

GCE

Chemistry A

Unit **F321**: Atoms, Bonds and Groups

Advanced Subsidiary GCE

Mark Scheme for June 2014

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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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These are the annotations, (including abbreviations), including those used in scoris, which are used when marking

Annotation	Meaning
	Blank Page – this annotation must be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
	Benefit of doubt given
	Contradiction
	Incorrect response
	Error carried forward
	Ignore
	Not answered question
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Rounding error
	Error in number of significant figures
	Correct response
	Noted but no credit given
	Repeat

Subject-specific Marking Instructions

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

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

All questions must be annotated with a tick placed close to where the mark is given but **NOT** obscuring the text (please refer to Scoris Annotations document from your Team Leader).

Additional pages/objects: You **must** annotate the additional pages (before Question 1) and the additional objects for each script you mark. If no credit is to be awarded for the additional object, please use a suitable annotation (either BP for blank page or SEEN).

ECF should also be used in the following questions where applicable: **2a, 3b, 3c, 3d, 5cii, 6b**.

The following questions should be fully annotated with ticks, crosses and other relevant annotations to show where marks have been awarded in the body of the text: **4aⁱⁱ, 4d, 5a**

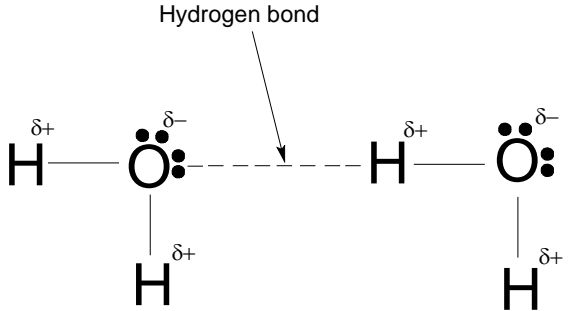
Question			Answer	Mark	Guidance
1	(a)		period = 5 AND block = p ✓	1	
1	(b)	(i)	Atom(s) of an element AND with different numbers of neutrons (and with different masses) ✓	1	ALLOW for ' atoms of an element': Atoms of the same element OR Atoms with the same number of protons OR Atoms with the same atomic number IGNORE different relative atomic masses IGNORE different mass number IGNORE same number of electrons DO NOT ALLOW different number 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)
1	(b)	(ii)	same number of electrons in outer shell OR same electron configuration OR electron structure ✓	1	IGNORE same number of protons IGNORE same number of electrons IGNORE they are the same element
1	(b)	(iii)	51p 70n 51e ✓	1	

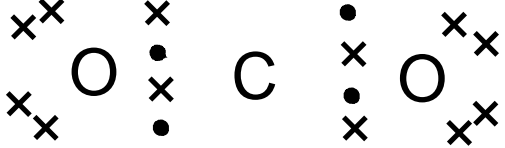
Question			Answer	Mark	Guidance
1	(c)	(i)	The (weighted) mean mass of an atom (of an element) OR The (weighted) average mass of an atom (of an element) ✓ compared with 1/12th (the mass) ✓ of (one atom of) carbon-12 ✓	3	ALLOW average atomic mass DO NOT ALLOW mean mass of an element ALLOW mean mass of isotopes OR average mass of isotopes DO NOT ALLOW the singular 'isotope' For second AND third marking points ALLOW compared with (the mass of) carbon-12 which is 12 For three marks; ALLOW mass of one mole of atoms compared to 1/12th (mass of) one mole OR 12g of carbon OR ALLOW <u> mass of one mole of atoms </u> 1/12th mass of one mole OR 12g of carbon-12
1	(c)	(ii)	123 ✓	1	ALLOW ¹²³ Sb OR Sb-123 OR antimony-123 ALLOW 123.0 IGNORE working
1	(d)	(i)	(Trigonal) Pyramidal ✓ (Sb has) three bonding pairs AND one lone pair of electrons ✓ Pairs of electrons repel ✓	3	ALLOW alternative phrases/words to repel eg 'push apart' ALLOW lone pairs repel more than bonding pairs ALLOW bonds for bonded pairs ALLOW lp and bp IGNORE electrons repel DO NOT ALLOW atoms repel

