

Markscheme

November 2025

Chemistry

Higher level

Paper 2

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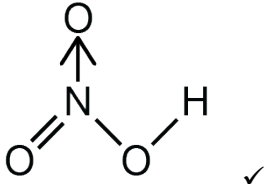
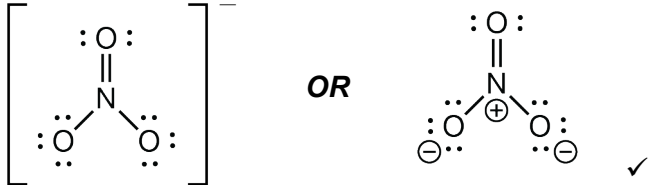
Subject Details: Chemistry Higher Level Paper 2 Markscheme

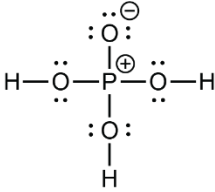
Candidates are required to answer **ALL** questions. Maximum total = **[90 marks]**.

1. Each row in the “Question” column relates to the smallest subpart of the question.
2. The maximum mark for each question subpart is indicated in the “Total” column.
3. Each marking point in the “Answers” column is shown by means of a tick (✓) at the end of the marking point.
4. A question subpart may have more marking points than the total allows. This will be indicated by “**max**” written after the mark in the “Total” column. The related rubric, if necessary, will be outlined in the “Notes” column.
5. An alternative word is indicated in the “Answers” column by a slash (/). Either word can be accepted.
6. An alternative answer is indicated in the “Answers” column by “**OR**”. Either answer can be accepted.
7. An alternative markscheme is indicated in the “Answers” column under heading **ALTERNATIVE 1** etc. Either alternative can be accepted.
8. Words inside chevrons « » in the “Answers” column are not necessary to gain the mark.
9. Words that are underlined are essential for the mark.
10. The order of marking points does not have to be as in the “Answers” column, unless stated otherwise in the “Notes” column.
11. If the candidate’s answer has the same “meaning” or can be clearly interpreted as being of equivalent significance, detail and validity as that in the “Answers” column then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by **OWTTE** (or words to that effect) in the “Notes” column.
12. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.
13. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. When marking, indicate this by adding **ECF** (error carried forward) on the script.
14. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the “Notes” column.
15. If a question specifically asks for the name of a substance, do not award a mark for a correct formula unless directed otherwise in the “Notes” column. Similarly, if the formula is specifically asked for, do not award a mark for a correct name unless directed otherwise in the “Notes” column.
16. If a question asks for an equation for a reaction, a balanced symbol equation is usually expected, do not award a mark for a word equation or an unbalanced equation unless directed otherwise in the “Notes” column.

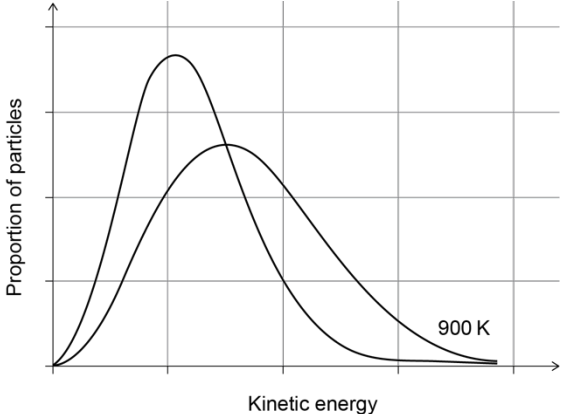
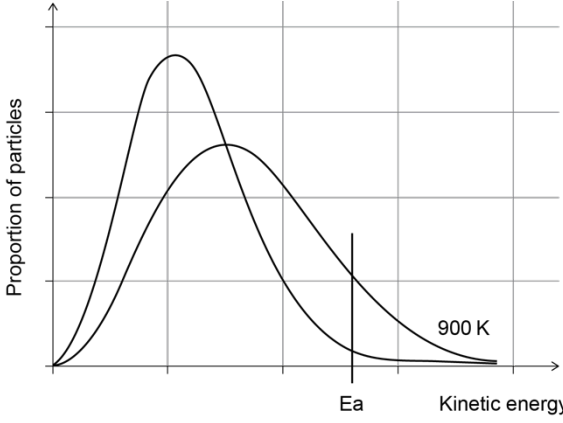
Ignore missing or incorrect state symbols in an equation unless directed otherwise in the “Notes” column.

