



Mark Scheme (Results)

January 2016

Pearson Edexcel International
Advanced Level in Chemistry
(WCH02) Paper 01 – Application of
Core Principles of Chemistry

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January 2016

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General Marking Guidance

- 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.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:
 - i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
 - ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
 - iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:

- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.

() means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.

ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:

- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.

Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A

Question Number	Correct Answer	Mark
1	B	1

Question Number	Correct Answer	Mark
2	D	1

Question Number	Correct Answer	Mark
3	A	1

Question Number	Correct Answer	Mark
4	B	1

Question Number	Correct Answer	Mark
5	C	1

Question Number	Correct Answer	Mark
6	D	1

Question Number	Correct Answer	Mark
7	D	1

Question Number	Correct Answer	Mark
8	C	1

Question Number	Correct Answer	Mark
9	B	1

Question Number	Correct Answer	Mark
10	A	1

Question Number	Correct Answer	Mark
11	B	1

Question Number	Correct Answer	Mark
12	A	1

Question Number	Correct Answer	Mark
13	A	1

Question Number	Correct Answer	Mark
14	D	1

Question Number	Correct Answer	Mark
15	B	1

Question Number	Correct Answer	Mark
16	C	1

Question Number	Correct Answer	Mark
17	C	1

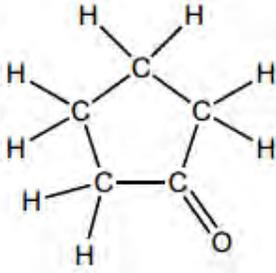
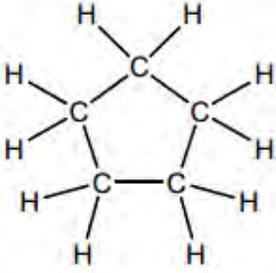
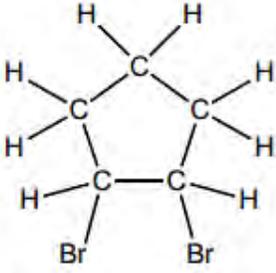
Question Number	Correct Answer	Mark
18	D	1

Question Number	Correct Answer	Mark
19	D	1

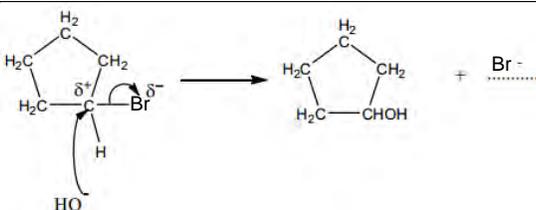
Question Number	Correct Answer	Mark
20	B	1

(Total for Section A = 20 marks)

Section B

Question Number	Acceptable Answers	Reject	Mark
21 (a)	<div style="text-align: center;">  <p>Compound A (1)</p>  <p>Compound B (1)</p>  <p>Compound C (1)</p> <p>Max 2 if any H atoms are missing from one or more structures</p> <p>ALLOW Correct 'rotated' structures CH₂ un-displayed</p> </div>		3

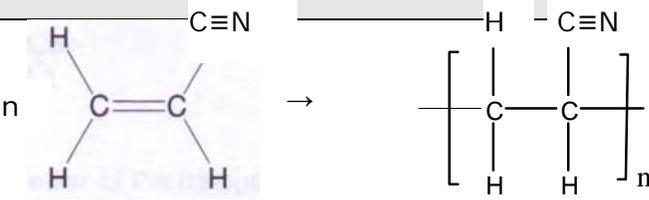
Question Number	Acceptable Answers	Reject	Mark
21 (b)	<p>(From) Orange OR brown</p> <p>ALLOW Shades of orange or yellow or brown including red-brown/reddish-brown OR 'red' if used as a 'qualifier' for a correct colour</p> <p>(To) Colourless</p> <p>IGNORE 'Clear'</p> <p>Both colours are needed for the mark</p>	Just 'red' for the initial colour	1

