


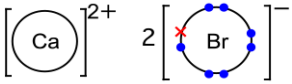
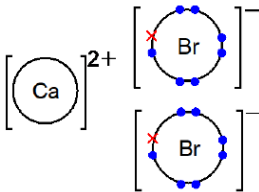
Mark scheme – Periodicity

Question		Answer/Indicative content	Marks	Guidance
1		<p>Refer to marking instructions on page 5 of mark scheme for guidance on marking this question.</p> <p>Level 3 (5–6 marks) Explains all three melting point values and conductivities in terms of structure, bonding, particles and relative strengths of the forces.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 2 (3–4 marks) Attempts to explain all three melting point values and conductivities in terms of the structure, bonding, particles of all three substances, but explanations may be incomplete or may contain only some correct statements or comparisons.</p> <p>OR</p> <p>Correctly explains two of the melting point values and conductivities in terms of the structure, bonding, particles.</p> <p><i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i></p> <p>Level 1 (1–2 marks) Identifies only some of the structures, forces and particles</p> <p>AND</p> <p>Attempts to explain the melting point values OR conductivities in terms of the structure, bonding, particles</p> <p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p>0 marks <i>No response or no response worthy of credit.</i></p>	<p>6 (AO 1.1×3) (AO 2.1×3)</p>	<p>Indicative scientific points may include:</p> <p><u>Structure and bonding</u></p> <p>Magnesium</p> <ul style="list-style-type: none"> • Structure: giant lattice • Metallic bonding • Delocalised electrons <p>Bromine</p> <ul style="list-style-type: none"> • Structure: simple molecular • induced dipole dipole forces (London forces) • (Between) molecules DO NOT ALLOW (between) atoms <p>Magnesium bromide</p> <ul style="list-style-type: none"> • Structure: giant lattice • Ionic bonding • (Between) oppositely charged ions <p><u>Comparison of bond strengths</u></p> <ul style="list-style-type: none"> • Metallic and ionic bonds are stronger than London forces OR Metallic and Ionic bonds need more energy to break than London forces <p><u>Conductivity</u></p> <ul style="list-style-type: none"> • Magnesium: conducts due to delocalised electrons can move/mobile. IGNORE 'Carry' charge for movement • Magnesium bromide: In solid IONS cannot move; in solution IONS can move. DO NOT ALLOW electrons. • Bromine: Does not conduct as no mobile charge carriers.
		Total	6	
2	a	Ca: metallic bonding OR giant metallic lattice ✓	5 (AO1.1×2)	ALLOW Metallic structure DO NOT ALLOW reference to molecules or intermolecular forces for calcium

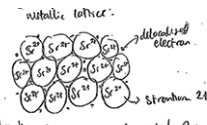
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	<p>Br₂: simple molecular OR simple covalent ✓</p> <p>Induced dipole(–dipole) forces/interactions OR London forces ✓</p> <p>Conductivity linked to mobile electrons In Ca electrons are mobile OR electrons are delocalised OR electrons can move AND in Br₂ charge carriers/electrons are not mobile ✓</p> <p>Melting point linked to bond strengths Metallic bonds are strong AND London forces are weak OR Metallic bonds need a large amount of energy to break AND London forces need little energy to break ✓</p>	<p>(AO2.1×1)</p> <p>(AO3.2×2)</p>	<p>ALLOW ‘are molecules’</p> <p>IGNORE</p> <ul style="list-style-type: none"> • permanent dipole(–dipole) forces • IDID and LDF • van der Waals <p>DO NOT ALLOW ‘free electrons’ for mobile electrons</p> <p>ALLOW comparison, e.g.</p> <ul style="list-style-type: none"> • Metallic bonds are stronger than London forces <p>OR</p> <ul style="list-style-type: none"> • Metallic bonds need more energy to break than London forces ✓ <p>ALLOW intermolecular forces instead of London forces for this mark</p> <p><u>Examiner’s Comments</u></p> <p>More able candidates scored well in this question, setting out their answers in a logical order. They often first discussed Ca and its bonding and structure, linking this to the physical properties and then doing the same for Br.</p> <p>A number of candidates discussed the chemical properties of Ca and Br, such as their ability to bond with other elements, ionisation energy and their reactivity based on their position in the periodic table. Some candidates gave a good description of metallic bonding but then went on to discuss melting point in terms of intermolecular forces.</p> <p> AfL</p> <p>A number of students still referred to Van der Waals forces in their answers. Van der Waals forces are a collective term for several different intermolecular forces (https://goldbook.iupac.org/terms/view/V06597), so when students intend to refer to specific</p>
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				intermolecular forces their specific names should be used.
b	i	 <p>Ca shown with either 8 or 0 electrons AND Br shown with 8 electrons with 7 crosses and 1 dot (or vice versa) ✓</p> <p>Correct charges on both ions ✓</p>	2 (AO1.2×1) (AO2.5×1)	<p>ALLOW separate Br⁻ ions, i.e.</p>  <p>For first mark, if eight electrons are shown around Ca, the 'extra' electrons around Br must match the symbol chosen for the electrons for Na.</p> <p>IGNORE inner shells</p> <p>Circles or brackets not required</p> <p>Examiner's Comments</p> <p>Most candidates were able to give the correct diagrams for ionic bonding, although care needs to be taken that diagrams are well drawn with both charges given. Some gave diagrams for covalent bonding.</p>
	ii	<p>Atomic radius</p> <p>Ba has a greater atomic radius than Ca OR Ba has more shells OR Ba has more shielding ✓</p> <p>Attraction</p> <p>Nuclear attraction is less in Ba OR (outer) electrons in Ba are less attracted (to nucleus) OR Increased distance / shielding in Ba outweighs increased nuclear charge ✓</p> <p>Ionisation energy</p> <p>Ionisation energy of Ba is less OR (outer) electrons in Ba are less attracted (to nucleus) OR easier to remove (outer) electrons in Ba ✓</p>	3 (AO1.1×1) (AO2.3×2)	<p>Comparison required throughout ORA throughout</p> <p>For more shells, ALLOW higher energy level IGNORE more orbitals OR more sub-shells IGNORE 'different shell' or 'new shell'</p> <p>ALLOW Ba has less nuclear pull' OR 'Ba electrons are less tightly held'</p> <p>IGNORE less effective nuclear charge' IGNORE 'nuclear charge' for 'nuclear attraction'</p> <p>ALLOW easier to oxidise Ba</p> <p>Examiner's Comments</p> <p>It was important to answer the question asked. A number of responses lost marks for describing the general trend down group 2 without making reference at all to calcium and barium. Most candidates managed to score at least one mark here but a considerable proportion missed the second marking point explaining that nuclear attraction was less in Ba.</p>
		Total	10	
3		Bonding and structure	5 (AO1.1×	Diagram must have at least two rows and a minimum of two ions per row (allow Sr⁺ or