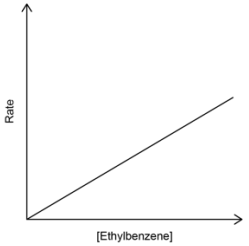
Question			Answers	Notes	Total
1.	(a)		<p>Any one of:</p> <p>forms nitrous acid / HNO_2 / nitric acid / HNO_3 ✓</p> <p>contributes to acid rain ✓</p> <p>catalyses decomposition of ozone / contributes to ozone hole/depletion ✓</p> <p>«respiratory» irritant/toxic ✓</p>	<p>Accept suitable equations showing acid rain formation or ozone depletion.</p> <p>Accept photochemical smog/forms NO_2.</p>	1 max
1.	(b)		<p>$T = 200 + 273$ «K» ✓</p> <p>«$n = PV/RT$»</p> <p>«$n = \frac{(1.0 \times 10^5)(1.0 \times 10^{-3})}{8.31(200+273)}$»</p> <p>«$n =$» 0.025 «mol» ✓</p> <p>«$0.10\% \times 0.025 =$» 2.5×10^{-5} «mol» ✓</p>	Award [3] for correct final answer.	3
1.	(c)		<p>NO polar AND N_2 non-polar</p> <p>OR</p> <p>NO has dipole-dipole «and LDF» AND N_2 has London/dispersion «forces between molecules» ✓</p> <p>stronger intermolecular forces in NO</p> <p>OR</p> <p>dipole-dipole «forces» are stronger «than LDF» ✓</p>		2
1.	(d)	(i)	Initial: +2 AND Final: 0 ✓	Accept II for initial oxidation state, but do not accept 2+ or 2.	1
1.	(d)	(ii)	$2\text{NO}(\text{g}) + 2\text{CO}(\text{g}) \rightarrow 2\text{CO}_2(\text{g}) + \text{N}_2(\text{g})$ ✓		1

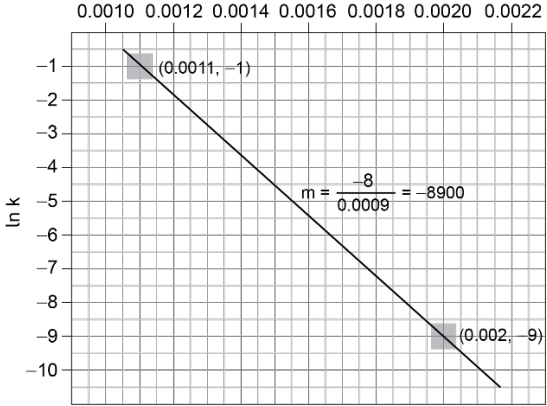
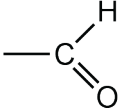
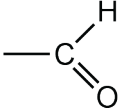
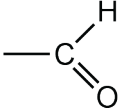
Question			Answers	Notes	Total
2.	(a)	(i)		<p>Accept other forms of labelling instead of an arrow. Mark is for identifying the bond.</p>	1
2.	(a)	(ii)	$\text{Na}_2\text{CO}_3(\text{s}) + 2\text{HNO}_3(\text{aq}) \rightarrow 2\text{NaNO}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g}) \checkmark$		1
2.	(b)	(i)		<p>Accept any combination of dots or crosses to represent electrons, or lines to represent electron pairs.</p> <p>Charge must be shown, but square brackets are not required.</p> <p>Do not accept delocalized structure.</p>	1
2.	(b)	(ii)	$\text{Ni}(\text{NO}_3)_2 \checkmark$		1
2.	(b)	(iii)	<p>resonance / delocalization «of π-electrons» \checkmark</p>		1
2.	(b)	(iv)	<p>124 «pm» \checkmark</p>	<p>Accept range $114 < x < 136$ «pm».</p>	1