Question Number	Acceptable Answers	Reject	Mark
21 (c) (i)	 <p>First mark – M1:</p> <p>Curly arrow from anywhere* on the OH⁻ ion to C atom of C—Br bond and dipole shown on C—Br bond, C^{δ+} and Br^{δ-}</p> <p>IGNORE δ⁻ on OH⁻ ion</p> <p style="text-align: right;">(1)</p> <p>Second mark – M2:</p> <p>Curly arrow from the C—Br bond to the Br atom</p> <p style="text-align: right;">(1)</p> <p>Third mark – M3:</p> <p>Br⁻ as the co-product</p> <p style="text-align: right;">(1)</p> <p>IGNORE intermediates or transition states even if incorrect</p>	<p>*If lone pair of e⁻ is shown on the H of the OH⁻ ion, no M1</p> <p>Just 'Br' NaBr / Na⁺Br⁻ / HBr</p>	3

Question Number	Acceptable Answers	Reject	Mark
21 (c)(ii)	(Type of reaction) substitution (1) IGNORE 'hydrolysis' (Mechanism) nucleophilic (1) ALLOW These words in either order or on one line Just S_N1 or S_N2 scores 1 (Otherwise IGNORE S _N 1 or S _N 2 if given with correct answer(s)) NOTE Spelling does not have to be 100% accurate, so long as the meaning is clear		2

Question Number	Acceptable Answers	Reject	Mark
21 (c)(iii)	Heterolytic (fission) NOTE Spelling does not have to be 100% accurate, so long as the meaning is clear	Homolytic	1

(Total for Question 21 = 10 marks)

Question Number	Acceptable Answers	Reject	Mark
22 (a)	<div style="text-align: center;">  </div> <p>ALLOW CN for C≡N throughout IGNORE 'connectivity' to the C≡N / CN group</p> <p>First mark – M1: Two "n" in the equation and a correct formula (molecular or structural or displayed) for propenenitrile on LHS of the equation LHS "n" must be to left of the monomer RHS "n" must be a subscript</p> <p>IGNORE Any square or round brackets around monomer on LHS (1)</p> <p>Second mark – M2: One correct displayed repeat unit (with or without a bracket or "n" shown in the equation) (1)</p> <p>Third mark – M3: Continuation bond at each end of the repeat unit (with or without a bracket or "n" shown in the equation) (1)</p> <p>NOTE M3 is awarded for the two continuation bonds, even if the repeat unit given is incorrect</p> <p>Polymer containing a C=C scores max (1)</p> <p>Additional comment Mark the three scoring points independently</p>	No M2 mark if more than one repeat unit shown	3

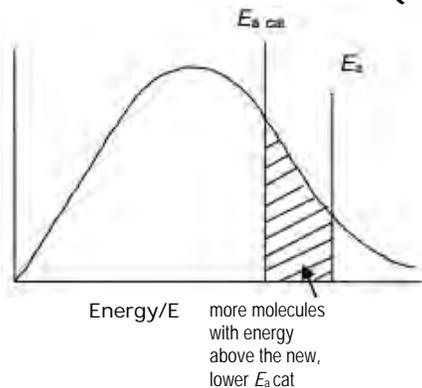
Question Number	Acceptable Answers	Reject	Mark
22 (b)	(It is an) addition reaction OR An addition polymer is made OR All the reactants are made into the desired / required product OR Only one product (is made) OR No waste products / no by-products ALLOW No 'side' products	Just 'all the product is useful' Just 'all the reactants become products' 'No product wasted'	1

Question Number	Acceptable Answers	Reject	Mark
<p>22 * (c) (i)</p>	<p>First mark – M1: (Position of equilibrium shifts/'favours')</p> <p>to the left OR to the reactants OR to the backward reaction/direction OR to the reverse reaction/direction OR towards C₃H₆ / NH₃ / O₂</p> <p>ALLOW decreases yield of products / decreases yield of CH₂CHCN / decreases yield of H₂O</p> <p style="text-align: right;">(1)</p> <p>Second mark – M2: This mark is dependent on the correct change in THE position of equilibrium (i.e. (0) overall for question if states that eq'm shifts to the RIGHT)</p> <p>(Forward) reaction is exothermic OR (Forward) reaction gives out heat OR Backward reaction is endothermic / takes in heat OR Reverse reaction is endothermic / takes in heat IGNORE References to just "decreasing the temperature" / "opposes the increase in temperature"</p> <p style="text-align: right;">(1)</p> <p>Additional comment JUST a statement that it "moves in / favours the endothermic direction" can get M1 ONLY IF M2 has already been awarded (as it is then clear that the candidate realises that from right to left is the endothermic direction).</p>		2