Question			Answer	Mark	Guidance
1	(d)	(ii)	<p>There is a difference in electronegativities (between Sb and Cl)</p> <p>OR (Sb-Cl) bonds are polar OR have a dipole</p> <p>OR Dipoles seen on the diagram ✓</p> <p>The molecule is not symmetrical AND dipoles do not cancel ✓</p>	2	<p>ALLOW Because Cl is more electronegative (than Sb) OR Because Sb is more electronegative (than Cl)</p> <p>ALLOW description that electrons are drawn along a covalent bond</p> <p>IGNORE single δ^+ or single δ^- for dipole</p> <p>IGNORE diagram if M1 awarded in text</p> <p>ALLOW partial charges do not cancel</p> <p>IGNORE references to lone pair causing dipoles</p>
			Total	13	

Question		Answer	Mark	Guidance															
2	(a)	<p>FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = $\text{CH}_4\text{N}_2\text{O}$ award 2 marks</p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="text-align: center;">C</td> <td style="text-align: center;">H</td> <td style="text-align: center;">N</td> <td style="text-align: center;">O</td> <td></td> </tr> <tr> <td style="text-align: center;">20.00/12.0</td> <td style="text-align: center;">6.67/1.0</td> <td style="text-align: center;">46.67/14.0</td> <td style="text-align: center;">26.66/16.0</td> <td></td> </tr> </table> <p>OR</p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="text-align: center;">1.67</td> <td style="text-align: center;">6.67</td> <td style="text-align: center;">3.33</td> <td style="text-align: center;">1.67</td> <td style="text-align: right;">ratio of mol ✓</td> </tr> </table> <p>to give $\text{CH}_4\text{N}_2\text{O}$ ✓</p>	C	H	N	O		20.00/12.0	6.67/1.0	46.67/14.0	26.66/16.0		1.67	6.67	3.33	1.67	ratio of mol ✓	2	<p>ALLOW 1.66 for C OR 1.66 for O</p> <p>IGNORE Significant figures beyond the 3rd significant figure. (eg ALLOW 3.3335 for N OR 1.666 for C)</p> <p>ALLOW ECF from incorrectly calculated ratio of mol, DO NOT ALLOW ECF from using an atomic number OR any original sums inverted (eg 12.00/20.00) ALLOW any order of atoms</p>
C	H	N	O																
20.00/12.0	6.67/1.0	46.67/14.0	26.66/16.0																
1.67	6.67	3.33	1.67	ratio of mol ✓															
2	(b)	NH_4^+ ✓ NO_3^- ✓	2	Mark incorrect ions first															
2	(c)	(i) H_3PO_4 ✓	1	ALLOW formula if seen as reactant in an equation IGNORE name															
2	(c)	(ii) Calcium oxide OR calcium hydroxide OR calcium carbonate ✓	1	IGNORE formulae IGNORE lime, quicklime and limestone															
Total			6																

Question		Answer	Mark	Guidance
3	(a)	Oxidised AND because aluminium has lost (three) electrons ✓	1	ALLOW 'donated' for 'lost' IGNORE where electrons are transferred to IGNORE $\text{Al} \rightarrow \text{Al}^{3+} + 3\text{e}^-$ DO NOT ALLOW 'an electron' or incorrect number of electrons
	(b)	FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = 2.88 dm³ award 2 marks Mol of H ₂ = 0.12 ✓ Volume of H ₂ = 0.12 x 24.0 = 2.88 dm ³ ✓	2	ALLOW ECF from incorrectly calculated moles of H ₂ 0.08 x 24 = 1.92 gets 1 mark
	(c)	FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = 10.7 g award 2 marks Correctly calculates molar mass of AlCl ₃ = 133.5 g ✓ Mass of AlCl ₃ formed = 0.0800 x 133.5 = 10.7 (g) ✓	2	If there is an alternative answer, check to see if there is any ECF credit possible using working below ALLOW ECF for incorrect molar mass of AlCl ₃ multiplied by 0.0800 and correctly rounded to 3 significant figures
	(d)	FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = 200(.0) cm³ award 2 marks Correctly calculates moles of HCl needed = 0.0800 x 3 = 0.24(0) mol ✓ Volume of HCl = 0.24(0) x 1000/1.2 = 200 cm ³ ✓	2	If there is an alternative answer, check to see if there is any ECF credit possible using working below ALLOW ECF for incorrect mol of HCl x 1000/1.20 ALLOW 66.7 (66.67 or 66.667 etc) for 1 mark DO NOT ALLOW 66.6 (66.66 or 66.666 etc)
Total			7	