2.	(c)		<table border="1" data-bbox="360 293 1368 552"> <thead> <tr> <th data-bbox="360 293 600 347">Metal added:</th> <th colspan="2" data-bbox="600 293 1010 347">Mn</th> <th colspan="2" data-bbox="1010 293 1368 347">Cu</th> </tr> </thead> <tbody> <tr> <td data-bbox="360 347 600 552">Observations:</td> <td data-bbox="600 347 909 552"> «solution» colour changes OR solid/metal product / coat «on metal» </td> <td data-bbox="909 347 1010 552" style="text-align: center;">AND</td> <td data-bbox="1010 347 1229 552"> no change «in solution colour» OR no solid/metal produced / no coat «on metal» ✓ </td> <td data-bbox="1229 347 1368 552"></td> </tr> </tbody> </table> <p data-bbox="360 600 524 632"><i>Explanation:</i></p> <p data-bbox="360 663 1274 695">Mn lower/more negative E^\ominus AND Cu higher/more positive E^\ominus than Ni</p> <p data-bbox="360 727 412 759">OR</p> <p data-bbox="360 791 1397 823">Mn more reactive/readily oxidized AND Cu less reactive/readily oxidized than Ni</p> <p data-bbox="360 855 412 887">OR</p> <p data-bbox="360 919 1274 951">Mn stronger reducing agent AND Cu weaker reducing agent than Ni ✓</p>	Metal added:	Mn		Cu		Observations:	«solution» colour changes OR solid/metal product / coat «on metal»	AND	no change «in solution colour» OR no solid/metal produced / no coat «on metal» ✓		<p data-bbox="1435 488 1789 552"><i>Accept “no reaction” for Cu observation.</i></p> <p data-bbox="1435 600 1933 663"><i>Award [1 max] for correct observation and explanation for one metal only.</i></p>	2
Metal added:	Mn		Cu												
Observations:	«solution» colour changes OR solid/metal product / coat «on metal»	AND	no change «in solution colour» OR no solid/metal produced / no coat «on metal» ✓												
2.	(d)	(i)	<p data-bbox="360 1023 1211 1054">Lewis formula 1: O -1 AND P $+1$ «are the only formal charges» ✓</p> <p data-bbox="360 1070 1375 1102">Lewis formula 2: formal charges zero/closest to zero «and hence preferred» ✓</p>	<p data-bbox="1435 1023 1744 1054"><i>Accept labelling for M1:</i></p> <div style="text-align: center;">  </div>	2										
2.	(d)	(ii)	<p data-bbox="360 1422 483 1453">H_2PO_4^- ✓</p>		1										

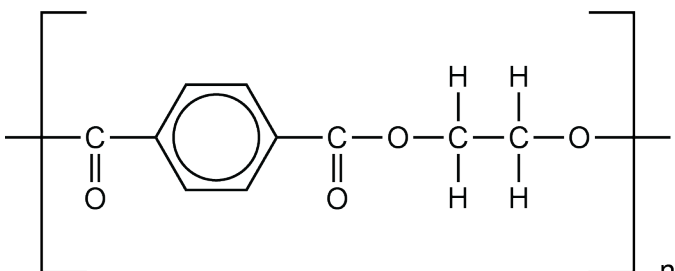
Question			Answers	Notes	Total
3.	(a)	(i)	$\llcorner \text{mol styrene} = \frac{90}{100} \times \frac{1000}{8(12.01)+10(1.01)} \gg$ $\llcorner \text{mol styrene} \Rightarrow 8.48 \llcorner \text{mol} \gg \checkmark$ $\llcorner \text{mass styrene} = 8.48 \times (8(12.01) + 8(1.01)) = 882.88 \gg$ $\llcorner \text{mass styrene} \Rightarrow 880 \llcorner \text{g} \gg \checkmark$	<p>Award [2] for correct final answer in range 880-890 «g».</p>	2
3.	(a)	(ii)	$\llcorner 100 \times \frac{104.16}{106.18} \gg$ $= 98.1\% \checkmark$		1
3.	(b)		<p>two curves, each passing through a maximum AND reaching same energy level \checkmark endothermic enthalpy change labelled \checkmark both activation energies correctly labelled \checkmark</p>	<p>Do not penalize curve showing multiple steps for the catalysis in M1.</p> <p>Accept double-headed arrows or lines in M2 and M3, but not arrows pointing down.</p>	3

<p>3.</p>	<p>(c)</p>	<p>(i)</p>	 <p>curve with peak higher AND to left AND decreasing at lower KE ✓</p>	<p><i>Do not award mark if line crosses x axis or rises above the 900K curve at high energy.</i></p>	<p>1</p>
<p>3.</p>	<p>(c)</p>	<p>(ii)</p>	 <p>✓</p>	<p><i>Accept a correct label on x-axis or on a drawn line.</i></p>	<p>1</p>
<p>3.</p>	<p>(c)</p>	<p>(iii)</p>	<p>correct reference to area under curve «to right of E_a» ✓ fewer particles with $E \geq E_a$ ✓</p>		<p>2</p>

