-) [2Cl(^-)](^-) [Cl(^-)](^-).</td>
</tr>
<tr>
<td>(e) (i)</td>
<td>The mixture would turn orange</td>
<td>1</td>
<td><strong>ALLOW</strong> shades and colours containing (eg dark orange, yellow-orange). <strong>ALLOW</strong> the following: yellow, yellow-brown, brown, brown-red BUT <strong>DO NOT ALLOW</strong> red alone. <strong>IGNORE</strong> initial colours. <strong>DO NOT ALLOW</strong> any response that includes ‘precipitate’ OR solid.</td>
</tr>
<tr>
<td>(ii)</td>
<td>Cl(_2) + 2Br(^-) → Br(_2) + 2Cl(^-)</td>
<td>1</td>
<td><strong>ALLOW</strong> multiples. <strong>IGNORE</strong> state symbols.</td>
</tr>
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<td>----------</td>
<td>--------</td>
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<td>----------</td>
</tr>
<tr>
<td>4</td>
<td>e (iii)</td>
<td>4</td>
<td><strong>Use annotations ie ticks crosses ECF ^ etc for this part</strong>&lt;br&gt;Look for ORA from perspective of Br throughout.&lt;br&gt;ALLOW all four marks applied to ‘as you go up OR as you down the group’&lt;br&gt;ALLOW C/ for chlorine AND Br for bromine&lt;br&gt;ALLOW ORA&lt;br&gt;DO NOT ALLOW the use of ‘ide’ BUT&lt;br&gt;ALLOW use of ‘ide’ as an ECF&lt;br&gt;ALLOW chlorine is better at electron capture&lt;br&gt;ALLOW chlorine has greater electron affinity&lt;br&gt;IGNORE chlorine is more electronegative&lt;br&gt;IGNORE chlorine has more oxidising power than bromine&lt;br&gt;ALLOW explanations given in terms of displacement&lt;br&gt;ALLOW chlorine has fewer shells&lt;br&gt;ALLOW the electron is added to the (outer) shell closer to the nucleus&lt;br&gt;<strong>IGNORE ‘easily’ for ‘greater’ or for ‘stronger’</strong>&lt;br&gt;ALLOW ‘chlorine has greater nuclear attraction (on its outermost electrons)’&lt;br&gt;OR&lt;br&gt;‘(the outermost) electrons in chlorine are more attracted (to the nucleus)’</td>
</tr>
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The electron GAIN mark<br>Chlorine will form a negative ion more easily than bromine OR<br>Chlorine will gain an electron more easily than bromine ✓

Atomic size mark<br>(An atom of) chlorine is smaller (than bromine) ✓

Shielding mark<br>(Outermost shell of) chlorine is less shielded (than bromine) ✓

Stronger nuclear attraction mark<br>Nuclear attraction (on the electron to be gained) by chlorine is greater (than bromine) OR<br>the electron (to be gained) is attracted more strongly (to the nucleus) in chlorine ✓

Total 18
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<tr>
<td>5 (a)</td>
<td></td>
<td>4</td>
<td><strong>Use annotations ie ticks crosses ECF ^ etc for this part</strong></td>
</tr>
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**F₂ forces mark**
- F₂ has van der Waals’ (forces)  
- OR  
- F₂ has induced dipole attractions OR interactions  
- OR  
- F₂ has temporary OR instantaneous dipole(–dipole) attraction OR interactions ✓

**HCl forces mark**
- HCl has permanent dipole(–dipole) attractions OR interactions ✓

**Comparison of strength of forces between molecules mark**
- intermolecular force in HCl is stronger than that in F₂  
- OR  
- permanent dipoles are stronger (than induced dipoles) ✓

**Boiling point mark**
- more energy is required to break stronger (intermolecular) forces ✓

**Guidance**

- ALLOW vdWs for van der Waals’  
- IGNORE F₂ has covalent bond for this mark  
- IGNORE F₂ has ‘intermolecular forces’

**Quality of written communication:** ‘dipole(s)’ spelled correctly and used in context for the second marking point  
- IGNORE HCl has ‘intermolecular forces’  
- IGNORE van der Waals’ forces in HCl  
- DO NOT ALLOW hydrogen bonding  
- DO NOT ALLOW ionic bonding

Look for strength of force comparison anywhere in the answer  
- ALLOW ECF for hydrogen bonding in HCl being stronger than the stated intermolecular forces in F₂  
- BUT DO NOT ALLOW this mark if HCl or F₂ has covalent bonds broken OR if HCl has ionic bonds broken (the question asks for forces between molecules)  
- IGNORE HCl has stronger van der Waals’ (forces) than F₂ (as they both have the same number of electrons)