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				<p>Diagram</p>  <p>Explanation: Strontium is a group 2 metal. This means it forms metallic bonds in which strontium ions (2+ charge) are attracted to the negatively charged delocalised electrons. Delocalised electrons are able to move around the lattice and so metals are able to carry a current of electricity even as a solid. This makes it a good electrical conductor. It has a high melting point due to the strong metallic forces of attraction. But this need to be overcome in order for it to change state.</p> <p>This candidate scored 5 marks for the excellent description with a well drawn and labelled diagram, clearly showing the electrons throughout the structure in-between the ions.</p>
		Total	5	
4		s-block AND highest energy or outer electron is in a s orbital or s sub-shell ✓	1 (AO 1.1)	<p>ALLOW 'outer' or 'valence' for 'highest energy' IGNORE electron configurations DO NOT ALLOW s shell / energy level</p> <p>Examiner's Comments</p> <p>Many candidates knew the block magnesium belonged but only very few could explain this was because magnesium's highest energy electron was in a s sub-shell or s orbital.</p>
		Total	1	
5		<p>Type of lattice 2 marks</p> <ul style="list-style-type: none"> • SiO₂: Giant (covalent lattice) ✓ • CO₂: Simple molecular/covalent (lattice) ✓ <hr/> <p>Explanation 2 marks</p> <p>1. Forces in CO₂</p> <ul style="list-style-type: none"> • Induced dipole-dipole interactions / London forces ✓ <hr/> <p>2. Comparison of forces with strength / melting point</p> <ul style="list-style-type: none"> • (Covalent) bonds in SiO₂ are stronger THAN intermolecular forces in CO₂ OR • More energy to break (covalent) bonds in SiO₂ THAN intermolecular forces in CO₂ ✓ 	<p>4 AO1.1×2</p> <p>AO1.1×1</p> <p>AO2.1×1</p>	<p>Throughout, IGNORE 'ionic' for SiO₂</p> <p>FOR SiO₂, IGNORE macromolecular DO NOT ALLOW giant metallic</p> <p>Mark explanation independently on type of lattice</p> <p>i.e. no ECF from incorrect lattice</p> <p>For CO₂ IGNORE</p> <ul style="list-style-type: none"> • covalent bonds • van der Waals' forces • idid • LDF <p>DO NOT ALLOW hydrogen bonds OR permanent dipole interactions</p> <hr/> <p>For SiO₂, comparison needs just 'bonds' OR 'forces'</p> <p>For intermolecular, ALLOW 'between molecules'</p>