3.	(c)	(iv)	shifts left/to reactants AND more moles/molecules «gas» in products ✓		1
3.	(c)	(v)	«forward» reaction is endothermic AND shifts to left/reactants OR $E_{a \text{ fwd}} > E_{a \text{ rev}}$, so forward reaction more affected by temperature AND shifts to left/reactants ✓	Accept “exothermic reverse reaction is favoured”.	1
3.	(d)	(i)	 straight line through origin ✓		1
3.	(d)	(ii)	<i>Rate equation:</i> «rate \Rightarrow » $k [\text{C}_8\text{H}_{10}]$ ✓ <i>Units of k:</i> s^{-1} ✓		2

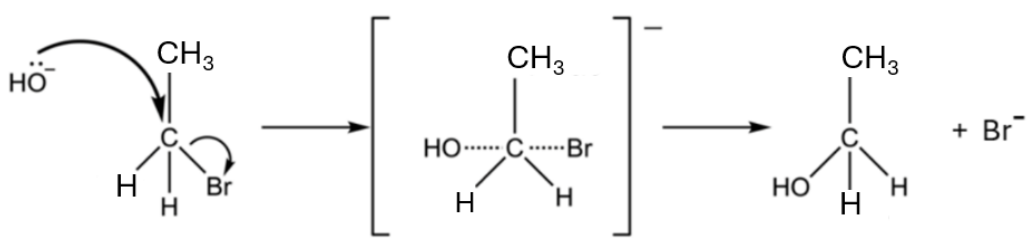
3.	(d)	(iii)	<div style="text-align: center;"> $\frac{1}{T} / K^{-1}$ </div>  <p>gradient = -8900 ✓ $\ll E_a = -(-8900 \times 8.31) = +74\,000 \text{ J mol}^{-1} \Rightarrow 74 \text{ kJ mol}^{-1} \checkmark$</p>	<p><i>Award [2] for correct final answer.</i></p> <p><i>Accept E_a in the range 66 to 76 «kJ mol⁻¹».</i></p> <p><i>Do not accept E_a in J mol⁻¹.</i></p> <p><i>Award [1 max] for -74 «kJ mol⁻¹».</i></p> <p><i>Accept gradient in the range: -8000 to -9100 for M1.</i></p>	2						
3.	(e)	(i)	isomers ✓	<i>Accept "same molecular formula".</i>	1						
3.	(e)	(ii)	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="padding: 5px;">Full structural formula</th> <th style="padding: 5px;">Functional group name</th> <th style="padding: 5px;">Homologous series</th> </tr> </thead> <tbody> <tr> <td style="text-align: center; padding: 10px;">  </td> <td style="text-align: center; padding: 10px;">carbonyl</td> <td style="text-align: center; padding: 10px;">aldehyde</td> </tr> </tbody> </table> <p>structure ✓ carbonyl AND aldehyde ✓</p>	Full structural formula	Functional group name	Homologous series		carbonyl	aldehyde	<p><i>Accept R/C attached to functional group in the full structural formula.</i></p> <p><i>Central C must have 4 bonds for M1.</i></p>	2
Full structural formula	Functional group name	Homologous series									
	carbonyl	aldehyde									
3.	(e)	(iii)	reflux ✓ oxidizing agent / oxidises B ✓	<i>Accept heat OR acidified for M1.</i>	2						

3.	(f)	(i)	$\frac{[C_6H_5COO^-][H^+]}{[C_6H_5COOH]}$	Accept H_3O^+ for H^+ .	1
3.	(f)	(ii)	horizontal line from point on curve at 10 cm ³ of NaOH to y-axis ✓	Accept line intersecting y-axis between 4.1 and 4.4.	1
3.	(f)	(iii)	bromothymol blue OR phenol red OR phenolphthalein ✓		1
3.	(f)	(iv)	«benzoate ion» hydrolysis/reaction with water AND forms OH ⁻ OR $C_6H_5COO^-(aq) + H_2O(l) \rightleftharpoons C_6H_5COOH(aq) + OH^-(aq)$ ✓		1
3.	(f)	(v)	«(0.020 × 0.010) ÷ 0.010 =» 0.020 «mol dm ⁻³ » ✓		1
3.	(g)	(i)	partially neutralize benzoic acid with NaOH OR amount/moles of NaOH added is smaller «than amount of benzoic acid» ✓		1
3.	(g)	(ii)	remains constant «as [A ⁻] : [HA] ratio is unchanged» ✓	Do not accept “slight/minimal change”.	1