Question	Answer	Mark	Guidance
4 (a) (i)	<p><i>The Dipole Mark</i> At least one $H^{\delta+}$ AND one $O^{\delta-}$ shown correctly on each water molecule (see diagram) ✓</p> <div style="text-align: center;">  </div> <p><i>The Hydrogen bonding Mark</i> One Hydrogen bond between H in one water molecule and a lone pair of O in an adjacent water molecule ✓</p>	2	<p>DO NOT ALLOW $H^{\delta-}$ OR $O^{\delta+}$ IGNORE lone pairs for first marking point</p> <p>All Hydrogen bonds must hit a lone pair Hydrogen bond does NOT need to be labelled but it must be different from the covalent bond if it is not labelled</p> <p>ALLOW H-bond as label ALLOW only one lone pair on O atom ALLOW additional, correctly drawn Hydrogen bonded water molecules with correct dipoles DO NOT ALLOW more than two lone pairs on O atom</p>

Question	Answer	Mark	Guidance
4 (a) (ii)	<p><i>Property 1</i> Ice is less dense than water ✓</p> <p><i>Explanation 1</i> The molecules in ice are held apart by hydrogen bonds ✓ OR ice has an open lattice OR structure</p> <p><i>Property 2</i> Ice has a relatively high melting point ✓</p> <p><i>Explanation 2</i> Hydrogen bonds are relatively strong OR Hydrogen bonds are stronger (than other intermolecular attractions or forces) OR More energy is needed to overcome hydrogen bonding</p>	4	<p>ALLOW ice floats (on water) ALLOW ice contracts when it melts</p> <p>ALLOW ice (water) has a higher melting point than expected OR predicted ALLOW other expressions which convey that the melting point is anomalously high eg 'Ice has an unusually high melting point' IGNORE boiling point IGNORE the following unqualified statements 'Ice has a higher melting point' or 'Ice has a high melting point' IGNORE references to surface tension as a property IGNORE explanations of surface tension</p> <p>ALLOW hydrogen bonds are the strongest intermolecular attraction or force DO NOT ALLOW 'hydrogen bonds are strong' but ALLOW this as part of a qualified statement (eg 'hydrogen bonds are strong compared with weak van der Waals forces')</p>
4 (b)	 <p>'dot-and-cross' of CO₂ ✓</p>	1	<p>Lone pairs on O must be seen Lone pairs may be seen as 4 individual electrons ALLOW correct use of three different symbols</p>