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			ORA		<p>For comparison, ALLOW strong in SiO₂ AND weak in CO₂</p> <p>DO NOT ALLOW responses containing intermolecular forces in SiO₂</p> <p>IGNORE 'More bonds'</p> <p>Examiner's Comments</p> <p>A good understanding of structure and bonding continues to be difficult for candidates, demonstrated by many explanations seen for the different melting points.</p> <p>Most candidates obtained two relatively easy marks for identifying the giant and simple molecular/covalent structures of SiO₂ and CO₂ respectively.</p> <p>The explanation proved to be much more difficult as candidates showed some misconceptions. Many identified that CO₂ had London forces but their action between molecules was often omitted. Many candidates realised that the forces broken on melting are much stronger in SiO₂ than in CO₂, but then went on to erroneously compare the strength of London forces or intermolecular forces in both SiO₂ and CO₂.</p>
			Total	4	
6			Highest energy electron(s) in a p orbital/p sub-shell ✓	1	<p>ALLOW outer electron(s) in a p orbital/sub-shell BUT IGNORE p shell</p> <p>ALLOW electron configuration ends in p OR the last electron is in a p orbital</p> <p>ALLOW valence electron(s) in p orbital/sub-shell</p> <p>Examiner's Comments</p> <p>Candidates were expected to identify that a p-block element has its highest energy electron(s), or outer electrons, in a p orbital or sub-shell. Lower ability candidates often omitted 'electrons' in their responses and just repeated the information in the question.</p>
			Total	1	
7	a	i	Hydrogen/H ✓	1	<p>ALLOW H₂</p> <p>Examiner's Comments</p>

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				<p>Most candidates were credited this straightforward mark and identified that hydrogen would gain an electron to form a 1⁻ ion. Some candidates opted for lithium, able to form an ion with the same electron configuration as helium, but with a 1⁺ rather than a 1⁻ charge.</p> <p>Candidates are recommended to look closely at the requirements of the question set.</p>
	ii	Helium/He ✓	1	<p><u>Examiner's Comments</u></p> <p>This part required candidates to recall their knowledge of trends in first ionisation energy. Candidates found this part harder than 1(a)(i) with only the higher ability candidates choosing the correct response of 'helium'.</p> <p>Many candidates instead chose another noble gas, with neon and argon commonly seen. Other common incorrect responses were hydrogen and fluorine.</p>
	iii	Magnesium/Mg ✓	1	<p><u>Examiner's Comments</u></p> <p>Most candidates did correctly select magnesium, but many other elements were seen, especially aluminium, silicon, beryllium and calcium.</p> <p>To identify the element's group, candidates needed to analyse the data to find the large increase in ionisation energy corresponding to a change in shell. From the responses, some candidates did not make use of 'Period 3' in the stem.</p>
	iv	Sulfur/S ✓	1	<p>ALLOW sulphur; S₈</p> <p><u>Examiner's Comments</u></p> <p>Most candidates selected sulfur as the correct response, recalling their knowledge of molecular shapes encountered early in the course. There was no real pattern for incorrect responses, suggesting that they were guesses.</p>
	v	Chlorine/C/ OR fluorine/F ✓	1	<p>ALLOW Cl₂ OR F₂</p> <p><u>Examiner's Comments</u></p> <p>Most candidates chose the correct response of chlorine, although hydrogen was a common incorrect response, presumably by linking to the acidic properties of H⁺ ions. Other candidates focused on 'reacts with water' and chose sodium</p>

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				(which does form a solution with water, but on that is alkaline rather than acidic).
	vi	Phosphorus/P ✓	1	<p>ALLOW P₄</p> <p><u>Examiner's Comments</u></p> <p>Almost all candidates correctly responded with phosphorus and this was the easiest part of 1(a).</p>
	vii	Carbon/C ✓	1	<p>ALLOW silicon/Si</p> <p><u>Examiner's Comments</u></p> <p>Most candidates correctly selected carbon. From their A Level studies, candidates would expect hydrogen to have an oxidation number of +1 and to form compounds with carbon (CH₄) and silicon (SiH₄) in which the element has an oxidation number of -4. Although hydrogen is actually slightly less electronegative than carbon, hydrogen is slightly more electronegative than silicon. Therefore, in the case of SiH₄, silicon has an oxidation number of +4. A response of silicon still indicates a correct understanding of oxidation number rules and was also credited</p>
	vii i	Oxygen/O ✓	1	<p>ALLOW O₂</p> <p><u>Examiner's Comments</u></p> <p>This proved to be the hardest part of 1(a) with only the higher ability candidates selecting oxygen. Sulfur proved to be the key distractor, having the same molar mass as O₂. Most candidates did not consider that the element was gaseous and could not be sulfur.</p>
b		<p>NaCl OR MgCl₂ 2 marks</p> <p>Giant ionic OR ionic lattice ✓</p> <p>Ions are mobile in liquid state ✓</p> <hr/> <p>SiCl₄ OR PCl₃ OR SCl₂ 2 marks</p> <p>(Simple) molecular OR simple covalent (lattice) ✓</p>	5	<p>IGNORE aqueous/dissolved ions are mobile</p> <p>IGNORE 'free ions'</p> <p>AND 'ions are free to carry current'</p> <hr/> <p>ALLOW 'are molecules'</p> <p>IGNORE</p> <ul style="list-style-type: none"> • permanent dipole(-dipole) forces