3.	(h)	(i)	condensation OR polyester ✓		1
3.	(h)	(ii)	 <p>ester linkage ✓ continuation bonds AND rest of structure ✓</p>	<p><i>Accept without square brackets or n.</i> <i>Do not award M2 if more than one repeating unit is included.</i></p>	2

Question			Answers	Notes	Total
4.	(a)	(i)	electrophilic addition ✓		1
4.	(a)	(ii)	high electron density of C=C/pi bond ✓	<i>Do not accept only "presence of C=C".</i>	1

4.	(b)	(i)	<p>ALTERNATIVE 1: «bonds broken» C=C + H-Br / 614 + 366 / 980 «kJ mol⁻¹» AND «bonds formed» C-C + C-H + C-Br / 346 + 414 + 285 / 1045 «kJ mol⁻¹» ✓ «ΔH = 980 – 1045 => -65 «kJ mol⁻¹» ✓</p> <p>ALTERNATIVE 2: «bonds broken» 1C=C + 4C-H + 1H-Br / 614 + 4×414 + 366 / 2636 «kJ mol⁻¹» AND «bonds formed» 1C-C + 5C-H + 1C-Br / 346 + 5×414 + 285 / 2701 «kJ mol⁻¹» ✓ «ΔH = 2636 – 2701 => -65 «kJ mol⁻¹» ✓</p>	<p><i>Award [2] for correct final answer.</i></p> <p><i>Award [1 max] for +65 «kJ mol⁻¹».</i></p>	2
4.	(b)	(ii)	<p><i>Any two of:</i></p> <p>bond enthalpies are average values ✓</p> <p>enthalpies of formation are specific to the compounds ✓</p> <p>bond enthalpies apply to gases AND this reaction involves a liquid ✓</p> <p>bond enthalpies do not account for the change of state ✓</p>		2 max
4.	(b)	(iii)	<p>two moles/molecules of reactants form one mole/molecule of product</p> <p>OR</p> <p>gaseous reactants form liquid product ✓</p>		1

4.	(b)	(iv)	<p>$\llcorner \Delta S = 199 - 220 - 199 \Rightarrow -220 \llcorner \text{J K}^{-1} \text{mol}^{-1} \llcorner \checkmark$</p> <p>$\llcorner \Delta G^\ominus = -65\,000 \text{ J mol}^{-1} - (298 \text{ K} \times -220 \text{ J K}^{-1} \text{mol}^{-1}) \llcorner$</p> <p>$\llcorner \Delta G^\ominus = +560 \llcorner \text{J mol}^{-1} \llcorner / \llcorner + \llcorner 0.56 \llcorner \text{kJ mol}^{-1} \llcorner$ AND non-spontaneous \checkmark</p>	<p>Award [2] for correct final answer (ΔG^\ominus value and spontaneity).</p> <p>If $\Delta H = -58 \text{ kJ mol}^{-1}$ used, answer is $\llcorner + \llcorner 7600 \llcorner \text{J mol}^{-1} \llcorner / \llcorner + \llcorner 7.6 \llcorner \text{kJ mol}^{-1} \llcorner$.</p>	2
4.	(c)	(i)	nucleophilic substitution \checkmark	Accept S_N2 , but not S_N1 .	1
4.	(c)	(ii)	 <p>curly arrow from lone pair/negative charge on O in HO^- to C \checkmark</p> <p>curly arrow from C–Br bond to Br \checkmark</p> <p>transition state showing negative charge AND partial bonds \checkmark</p>	<p>Award [2 max] for correct S_N1 mechanism if not stated in (i).</p> <p>Accept curly arrow going from C–Br bond to Br either in bromoethane or in the transition state for M2.</p> <p>Do not penalize if HO and Br are not at 180°, or the square bracket is missing, in M3.</p> <p>Do not award M3 if OH ---- C connection is seen.</p>	3
4.	(c)	(iii)	primary halogenoalkane \checkmark	Accept reasons why, such as lack of steric hindrance or less stable carbocation.	1
4.	(c)	(iv)	2 / second \checkmark		1

4.	(c)	(v)	iodoethane AND «C–I» bond weaker/easier to break ✓	Accept “iodoethane AND I is a better leaving group”.	1
4.	(c)	(vi)	quartet / quadruplet / 4 ✓		1
4.	(c)	(vii)	bromoethane AND absence of O–H «peak» AND in 3200–3600 «cm ⁻¹ range» OR bromoethane AND C–Br «peak» AND 500–600 «cm ⁻¹ » ✓	Accept specific value in 500 – 600 «cm ⁻¹ » range.	1