Question	Answer	Mark	Guidance
4 (c)	Giant covalent (lattice) ✓	1	ALLOW 'Giant lattice with covalent bonds' ALLOW 'Giant covalent bonds' IGNORE 'Giant molecular' or 'macromolecular' DO NOT ALLOW 'Covalent bonds between molecules'
4 (d)	<p><i>Conductivity of Na mark</i> M1: Sodium conducts in the solid and molten states ✓</p> <p><i>Reason for conductivity of Na mark</i> M2: Sodium has delocalised electrons (in both solid and liquid state) ✓</p> <p><i>Conductivity of Na₂O mark</i> M3: Na₂O conducts when molten and not when solid ✓</p> <p><i>Reason for conductivity of Na₂O marks</i> M4: Molten Na₂O has ions which are mobile ✓</p> <p>M5: Solid Na₂O has ions which are fixed (in position) OR ions are held (in position) OR ions are not mobile AND in an (ionic) lattice OR structure ✓</p>	5	<p><i>Quality of written communication</i> 'delocalis(z)ed spelled correctly once and used in context for second marking point</p> <p>ALLOW 'carries charge' for conducts for M1 and M3 IGNORE 'charge carriers' for electrons OR ions for M2, M4 and M5</p> <p>DO NOT ALLOW M2 if incorrect bonding is seen for Na DO NOT ALLOW ions move for solid Na for M2 IGNORE ions move for molten Na for M2</p> <p>ALLOW solid Na₂O is a poor conductor for M3 IGNORE references to aqueous Na₂O for M3</p> <p>IGNORE references to aqueous Na₂O for M4 IGNORE 'delocalised ions' OR 'free ions' for 'mobile ions' for M4 DO NOT ALLOW M4 AND M5 if incorrect bonding is seen in Na₂O DO NOT ALLOW any mention of electrons moving for M4 DO NOT ALLOW suggestion that it is only positive or only negative ions move for M4 IGNORE 'there are no delocalised electrons' for M5 ALLOW first and second statements of M5 to be unlinked in separate sentences ALLOW 'ions fixed in position by ionic bonds' for M5</p>
Total		13	

Question	Answer	Mark	Guidance
5 (a)	<p>M1 <i>Trend AND nuclear charge mark</i> (from Li to F) atomic radius decreases AND nuclear charge increases or number of protons increases ✓</p> <p>M2 <i>same shell/shielding mark</i> (outer) electrons are in same shell OR (outer) electrons experience similar or same shielding ✓ OR same number of shells</p> <p>M3 <i>nuclear attraction mark</i> Greater nuclear attraction on (outer) electrons or shells OR (Outer) electrons or shells are attracted more strongly to the nucleus ✓</p>	3	<p>ALLOW ORA throughout if it is clear that the Period is being crossed right to left</p> <p>ALLOW 'proton number increases' IGNORE 'atomic number increases' IGNORE 'nucleus gets bigger' IGNORE 'effective nuclear charge increases' DO NOT ALLOW 'charge increases' without reference to nuclear'</p> <p>IGNORE there is shielding DO NOT ALLOW sub-shells OR orbitals DO NOT ALLOW 'electrons are at a similar distance' This will also contradict M1 ALLOW 'there is no change in shielding' IGNORE 'shielding has no effect' DO NOT ALLOW 'there is no shielding'</p> <p>Quality of written communication 'nucleus' OR 'nuclear' spelled correctly once and used in context for third marking point</p> <p>ALLOW pull for attraction IGNORE for M3, 'electrons are pulled closer to nucleus' as this is a re-statement of the trend mark. DO NOT ALLOW 'greater nuclear charge' for 'greater nuclear attraction' for M3</p>

Question			Answer	Mark	Guidance
5	(b)	(i)	$(1s^2) 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$ ✓	1	ALLOW ... $4s^2 3d^{10} 4p^6$ ALLOW subscripts AND 3D IGNORE $1s^2$ seen twice
5	(b)	(ii)	Cream AND precipitate ✓	1	ALLOW solid OR ppt for precipitate IGNORE 'does not dissolve' OR 'partially dissolves'
5	(b)	(iii)	$Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)$ ✓	1	Equation AND state symbols required
5	(c)	(i)	Equation $2NaOH + Cl_2 \rightarrow NaCl + NaClO + H_2O$ ✓ Conditions cold AND dilute (sodium hydroxide) ✓	2	ALLOW correct multiples IGNORE state symbols ALLOW room temperature OR $\leq 20^\circ C$ for cold