Question Number	Acceptable Answers	Reject	Mark
<p>22 * (c) (ii)</p>	<p>First mark – M1: (Position of equilibrium shifts/'favours')</p> <p>to the left OR to the reactants OR to the backward reaction/direction OR to the reverse reaction/direction OR towards C₃H₆ / NH₃ / O₂</p> <p>ALLOW decreases yield of products / decreases yield of CH₂CHCN / decreases yield of H₂O</p> <p style="text-align: right;">(1)</p> <p>Second mark – M2: This mark is dependent on the correct change in THE position of equilibrium (i.e. (0) overall for question if states that eq'm shifts to the RIGHT)</p> <p>Right-hand side has more moles/molecules (of gas) OR Products have more moles/molecules (of gas) OR Left-hand side has fewer moles/molecules (of gas) OR Reactants have fewer moles/molecules (of gas)</p> <p>NOTE: 2nd mark awarded if mentions: 3½ moles/molecules (of gas) on LHS and 4 moles/molecules (of gas) on RHS</p> <p style="text-align: right;">(1)</p>	<p>References to ATOMS/PARTICLES, if chooses to refer to these, (instead of molecules) no 2nd mark</p>	<p>2</p>

Question Number	Acceptable Answers	Reject	Mark
22 (d) (i)	(y-axis:) Fraction of molecules / number of molecules ALLOW Proportion of molecules ALLOW 'particles' instead of molecules for the label on the y-axis and (x-axis:) Energy / E / kinetic energy NOTE: BOTH graphs' axes (on p14 and p15 of script) need to be labelled correctly for this mark	'atoms' instead of molecules/particles	1

Question Number	Acceptable Answers	Reject	Mark
<p>*22 (d) (ii)</p>	<p>First mark – M1: Correct drawing of Maxwell-Boltzmann distribution at T_2 clearly identified NOTE As long as it is clear which curve the candidate has drawn, if it is correctly drawn award this mark, even if their curve is not actually labelled "T_2"</p> <p>NOTE Peak of candidate's curve (at the higher temperature) should be clearly lower and to the right of that at the lower temperature (1)</p> <p>Second mark – M2: Suitable E_a shown on graph (1)</p> <p>Third mark – M3: (At higher temperature) more molecules/more collisions / more particles have energy greater than the activation energy (1)</p> <p>NOTE: Must refer to activation energy / E_a for M3 IGNORE 'more frequent collisions'</p> <div data-bbox="337 1310 1008 1686" style="text-align: center;"> <p>The graph shows two Maxwell-Boltzmann distribution curves. The vertical axis is labeled 'Number of molecules' and the horizontal axis is labeled 'Energy E'. A vertical line represents the activation energy E_a. The curve for temperature T_2 is lower and shifted to the right (higher energy) compared to the curve for temperature T_1.</p> </div> <p>Only M1 can be awarded if two E_a values drawn on graph for this part</p>	<p>E_a shown at peak or to the left of peak</p> <p>"More atoms"</p>	<p>3</p>

Question Number	Acceptable Answers	Reject	Mark
<p>22 * (d) (iii)</p>	<p>First mark – M1: E_a for the catalysed reaction shown to the left of E_a for the un-catalysed reaction</p> <p>NOTE Do not penalise again the actual position of either E_a if M2 was not awarded in Q22(d)(ii) for the same reason</p> <p style="text-align: right;">(1)</p> <p>Second mark – M2: EITHER (With catalyst) more molecules / more collisions / more particles have energy greater than the (new, lower) activation energy OR Diagram labelled as shown below</p> <p>NOTE If a shaded area is shown between the two E_a lines, even if it is unlabelled, award M2</p> <p>NOTE ALLOW alternatives for M2 such as "More molecules have enough energy to react (with the catalyst)" OR "More molecules are able to react at lower energies (with the catalyst)" [Unlike in Q22(d)(i), E_a doesn't HAVE to be mentioned.]</p> <p style="text-align: right;">(1)</p> <div style="text-align: center;">  </div> <p>IGNORE Just a statement that "a catalyst provides an alternative reaction route/pathway of lower activation energy"</p>	<p>Two curves shown (no M1)</p> <p>"More atoms"</p>	<p style="text-align: center;">2</p>