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	<p>Induced dipole(-dipole) forces/interactions OR London forces ✓</p> <hr/> <p>Comparison of bond strengths 1 marks</p> <ul style="list-style-type: none">• Ionic bonds are stronger than London forces OR• Ionic bonds need more energy to break than London forces ✓	<ul style="list-style-type: none">• IDID and LDF• van der Waals <hr/> <p>ALLOW attraction between ions for ionic bonds ALLOW intermolecular forces for London forces ALLOW overcome for break</p> <p>ALLOW indirect comparison, i.e.</p> <p>Ionic bonds are strong AND London forces</p> <ul style="list-style-type: none">• are weak OR• Ionic bonds need a large amount of energy to break AND London forces need little energy to break <p><u>Examiner's Comments</u></p> <p>This part required candidates to determine the structure and bonding of unfamiliar compounds from their melting points and electrical conductivities.</p> <p>This part discriminated very well. Candidates with a good knowledge and understanding of structure and bonding, often produced concise, clear responses which were credited with a high mark, as shown in the Exemplar 1.</p> <p>Poor understanding often showed up with contradictions and it was common to see ionic lattices with strong intermolecular forces and able to release mobile electrons (rather than mobile ions) in the liquid state. Weaker candidates often wrote extensive answers, although the extra length did not lead to more marks as correct responses were then often contradicted. Exemplar 2 shows part of a very muddled and rambling response in which NaCl is described as having both ionic bonding and London forces.</p> <p>The best responses identified NaCl and MgCl₂ as having giant ionic lattices with strong forces between their ions. This structure was then compared with the simple molecular structures of SiCl₄, PCl₃ and SCl₂ with weak London forces between their molecules. A common error was for SiCl₄ to have a giant covalent lattice, presumably linking with the structure of elemental silicon and not using the low boiling point in the supplied data.</p>
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			<p>Exemplar 1</p> <p>Metals and MgCl₂ are poor electrical conductors when solid. They have to giant ionic lattice structures when solid. Ions in fixed positions in lattice cannot move over home no mobile charge carriers. When liquid, metal cations and Cl⁻ ions free to move so can act as mobile charge carriers so good conductivity when liquid. Strong electrostatic attraction between oppositely charged ions in giant ionic lattice requires lots of energy to overcome, so have high melting points. SiCl₄, PCl₃ and SCl₂ have simple molecular structures only weak intermolecular forces (London forces) present between molecules. They are easy to overcome and as such they have low melting points. In both solid and liquid states, they have no delocalised electrons or ions which can act as mobile charge carriers so they are poor conductors. [5]</p> <p>Exemplar 2</p> <p>NaCl has a high melting point due to strong induced dipole bonds and London forces. They also have high ionic charges and radius which increase their electrical conductivity when in liquid form. The amount of Cl⁻ ions they bond to is dependent on the charge so Na is 1⁺ so bonds to one Cl⁻. SiCl₄ is a giant covalent structure and has its electrons conductivity is low as its bonds are held far apart. It also has a low melting point due to the fact it is bonded and its surface energy is increased raising it to be too high to overcome bonds. This is not for SiCl₄ not of the (continued) [5]</p> <p>1b. In ionic compounds conduct electricity when solid as there are no free electrons so they cannot conduct electricity only NaCl and MgCl₂ do when liquid as they are ionic and simply will have an ionic charge. Their melting point is high due to the strong electrostatic forces so more energy is required to break their bonds.</p>																				
	<p>Total</p>	<p>13</p>																					
<p>8</p>	<table border="1" data-bbox="247 1310 798 1624"> <thead> <tr> <th></th> <th>Na₂S</th> <th>Na</th> <th>S</th> </tr> </thead> <tbody> <tr> <td>Melting point / °C</td> <td>1180</td> <td>98</td> <td>113</td> </tr> <tr> <td>Type of structure</td> <td>giant</td> <td>giant</td> <td>simple</td> </tr> <tr> <td>Conductivity of solid</td> <td>poor</td> <td>good</td> <td>poor</td> </tr> <tr> <td>Conductivity of liquid</td> <td>good</td> <td>good</td> <td>poor</td> </tr> </tbody> </table> <p style="text-align: center;"> ✓ ✓ ✓ </p> <p>One mark for each correct column</p>		Na ₂ S	Na	S	Melting point / °C	1180	98	113	Type of structure	giant	giant	simple	Conductivity of solid	poor	good	poor	Conductivity of liquid	good	good	poor	<p>3</p>	<p>Mark by COLUMN</p> <p>Examiner's Comments</p> <p>The majority of candidates obtained 2 or 3 marks on this question. Many candidates seemed unaware that sodium was a metal.</p>
	Na ₂ S	Na	S																				
Melting point / °C	1180	98	113																				
Type of structure	giant	giant	simple																				
Conductivity of solid	poor	good	poor																				
Conductivity of liquid	good	good	poor																				
	<p>Total</p>	<p>3</p>																					
<p>9</p>	<p><i>Increasing size:</i></p> <p>Atomic radius increases OR more shells OR</p>	<p>3</p>	<p>FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc MUST BE USED</p> <p>IGNORE more orbitals OR more sub-shells <i>Alternative must refer to shells</i></p> <p>ALLOW Energy levels for shells</p>																				