Question	Answer	Mark	Guidance
(5) (c) (ii)	<p><i>Definition of disproportionation mark</i></p> <p>M1 (Disproportionation) is the (simultaneous) oxidation and reduction of the same element (in the same redox reaction) ✓</p> <p>M2 Assigning of oxidation numbers</p> <p>Cl in Cl₂ is 0 AND Cl in NaCl is -1 AND Cl in NaClO₃ is +5 ✓</p> <p>M3 Chlorine has been oxidised from 0 to +5 AND Chlorine has been reduced from 0 to -1 ✓</p> <p>'Chlorine has been oxidised from 0 in Cl₂ to +5 in NaClO₃ and chlorine has been reduced from 0 in Cl₂ to -1 in NaCl' would secure M2 and M3</p> $ \begin{array}{ccccccc} 3\text{Cl}_2 & + & 6\text{NaOH} & \rightarrow & 5\text{NaCl} & + & \text{NaClO}_3 & + & 3\text{H}_2\text{O} \\ \begin{array}{c} 0 \\ \\ \text{reduction} \\ \hline \end{array} & & & & \begin{array}{c} -1 \\ \uparrow \\ \text{oxidation} \\ \hline \end{array} & & \begin{array}{c} +5 \\ \uparrow \\ \hline \end{array} & & \\ \hline \end{array} $ <p>This diagram, along with a correct definition, would secure all three marks.</p>	3	<p>ALLOW 'an element' OR 'a species' for 'the same element' Assume 'it' means disproportionation M1 can be awarded for 'chlorine is oxidised and reduced and this is disproportionation'</p> <p>ALLOW oxidation numbers written above the equation if not seen in the text but IGNORE oxidation numbers written above the equation if seen in the text ALLOW 1- AND 5 AND 5+ DO NOT ALLOW chloride in place of chlorine except for NaCl DO NOT ALLOW Cl⁻ in NaCl AND Cl⁵⁺ in NaClO₃ (ie do not allow ionic charges for oxidation numbers) ALLOW Cl OR Cl₂ for chlorine DO NOT ALLOW M2 if incorrect oxidation numbers of other elements are seen in the text eg H = +2 ALLOW ECF for third marks if ONE incorrect oxidation number is assigned but directional changes are correct eg Cl = 0 and -1 and +3 instead 0 and -1 and +5</p> <p>DO NOT ALLOW ECF if two oxidation numbers are incorrectly assigned</p> <p>IGNORE references to electron loss/gain</p> <p>If oxidation numbers are correct ALLOW third mark for: chlorine is oxidised to form NaClO₃ AND chlorine is reduced to form NaCl</p>
	Total	11	

Question			Answer	Mark	Guidance
6	(a)	(i)	$\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g}) \checkmark$	1	
6	(a)	(ii)	BaCO_3 OR $\text{RaCO}_3 \checkmark$	1	ALLOW formula if seen as reactant in an equation IGNORE name
6	(b)		<p>FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = $\text{SrCl}_2 \cdot 2\text{H}_2\text{O}$ award 3 marks</p> <p>M1 Correctly calculates Mol of $\text{SrCl}_2 \cdot 6\text{H}_2\text{O} = (5.332 / 266.6) = 0.02 \text{ mol} \checkmark$</p> <p>M2 Correctly calculates Mol of water given off $[(5.332 - 3.892)/18] = 0.08 \text{ mol} \checkmark$</p> <p>M3 Correctly calculates $0.08/0.02 = 4$ mol of water lost from one mol of $\text{SrCl}_2 \cdot 6\text{H}_2\text{O}$ Therefore Answer = $\text{SrCl}_2 \cdot 2\text{H}_2\text{O} \checkmark$</p>	3	<p>Allow alternative methods eg M1 Correctly calculates mol of $\text{SrCl}_2 \cdot 6\text{H}_2\text{O}$ as $5.332/266.6 = 0.02(00) \text{ mol}$ DO NOT ALLOW M1 if a second mass is divided by 266.6</p> <p>M2 Correctly calculates molar mass of partially hydrated product as $3.892/0.02(00) = 194.6$</p> <p>M3 Correctly calculates mass of H_2O present as $194.6 - 158.6 = 36.0$ AND product is $\text{SrCl}_2 \cdot 2\text{H}_2\text{O}$</p> <p>ALLOW ECF for the third mark for showing 158.6 taken from an incorrect stated molar mass leading to an ECF formula OR ALLOW $266.6 - 194.6 = 72.0$ to find amount of water lost</p>
6	(c)	(i)	<p>Reaction 1: $\text{Ba} + 2\text{H}_2\text{O} \rightarrow \text{Ba}(\text{OH})_2 + \text{H}_2 \checkmark$</p> <p>Reaction 2: $\text{Ba}_3\text{N}_2 + 6\text{H}_2\text{O} \rightarrow 3\text{Ba}(\text{OH})_2 + 2\text{NH}_3$ Correct products \checkmark Balancing \checkmark</p>	3	Ignore state symbols
6	(c)	(ii)	Giant ionic (lattice) \checkmark	1	ALLOW 'Giant lattice with ionic bonds' ALLOW 'Giant ionic bonds' DO NOT ALLOW 'atoms or molecules or dipoles'