(Total for Question 22 = 14 marks)

Question Number	Acceptable Answers	Reject	Mark
23(a)(i)	Any value or range of values from pH 8 to 13 (inclusive)	Just greater / > than any value	1

Question Number	Acceptable Answers	Reject	Mark
23(a)(ii)	$\text{Ca(OH)}_2(\text{aq}) + \text{CO}_2(\text{g}) \rightarrow \text{CaCO}_3(\text{s}) + \text{H}_2\text{O}(\text{l})$ M1 - All four species are correct (1) M2 - State symbols all correct (1) M2 can only be awarded for the correct state symbols if M1 has already been awarded OR for a 'near-miss' equation with species almost correct		2

Question Number	Acceptable Answers	Reject	Mark
23(b)(i)	Three / 3 (moles of ions)		1

Question Number	Acceptable Answers	Reject	Mark
23(b)(ii)	Ten / 10 (moles of electrons)		1

Question Number	Acceptable Answers	Reject	Mark
23 (c)	<p>Mark independently:</p> <p>First mark – M1: Heat (strongly) CaCO₃</p> <p>ALLOW 'thermal decomposition' / 'thermally decompose' / 'high temperature' (1)</p> <p>Second mark – M2: CaCO₃ → CaO + CO₂</p> <p>IGNORE State symbols, even if incorrect (1)</p> <p>NOTE The correct equation for M2 with 'heat' or just a 'Δ' written above the arrow would also score M1.</p> <p>Third mark – M3: Add (a few drops of) water to CaO</p> <p>ALLOW If CaO + H₂O(l)/H₂O seen on the LHS of any equation, even if the equation overall is incorrect (1)</p> <p>Fourth mark: CaO + H₂O → Ca(OH)₂</p> <p>IGNORE State symbols, even if incorrect (1)</p>	<p>No M1 if refers to 'oxidation' of CaCO₃ when heated / Heating CaCO₃ in a sealed tube / closed apparatus</p> <p>Add 'steam' to CaO Adding water to CaCO₃ Adding water to Ca Use of heat / gentle heat / use of warm water / Forming Ca(OH)₂ solution / 'Dissolve the CaO in water' / Drying or heating the Ca(OH)₂ product All no M3</p> <p>CaO + 2H₂O → Ca(OH)₂ + H₂</p>	4

Question Number	Acceptable Answers	Reject	Mark
23 (d) (i)	$2\text{SO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{SO}_4(\text{aq})$ <p>ALLOW Multiples</p> <p>M1 - Species and balancing (1)</p> <p>M2 - All state symbols correct</p> <p>M2 can only be awarded for the correct state symbols if M1 has already been awarded OR for a 'near-miss' equation with the species almost correct</p> <p>(1)</p>		2

Question Number	Acceptable Answers	Reject	Mark
23 (d) (ii)	<p>CaO is basic / is a base / is a metal oxide OR CaO neutralizes (acidic) SO₂ / H₂SO₄ OR CaO reacts with a non-metal oxide (SO₂) OR Basic oxides react with acidic gases</p> <p>ALLOW Alkaline for basic/ alkali for base</p> <p>IGNORE References to forming a salt / formation of calcium sulfate</p> <p>References to the large surface area of powder / effect on rate of reaction</p>		1