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		<p>more (electron) shielding ✓</p> <p><i>Attraction</i> Nuclear attraction decreases OR (outer) electron(s) experience less attraction ✓</p> <p><i>Ionisation energy</i> Ionisation energy decreases OR less energy needed to remove electron(s) ✓</p>		<p>ALLOW more electron repulsion between shells IGNORE just 'shielding' (<i>more / greater needed</i>) IGNORE 'nuclear shielding'</p> <p>IGNORE 'pull' for attraction IGNORE 'electrons less tightly held' IGNORE 'nuclear charge' for 'nuclear attraction'</p> <p>IGNORE 'easier to remove electron' Energy is required</p> <p>ALLOW less energy to oxidise</p> <p>Examiner's Comments This question was another one based upon the AS part of the specification, and most candidates secured the first two marking points. The third mark, based upon the idea of less energy needed to remove electron(s) as the group is descended, was not scored by many. Instead, candidates loosely talked about an increasing ease of electron removal.</p>
		Total	3	
1 0		<p>Observations linked to anion identifications</p> <p>Bubbles/effervescence/fizzing/gas AND carbonate ✓</p> <p>(white OR precipitate) AND sulfate ✓</p> <p>Use of molar mass in reasoning</p> <p>Molar mass used ONCE with carbonate OR sulfate ✓</p> <p>Identification</p> <p>B: K_2CO_3 ✓</p>	5	<p>FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc MUST BE USED</p> <p>For bubbles, ALLOW carbon dioxide/CO_2 BUT DO NOT ALLOW hydrogen/H_2</p> <p>For carbonate, ALLOW CO_3 For sulfate, ALLOW SO_4</p> <p>e.g. Carbonate: $140 - (12 + 48)$; $140 - 60$ Sulfate: $140 - (32.1 + 64)$; $140 - 96.1$ $K_2CO_3 = 138.1$ $Na_2SO_4 = 142.1$</p> <p>ALLOW ONE of the two identification marks for:</p> <ul style="list-style-type: none"> • Correct names: B potassium carbonate AND C sodium sulfate • Incorrect formulae i.e. B KCO_3 AND C $NaSO_4$ <i>Communicates the same as names</i>

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		<p>C: Na₂SO₄ ✓</p>		<p>Examiner's Comments</p> <p>This was a challenging question that discriminated extremely well. The more able candidates derived the anions from the two chemical tests and identified the cations using the molar masses of the salt and the anions.</p> <p>Weak candidates seemed to have little idea on how to approach such a question and they often achieved no credit.</p> <p>It was disappointing that many candidates were unable to identify a carbonate and sulfate from their chemical tests. Common errors included incorrectly identifying the gas with dilute acid as hydrogen, and identifying the white precipitate with barium ions as characteristic of a chloride.</p> <p>Candidates who used the provided molar mass of 140 usually went on to show that the cations contributed masses of approximately 80 for the carbonate and 44 for the sulfate. Candidates then needed to divide each value by 2 to obtain formulae of K₂CO₃ and Na₂SO₄. Many did not divide by 2 and instead concluded that the compounds were RbCO₃, KSO₄ or CaSO₄.</p> <p>Strangely, some candidates thought they were identifying Group 1 metals and not salts.</p>
		Total	5	
1 1	i	<p>Increase from 5–7 (B→N) AND 5 below 4 but above 3 ✓</p> <p>8(O) below 7 and 9 AND above 6 ✓</p>	2	<p>ALLOW if points correct but straight lines not drawn</p>
	ii	<p>Trend described down group</p> <p><i>Atomic radius</i></p>	3	<p>FULL ANNOTATIONS MUST BE USED</p> <p>.....</p> <p>.</p> <p>ALLOW ORA but comparison should be used for each mark.</p>