Question	Answer	Mark	Guidance
(iii)	<p> $\left[\begin{array}{c} \text{x x} \\ \text{x Ba x} \\ \text{x x} \end{array} \right]^{2+} \left[\begin{array}{c} \bullet\bullet \quad \bullet\bullet \\ \text{x O} \bullet\bullet \text{ O x} \\ \bullet\bullet \quad \bullet\bullet \end{array} \right]^{2-}$ </p> <p>OR</p> <p> $\left[\begin{array}{c} \text{x x} \\ \text{x Ba x} \\ \text{x x} \end{array} \right]^{2+} \left[\begin{array}{c} \bullet\bullet \quad \circ\circ \\ \text{x O} \bullet\bullet \text{ O x} \\ \bullet\bullet \quad \circ\circ \end{array} \right]^{2-}$ </p> <p>OR</p> <p> $\left[\begin{array}{c} \text{x x} \\ \text{x Ba x} \\ \text{x x} \end{array} \right]^{2+} \left[\begin{array}{c} \bullet\bullet \quad \circ\circ \\ \text{x O} \bullet\bullet \text{ O} \circ \\ \bullet\bullet \quad \circ\circ \end{array} \right]^{2-}$ </p> <p>OR</p> <p> $\left[\begin{array}{c} \text{x x} \\ \text{x Ba x} \\ \text{x x} \end{array} \right]^{2+} \left[\begin{array}{c} \bullet\bullet \quad \bullet\bullet \\ \text{x O} \bullet\bullet \text{ O} \bullet\bullet \\ \bullet\bullet \quad \bullet\bullet \end{array} \right]^{2-}$ </p>	1	<p>Ba must have a 2+ charge Ba can be with or without octet. IGNORE lack of charge on O_2^{2-} ion</p> <p>O_2^{2-} ion to have 12 electrons belonging to O atoms + 2 other electrons of another symbol. The 2 other electrons must match Ba if Ba has an octet.</p> <p>If O electrons are shown as 6 of one symbol and 6 of another, each O must have six electrons of the same symbol</p> <p>ALLOW</p> <p> $\left[\begin{array}{c} \text{x x} \\ \text{x Ba x} \\ \text{x x} \end{array} \right]^{2+} \left[\begin{array}{c} \bullet\bullet \quad \bullet\bullet \\ \bullet\bullet \text{ O} \bullet\bullet \text{ O} \bullet\bullet \\ \bullet\bullet \quad \bullet\bullet \end{array} \right]^{2-}$ </p> <p>OR</p> <p> $\left[\begin{array}{c} \text{x x} \\ \text{x Ba x} \\ \text{x x} \end{array} \right]^{2+} \left[\begin{array}{c} \bullet\bullet \quad \bullet\bullet \\ \bullet\bullet \text{ O} \text{ x} \text{ O} \bullet\bullet \\ \bullet\bullet \quad \bullet\bullet \end{array} \right]^{2-}$ </p>
	Total	10	

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