Question Number	Acceptable Answers	Reject	Mark
23 (d) (iii)	<p>NOTE: Can only award scoring point for the environmental problem if it is linked to the correct substance Substance mark (M1) stand-alone Carbon dioxide/ CO₂ (1)</p> <p>with</p> <p>Global warming OR Greenhouse effect ACCEPT as an alternative a description of the above phenomenon IGNORE acid rain for CO₂ (1)</p> <p>OR</p> <p>Carbon particulates / soot (1)</p> <p>with</p> <p>Breathing difficulties / breathing disorders / carcinogenic / 'blocking out' sky / blackening of buildings / covering buildings (1)</p> <p>ALLOW</p> <p>Nitrogen dioxide/ NO₂ OR nitrogen monoxide/ NO (1)</p> <p>with</p> <p>Destruction of ozone layer/breathing problems IGNORE acid rain for NO₂ (1)</p> <p>ALLOW Carbon monoxide/ CO (1)</p> <p>with</p> <p>(Highly) toxic (gas) / poisonous / 'lethal' (gas) (1)</p>	<p>SO₂ / SO₃ / H₂SO₃ / H₂SO₄ scores (0) for question as already mentioned earlier</p> <p>2nd mark for 'ozone depletion' IF this is linked to CO₂</p>	2

(Total for Question 23 = 14 marks)

Question Number	Acceptable Answers	Reject	Mark
24 (a)(i)	<p>FIRST, CHECK THE FINAL ANSWER</p> <p>IF answer $\text{IO}_3^- + 6 \text{H}^+ + 5 \text{I}^- \rightarrow 3 \text{I}_2 + 3 \text{H}_2\text{O}$ (ALLOW multiples) then award (2) marks, with or without any working</p> <p>OTHERWISE</p> <p>First mark: Any evidence of correctly multiplying the half-equations in order to cancel electrons</p> <p>(e.g. second equation x 5 OR first equation x 2 and second equation x 10) (1)</p> <p>Second mark: For correctly balanced equation overall $\text{IO}_3^- + 6 \text{H}^+ + 5 \text{I}^- \rightarrow 3 \text{I}_2 + 3 \text{H}_2\text{O}$ OR $2 \text{IO}_3^- + 12 \text{H}^+ + 10 \text{I}^- \rightarrow 6 \text{I}_2 + 6 \text{H}_2\text{O}$ (1)</p> <p>IGNORE State symbols, even if incorrect</p>		2

Question Number	Acceptable Answers	Reject	Mark
24 (a)(ii)	<p>IO_3^- / NaIO_3 and gains electrons (from the iodide ions) ALLOW 'electron gain' (singular)</p> <p>IGNORE References to iodate(V) or sodium iodate</p> <p>NOTE: IGNORE Just correct changes in oxidation number, as answer requires reference to gain of electrons</p>		1

Question Number	Acceptable Answers	Reject	Mark
24 (c) (i)	<p>FIRST CHECK THE ANSWER ON ANSWER LINE, IF answer = 183 (µg), N.B. must be 3 sf, then award (2) marks, with or without any working</p> <p>OTHERWISE look for:</p> <p>1st mark – M1 EITHER (Moles of I⁻) = $140 \times 10^{-6} \div 126.9$ OR (Moles of I⁻) = $140 \times 10^{-6} \div 127$ OR (Moles of I⁻) = $1.1(0) \times 10^{-6}$ (mol)</p> <p>ALSO ALLOW $140 \div 126.9$ OR $140 \div 127$ for M1</p> <p style="text-align: right;">(1)</p> <p>2nd mark – M2 (Mass of KI) = mol of I⁻ x 166 ÷ 10⁻⁶ and 3 s.f. [NOTE: Expected answer: [(1.1(0) x 10⁻⁶ / 10⁻⁶) x 166] = 183(µg) to 3 sf</p> <p>2nd mark is CQ on moles of I⁻ calculated</p> <p>ALLOW $140 \times 166 \div 126.9$ for M2 OR $140 \times 166 \div 127$ for M2 ALLOW</p> <p>M_r for KI as 166 or 166.1 or 165.9</p> <p style="text-align: right;">(1)</p>		2