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		<p>larger atomic radius OR more shells ✓</p> <p><i>Effect of nuclear charge/shielding</i> Increased nuclear charge is outweighed by increased distance/shielding OR more/increased shielding ✓</p> <p><i>Reactivity AND Nuclear attraction</i> Reactivity increases AND less nuclear attraction OR less attraction on electrons ✓</p>		<p>ALLOW 'more/higher energy levels' ALLOW 'electrons further from nucleus' ALLOW 'different shell' OR 'new shell'</p> <p>IGNORE more orbitals OR more sub-shells</p> <p>ALLOW more electron repulsion from inner shells IGNORE responses with no comparison e.g. 'is shielding' Mark requires statement that reactivity increases AND reason</p> <p>IGNORE nuclear charge/effective nuclear charge</p> <p>ALLOW 'less nuclear pull' OR 'electrons held less tightly'</p>
		Total	5	
1 2	a	Periodicity ✓	1	<p>Examiner's Comments</p> <p>The term 'periodicity' was known to all but a very small minority of candidates.</p>
	b	<p>Sodium OR Na ✓ Silicon OR Si ✓ Neon OR Ne ✓</p>	3	<p>Examiner's Comments</p> <p>The periodic properties of elements were not fully known. Most realised that sodium had the lowest first ionisation energy, less were aware that silicon had the lowest fourth ionisation energy and fewer still were unable to deduce that neon had the lowest boiling point.</p>
	c	<p><i>M1 Number of bonding electrons mark</i> Magnesium has more outer OR bonding electrons ✓</p> <p><i>M2 Ionic charge mark</i> Magnesium ions have a greater (positive) charge (density) ✓</p>	3	<p>ALLOW reverse argument throughout ALLOW 'more delocalised electrons' for 'more outer electrons' DO NOT ALLOW 'Magnesium molecules' for M1</p> <p>ALLOW Mg²⁺ ion OR Mg ion for 'magnesium ion' ALLOW Mg²⁺ and Na⁺ for M2 (may be seen in a diagram) IGNORE magnesium has a greater charge but</p>

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			<p><i>M3 Attraction mark</i></p> <p>Magnesium has a greater attraction between ions and delocalised electrons ✓</p>	<p>ALLOW magnesium has a greater ionic charge IGNORE nuclear charge DO NOT ALLOW 'atoms' or 'molecules' having a greater charge for M2</p> <p>ALLOW 'stronger metallic bonds' only when a clear description of metallic bonding is given. Eg 'The attraction of positive (metal) ions to delocalised electrons'</p> <p>QWC 'delocalised/delocalized' spelled correctly at least once in context of M3 (may be seen in M1 but used in M3)</p> <p>'delocalised' need not be directly next to electrons eg Mg has more delocalised electrons and the ions have a greater attraction to these electrons would secure M3</p> <p>Examiner's Comments</p> <p>This question proved to be a good question in terms of distinguishing candidates. Good candidates were able to secure three marks with succinct, but well-explained answers. Weaker candidates were confused as to why the strength of metallic bonding increased from Na to Mg.</p>	
			Total	7	
1 3	a		Phosphorus has more electrons ✓	1	<p>ALLOW ORA but comparison should be used for the all marks DO NOT ALLOW Phosphorus has more electrons in the outer shell or larger electron cloud.</p> <p>IGNORE Phosphorus molecules are bigger or have greater M_r.</p> <p>Examiner's Comments</p> <p>It as pleasing to see that the vast majority of candidates were able to use the terms London forces or induced dipole–dipole interactions rather than van der Waals as used in the legacy specification. Unfortunately, many candidates also chose to discuss how the strength of the covalent bonds increased melting points rather than just considering the intermolecular forces. Answers were either very good or very poor. Where a candidate only scored two marks it was</p>

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			Stronger London forces OR Stronger induced dipole(-dipole) interactions ✓	1	mainly due to not discussing the influence the number of electrons has on the strength of the force. ALLOW 'more' for 'stronger' ALLOW stronger van der Waals' / vdW forces
			More energy required to break the intermolecular forces / bonds OR London forces ✓	1	DO NOT ALLOW attraction between atoms-or that covalent bonds are broken
	b		Magnesium metallic (bonds) ✓	1	ALLOW the (electrostatic) attraction between cations / positive ions and delocalised electrons for both Mg marks ✓✓
			cations/positive ions/Mg ²⁺ AND delocalised electrons ✓	1	DO NOT ALLOW molecules for second mark IGNORE 'sea of electrons'
			Silicon covalent ✓	1	ALLOW the attraction between a shared pair of electrons and the nuclei of the (bonded) atoms for both marks ✓✓
			between atoms ✓	1	DO NOT ALLOW any intermolecular forces in marking points 2 and 4 or silicon molecules Examiner's Comments The best answers linked the type of bonding with the correct particles in just a few statements to score all four marks. Those candidates who attempted to fill the answer space often contradicted correct answers by discussing the intermolecular forces between the particles. Some very able candidates did not include that the particles in silicon are atoms whereas others gave answers which suggested that silicon was made up of molecules.
			Total	7	
1 4		i	$\text{Sr}^+(\text{g}) \rightarrow \text{Sr}^{2+}(\text{g}) + \text{e}^-$ ✓	1	ALLOW $\text{Sr}^+(\text{g}) - \text{e}^- \rightarrow \text{Sr}^{2+}(\text{g})$ ALLOW e for electron (i.e. charge omitted) IGNORE states on the electron Examiner's Comments The equation for the second ionisation energy of strontium proved no difficulty for the most able candidates who provided both the correct state symbols and charges. It was surprising however that 40% of candidates failed to score what was meant to be a straightforward mark.
		ii		3	FULL ANNOTATIONS MUST BE USED