DO NOT ALLOW fourth mark if covalent bonds are broken in HCl or F₂ OR if ionic bonds are broken in HCl  
- IGNORE ‘heat’ but ALLOW ‘heat energy’
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| 5 (b) (i) | ![Diagram](image) | 2 | Must be ‘dot-and-cross’
| | | | Must be H<sub>2</sub>O for either mark
| | | | Circles for shells not needed
| | | | IGNORE inner shells
| | | | IGNORE lack of positive charge and square brackets
| | | | DO NOT ALLOW second marking point if negative charge is shown on the ion
| | | | Non-bonding electrons do not have to be seen as a pair
| | | | ALLOW second mark for one non-bonding pair of electrons and three dot-and-cross bonding pairs of electrons

Two *dot-and-cross* bonding pairs of electrons and one dative covalent bond pair of electrons consisting of either two dots or two crosses

**One** non-bonding pair of electrons

**AND**

which match the dative covalent bond pair of electrons
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<td>5 (c) (i)</td>
<td>FIRST CHECK THE ANSWER ON ANSWER LINE IF answer = 7.624 OR 7.62 (g) award 3 marks</td>
<td>3</td>
<td>If there is an alternative answer, check to see if there is any ECF credit possible using working below</td>
</tr>
<tr>
<td></td>
<td>Molar mass of borax = 381.2 (g mol(^{-1})) ✓</td>
<td></td>
<td>ALLOW 381 DO NOT ALLOW 380</td>
</tr>
<tr>
<td></td>
<td>Correctly calculates the mass of borax in 1000 cm(^3) = 0.0800 x 381.2 = 30.496 g OR 30.50 g OR 30.5g ✓</td>
<td></td>
<td>ALLOW 0.0800 x [molar mass of borax] correctly calculated for 2nd mark (ie mass of borax in 1000 cm(^3))</td>
</tr>
<tr>
<td></td>
<td>Correctly calculates the mass of borax in 250 cm(^3) = 30.496/4 = 7.624 g OR 7.62 g ✓</td>
<td></td>
<td>ALLOW [mass of borax in 1000 cm(^3)] / 4 correctly calculated for 3rd mark</td>
</tr>
<tr>
<td></td>
<td>OR Molar mass of borax = 381.2 (g mol(^{-1})) ✓</td>
<td></td>
<td>ALLOW calculator value or rounding to three significant figures or more</td>
</tr>
<tr>
<td></td>
<td>Amount of borax in 250 cm(^3) of solution = 0.0800 x 250 /1000 = 0.02(00) mol ✓</td>
<td></td>
<td>IGNORE (if seen) a second rounding error</td>
</tr>
<tr>
<td></td>
<td>Mass of borax = 0.02(00) x 381.2 of borax = 7.624 g OR 7.62 g ✓</td>
<td></td>
<td>ALLOW 381 DO NOT ALLOW 380</td>
</tr>
<tr>
<td></td>
<td>OR [incorrect amount of borax] x 381.2 OR [incorrect amount of borax] x [incorrect molar mass of borax] OR 0.02(00) x [incorrect molar mass of borax] correctly calculated for this mark</td>
<td></td>
<td>ALLOW [incorrect amount of borax] x 381.2</td>
</tr>
<tr>
<td></td>
<td>ALLOW calculator value or rounding to three significant figures or more</td>
<td></td>
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<td>IGNORE (if seen) a second rounding error</td>
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<td>5 (d)</td>
<td>(i) Correctly calculates the amount of borax used = 0.0800 x 22.5/1000 &lt;br&gt; = 1.8(0) x 10(^{-3}) mol OR 0.0018(0) mol ✓</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>(ii) Correctly calculates the amount of HCl used = 1.8(0) x 10(^{-3}) x 2 mol &lt;br&gt; = 3.6(0) x 10(^{-3}) mol OR 0.0036(0) mol ✓</td>
<td>1</td>
<td>ALLOW [incorrect amount of borax] x 2 correctly calculated for the 2nd mark. ALLOW calculator value or rounding to 3 significant figures or more BUT IGNORE ‘trailing’ zeroes, eg 0.200 allowed as 0.2</td>
<td></td>
</tr>
<tr>
<td>(iii) Correctly calculates the concentration of HCl &lt;br&gt; = 3.6(0) x 10(^{-3}) / (25 / 1000) = 0.144 (mol dm(^{-3})) ✓</td>
<td>1</td>
<td>ALLOW [incorrect amount of HCl] / (25/1000) correctly calculated for the 3rd mark given to 3 SF</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Total</strong></td>
<td><strong>12</strong></td>
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</tbody>
</table>
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