Question			Answers	Notes	Total
5.	(a)		«two» more neutrons/n in ⁸¹ Br ✓		1
5.	(b)	(i)	<p>Any two of:</p> <p>«Br₂ molecules made up of» ⁷⁹Br – ⁷⁹Br «158 peak» AND ⁷⁹Br – ⁸¹Br «160 peak» AND ⁸¹Br – ⁸¹Br «162 peak» ✓</p> <p>number/probability/abundance of ⁷⁹Br – ⁷⁹Br and ⁸¹Br – ⁸¹Br «molecules» is «nearly» same «hence peaks same height» ✓</p> <p>number/probability/abundance of ⁷⁹Br – ⁸¹Br «molecules» is double «of ⁷⁹Br – ⁷⁹Br and ⁸¹Br – ⁸¹Br molecules hence peak is double the height» ✓</p>		2 max

5.	(b)	(ii)	$79 \times 50.75\% + 81 \times 49.25\% \checkmark$ $= 79.99 \checkmark$	<p><i>Award [2] for correct final answer.</i></p> <p><i>Do not accept 79.90, the value in the data booklet.</i></p>	2
5.	(c)	(i)	<p>«electronegativity difference \Rightarrow 2.0 AND «average electronegativity \Rightarrow 2.0 \checkmark</p> <p>ionic AND 35% covalent \checkmark</p>	<p><i>Accept range 30 - 40% for percentage covalent character.</i></p>	2

<p>5.</p>	<p>(c)</p>	<p>(ii)</p>	<p>three values from data booklet: «Br-Br enthalpy» 193 AND «1st IE Ca» 590 AND «EA of Br» -325 «kJ mol⁻¹» ✓ -325 x 2 / -650 «kJ mol⁻¹» ✓</p> <p>648 + 178 + 31 + 193 + 590 + 1145 = ΔH_{latt.} + 650 AND «ΔH_{latt.} = +2135 = +»2100 «kJ mol⁻¹» ✓</p>	<p><i>Award [3] for correct final answer.</i></p> <p><i>Award [2 max] for -2100 «kJ mol⁻¹».</i></p> <p><i>M1 and M2 can be scored on the diagram.</i></p> <p><i>Award ECF for M3 for correct application of Hess's law based on the candidate's values/cycle.</i></p>	<p>3</p>
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5.	(c)	(iii)	<p>Ca²⁺ and Co²⁺ lost 4s² electrons «so smaller than Br⁻» OR Ca²⁺ and Co²⁺ have electrons in 3 shells/energy levels «so smaller than Br⁻» ✓ Co²⁺ has greater «effective» nuclear charge/more protons than Ca²⁺ «so smaller» ✓ Br⁻ has electrons in 4 shells/energy levels / 4p⁶ «so larger than cations» ✓</p>		3
5.	(c)	(iv)	<p>cobalt(II) bromide AND «cation has» higher charge density / smaller radius ✓</p>		1
5.	(d)	(i)	[Ar] 4s ² 3d ⁷ / [Ar] 3d ⁷ 4s ² ✓		1
5.	(d)	(ii)	incomplete/partially-filled d «sub-level» ✓		1
5.	(d)	(iii)	<p>«wavelength = $3.00 \times 10^8 \text{ ms}^{-1} \div 4.5 \times 10^{14} \text{ s}^{-1} \Rightarrow 6.7 \times 10^{-7} \text{ «m»}$ / 670 «nm» ✓ red is absorbed AND green is complementary ✓</p>	Accept any units for wavelength in M1.	2

5.	(e)	(i)	<p>Anode: $\text{Co(s)} \rightarrow \text{Co}^{2+}(\text{aq}) + 2\text{e}^{-}$ ✓ Cathode: $\text{Co}^{2+}(\text{aq}) + 2\text{e}^{-} \rightarrow \text{Co(s)}$ ✓</p>	<p>Award [1 max] for correct half-equations at incorrect electrodes.</p>	<p>2</p>
5.	(e)	(ii)	<p>$\text{Cl}_2(\text{g}) + 2\text{Br}^{-}(\text{aq}) \rightarrow 2\text{Cl}^{-}(\text{aq}) + \text{Br}_2(\text{aq})$ ✓</p>		<p>1</p>