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		<p><i>Atomic radius</i></p> <p>larger atomic radius OR more shells ✓</p> <p><i>Effect of nuclear charge / shielding</i></p> <p>Increased nuclear charge outweighed by increased distance / shielding OR more / increased shielding ✓</p> <p><i>Nuclear attraction</i></p> <p>less nuclear attraction OR less attraction on electrons ✓</p>		<p>.</p> <p>ALLOW ORA: comparison needed for each mark.</p> <p>ALLOW 'more / higher energy levels' ALLOW 'electrons further from nucleus' ALLOW 'extra / new shell'</p> <p>IGNORE more orbitals OR more sub-shells OR different shell</p> <p>ALLOW more electron repulsion from inner shells IGNORE responses with no comparison</p> <p>IGNORE nuclear charge / effective nuclear charge ALLOW 'less nuclear pull' OR 'electrons held less tightly'</p> <p>Examiner's Comments</p> <p>This descriptive question was well answered with the vast majority of candidates picking up two of the three available marks. Where a candidate scored two marks it was often due to the omission of any comment about the reduction in attraction between the nucleus and the electron as the group was descended. A common error was to discuss the reduction in nuclear charge rather than nuclear attraction.</p>
		Total	4	
1 5		<p>The attraction (between nuclei and outermost electrons) increases (across the period) AND The nuclear charge increases OR The number of protons increase ✓</p> <p>(Outer) electrons are in the same shell OR (Outer) electrons experience similar shielding OR Same number of shells OR Atomic radius decreases ✓</p>	2	<p>ALLOW There is no change in shielding But DO NOT ALLOW 'there is no shielding'</p> <p>DO NOT ALLOW electrons are at the same distance</p> <p>Examiner's Comments</p> <p>This question was well answered.</p>
		Total	2	

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1 6	i	$\text{Al}^{2+}(\text{g}) \rightarrow \text{Al}^{3+}(\text{g}) + \text{e}^{-}$ ✓	1	<p>State symbols required (ignore states on electrons)</p> <p>ALLOW $\text{Al}^{2+}(\text{g}) - \text{e}^{-} \rightarrow \text{Al}^{3+}(\text{g})$</p> <p>ALLOW e for e^{-}</p> <p>Examiner's Comments</p> <p>This was well answered. The most common error was to omit the state symbols. Only occasionally did candidates attempt to ionise Al directly to Al^{3+}.</p>
	ii	<p>All (thirteen) ionisation energies show an increase ✓</p> <p>The two largest increases are between the third and fourth</p> <p>AND</p> <p>the eleventh and twelfth ionisation energies ✓</p>	2	<p>IGNORE line if drawn</p> <p>IGNORE 0 if included</p> <p>ALLOW one mark for three lines (no crosses) showing an increase between: first and third; fourth and eleventh; twelfth and thirteenth</p> <p>AND</p> <p>Largest increases between each line</p> <p>ALLOW crosses outside grid</p> <p>Examiner's Comments</p> <p>Candidates made a good attempt at this question. For the first mark, successive ionisation energies had to increase. The most common error was to confuse the plot with that for the first ionisation energy against atomic number and so show step drops after the 3rd and 11th values.</p> <p>For the second mark the candidates had to show major increases after the 3rd and 11th values. Here the most common error was to reverse the plot and so show these after the 2nd and 10th values as clearly the candidates were thinking about removing the electrons in the pattern of the configuration (2:8:3).</p>
		Total	3	
1 7	a	Giant covalent (lattice) ✓	1	<p>ALLOW 'Giant lattice with covalent bonds'</p> <p>ALLOW 'Giant covalent bonds'</p> <p>IGNORE 'Giant molecular' or 'macromolecular'</p> <p>DO NOT ALLOW 'Covalent bonds between molecules'</p> <p>Examiner's Comments</p> <p>This question allowed many candidates to achieve the mark but only the more succinct wrote the expected response of 'giant covalent'. Candidates unfamiliar with the concept of</p>

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				<p>give the required explanation of why they lacked mobility.</p> <p>Centres are recommended to advise candidates, particularly weaker ones, that the use of bullet points often helps as a form of response that allows candidates to check that all aspects of the answer have been addressed.</p>
		Total	6	
1 8		<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> <p>Examiner's Comments</p> <p>Of the three marks on offer, the mark most commonly awarded was the one for the correct statement of the trend linked to an increase in each atom's nuclear charge. The next most popular mark was given for identifying that this increase in proton number would increase the attractive forces operating on the outer shell electrons, although a number of candidates did not get this as they rushed the answer and so just referred vaguely to increased attraction, without describing it in the required level of detail. The mark related to shielding, or the fact that each subsequent electron is being accommodated in the same shell was awarded the least of the three, with a significant number</p>