Question Number	Acceptable Answers	Reject	Mark
24 (c) (ii)	<p>Any ONE of:</p> <p>(Morally) wrong to put additives in food supplies;</p> <p>People should be able to choose if I⁻ is added to their food;</p> <p>Food / tap water already has sufficient I⁻ (from other sources);</p> <p>Other foodstuffs contain I⁻;</p> <p>Excess K⁺ (ions) harmful;</p> <p>Excess I⁻ (ions) harmful;</p> <p>Any reference to radioactivity;</p> <p>Allergies/intolerance (to I⁻);</p> <p>Raises blood pressure;</p> <p>Any reference to thyroid issues</p> <p>NOTE ALLOW 'dangerous' for 'harmful'</p> <p>IGNORE Any references to cost</p>	<p>KI/I⁻ 'toxic' or 'poisonous';</p> <p>References to just "K" or "I" or "I₂";</p> <p>"KI reacts with (stomach) acid";</p> <p>(KI) difficult to obtain;</p> <p>(KI) difficult to prepare;</p> <p>(KI) difficult to store;</p> <p>(KI) not readily available;</p> <p>(KI) strong reducing agent;</p> <p>(KI) bad taste</p>	1

Question Number	Acceptable Answers	Reject	Mark
24 (d) (i)	<p>First mark (M1) ICl has permanent dipole (-permanent dipole) forces OR ICl has dipole-dipole forces</p> <p>IGNORE Just I–Cl bond is polar or just ICl is a polar molecule (1)</p> <p>Second mark (M2) Cl₂ has London forces / Cl₂ has van der Waals' forces / Cl₂ has dispersion forces / Cl₂ has INDUCED-dipole forces/ temporary dipole forces (1)</p> <p>Third mark (M3) Any suggestion that the intermolecular forces / any named intermolecular forces / any 'interactions' between molecules are stronger in ICl (than in Cl₂) / need more (heat) energy to overcome forces in ICl OR Mentions that ICl has BOTH London AND permanent dipole forces (1)</p> <p>Fourth mark (M4) EITHER ICl has stronger London forces / stronger van der Waals' forces / stronger dispersion forces (than Cl₂) OR ICl has more electrons (per molecule than Cl₂) / ICl larger molecule (than Cl₂) (1)</p>	<p>Reference to ionic bonds (no M3)</p> <p>Reference to/implication of the breaking of ionic bonds or covalent bonds or hydrogen bonds or ambiguity as to what interactions are being broken (no M3)</p>	4

Question Number	Acceptable Answers	Reject	Mark
24 (d) (ii)	<p>2 lone pairs on the iodine (1)</p> <p>Rest of molecule correct (i.e. 3 I-Cl bond pairs and 3 lone pairs on each Cl atom) (1)</p> <p>IGNORE Inner-shell electrons Circles are not required</p> <p>NOTE Must use the dot and cross convention to distinguish the electrons</p> <p>ALLOW Lone pair electrons shown separately rather than in pairs (totals of the non-bonding electrons must be correct)</p>		2

Question Number	Acceptable Answers	Reject	Mark
24 (e) (i)	<p>$\text{Cl}_2 + 2\text{I}^- \rightarrow 2\text{Cl}^- + \text{I}_2$</p> <p>ALLOW multiples</p> <p>IGNORE State symbols, even if incorrect</p> <p>Full equation also given</p>	If K^+ ions are left in the equation	1

Question Number	Acceptable Answers	Reject	Mark
*24 (e) (ii)	<p>(So from 0.66 mol NaI)</p> <p>0.33 mol I₂ formed (1)</p> <p>(So) 0.17 mol Br₂ formed (1)</p> <p>NOTE: 0.33 mol I₂ scores (1), with or without working 0.17 mol Br₂ scores (1), with or without working</p> <p>M3 - [Justification] Stand alone</p> <p>EITHER</p> <p>I⁻ has greater reducing power (than Br⁻)</p> <p>OR</p> <p>NaI has greater reducing power (than NaBr)</p> <p>OR</p> <p>Reducing power (of the halide ions) increases down the group</p> <p>OR</p> <p>I⁻ more easily oxidised (than Br⁻)</p> <p>(1)</p>	<p>TE on incorrect moles of I₂ or incorrect moles of Br₂</p> <p>Iodine/I₂ has greater reducing power than bromine/Br₂</p>	3

(Total for Question 24 = 22 marks)

TOTAL FOR PAPER = 80 marks