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					of candidates omitting to mention this at all. Candidates should be aware that using incorrect statements such as 'there is no shielding' could lead to correct statements being contradicted.
			Total	3	
1 9			Potassium (atoms) have one more proton (than argon)	1	
			Total	1	
2 0			<p>HgBr₂ conducts when molten but not when solid (1)</p> <p>... because ions are mobile in molten HgBr₂ (1)</p> <p>... but are fixed in a lattice in solid HgBr₂ (1)</p> <p>Mercury conducts in both the solid and molten states ... (1)</p> <p>... because delocalised electrons move (in both solid and liquid state) (1)</p>	5	<p>Explanations must be included for 2nd and 3rd marks.</p> <p>ignore references to aqueous HgBr₂</p> <p>ignore 'delocalised ions' OR 'free ions' for 'mobile ions'</p> <p>do not allow any mention of electrons moving</p> <p>do not allow any mention of + ions moving</p>
			Total	5	
2 1			<p><i>Please refer to the marking instruction point 10 for guidance on how to mark this question.</i></p> <p>Level 3 (5–6 marks) Explains trend in melting point across Period 3 in terms of structure, particles and the relative strengths of the forces AND identifies that the high melting point of arsenic suggests a giant structure</p> <p><i>There is a detailed explanation of the different melting points which is clear and logically structured.</i></p> <p>Level 2 (3–4 marks) Attempts to explain all three main points but the explanations may be incomplete or may contain only some correct statements or comparisons OR Correctly explains two of the three main points with most elements included.</p> <p><i>There is an explanation of the different melting points which is mostly clear and logically structured.</i></p> <p>Level 1 (1–2 marks) Explains the trend in melting point across Period 3</p>	6	<p>Indicative scientific points may include:</p> <p>1. Structure and bonding / forces in Period 3 Si:</p> <ul style="list-style-type: none"> • Structure: giant covalent • Forces: Covalent bonding • Particles: atoms <p>P–S–Cl:</p> <ul style="list-style-type: none"> • Structure: simple molecular • Forces: induced dipole-dipole interactions (London forces) OR van der Waals' forces • Particles: molecules <p>2. Comparison of strength in Period 3</p> <ul style="list-style-type: none"> • Covalent bonds in Si are much stronger than London forces in P–ArCl • P–ArCl: London forces greatest with larger molecules (more electrons), i.e. S₈ > P₄

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		<p>but identifies only some of the structure, forces and particles</p> <p>AND</p> <p>attempts to compare strengths but does not compare correct forces.</p> <p><i>The explanation is basic and communicated in an unstructured way. The response lacks fine detail.</i></p> <p>0 marks: No response or no response worthy of credit.</p>		<ul style="list-style-type: none"> (The stronger the force, the higher the melting point) <p>3. Period 4</p> <ul style="list-style-type: none"> Ge, Se and Br have similar trend As has much higher melting point (than P) suggesting giant (covalent) structure (Ge has lower melting point suggesting weaker covalent bonds)
		Total	6	
2 2	a	$\text{Cl(g)} \rightarrow \text{Cl}^{\text{+}}(\text{g}) + \text{e}^{-}$ Correct species, balanced AND correct state symbols	1	allow $\text{Cl(g)} - \text{e}^{-} \rightarrow \text{Cl}^{\text{+}}(\text{g})$ ignore state symbols after electron
	b	Group: 2 (1) Justification: Large increase between 2nd and 3rd ionisation energy values. (1)	2	allow alkaline earth No ecf for justification (dependent on correct group)
		Total	3	
2 3	i	$\text{Na}^{6+}(\text{g}) \rightarrow \text{Na}^{7+}(\text{g}) + \text{e}^{-}$ <i>State symbols must be included</i>	1	ALLOW $\text{Na}^{6+}(\text{g}) - \text{e}^{-} \rightarrow \text{Na}^{7+}(\text{g})$ ALLOW e for electron (i.e. charge omitted) IGNORE state with e^{-}
	ii	radius decreases AND attraction between (the remaining) electrons and nucleus increases	1	ALLOW same number of protons attract fewer electrons ALLOW electron removed from increasing + ion IGNORE: atomic / ionic before radius electron shielding / repulsion decreases effective nuclear charge increases
	iii	large difference / increase / rise shows a different / new shell large difference / increase / rise between 1st and 2nd IEs AND 9th and 10th IEs	2	ALLOW energy level for shell DO NOT ALLOW sub-shell or orbital for 1st mark ALLOW a response that clearly shows where there is a large difference / increase, e.g. 'after 1st IE; before 2nd IE'
	iv	Mg has (outer) electron in (3)s sub-shell AND Al has (outer) electron in (3)p sub-shell (3)p sub-shell has higher energy than (3)s sub-shell	2	ALLOW Mg and Al has (outer) electron in different sub-shells
		Total	6	

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