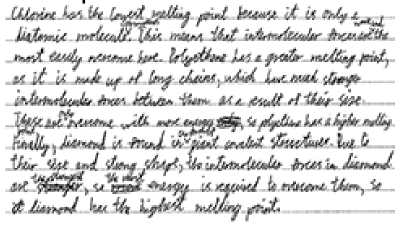
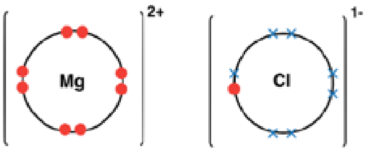
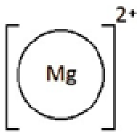
Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1	a		**Level 3 (5–6 marks)** Demonstrates detailed knowledge and understanding of the structure and bonding in all 3 structures **AND** Accurately applies knowledge and a detailed understanding to explain why diamond has the highest melting point. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Demonstrates clear knowledge and understanding of the structure and bonding in some of the structures **AND** Applies clear knowledge and understanding to explain why diamond has the highest melting point. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Demonstrates limited knowledge and understanding of the structure and bonding in some of the structures **OR** Attempts to apply knowledge and understanding to explain why diamond has the highest melting point. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 mark** *No response or no response worthy of credit.*	6 (3 x AO 1.1) (3 x AO 2.1)	**AO1.1 – Demonstrates knowledge and understanding of structures and bonding.** • covalent bonds are very strong • a lot of energy is required to break covalent bonds • intermolecular forces are weaker than covalent bonds • more energy is needed to break covalent bonds than overcome intermolecular forces • more atoms in a molecule mean more intermolecular forces • more intermolecular forces require more energy to overcome **AO2.1 – Applies knowledge and understanding of structures and bonding to diamond, Cl_2 and polyethene** • diamond only contains covalent bonds • diamond requires high energy to break covalent bonds between atoms • chlorine has intermolecular forces between the molecules • chlorine requires low energy to break intermolecular forces between molecules • polyethene has intermolecular forces between the polymer chains • covalent bonds in chlorine and polyethene are not broken on melting • polyethene has more / stronger intermolecular forces between chains than chlorine does between molecules

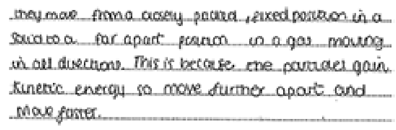
					Examiner's Comments This 6 mark Level of Response question assessed AO1 and AO2. At Level 3 (5 – 6 marks) candidates needed to demonstrate detailed knowledge and understanding of the structure and bonding in all three structures and accurately apply this knowledge to explain why diamond has the highest melting point. All candidates attempted the question which generated a wide range of responses and differentiated well between those who had a detailed level of knowledge and understanding of the three types of structure and bonding and those who had limited understanding. Most candidates correctly identified diamond as having the highest melting point and there were some excellent answers describing it as a giant covalent structure requiring large amounts of energy to break the many strong covalent bonds. However, there were a significant proportion of candidates who went on to write about diamond also having intermolecular forces. Many candidates were able to identify chlorine as a simple covalent molecule and poly(ethene) as a polymer but only those who expanded their answers to include correct reference to intermolecular forces for both achieved Level 3 marks. Many candidates ranked chlorine and poly(ethene) by the number of covalent bonds needing to be broken or wrote about poly(ethene) having crosslinks rather than intermolecular forces. Exemplar 2  Chlorine has the lowest melting point because it is only a small diatomic molecule. This means that intermolecular forces are the most easily overcome here. Polyethene has a greater melting point, as it is made up of long chains, which have much stronger intermolecular forces between them as a result of their size. These are overcome with more energy, so polythene has a higher melting point. Finally, diamond is found in a giant covalent structure. Due to their size and strong shape, the intermolecular forces in diamond are the strongest, so the most energy is required to overcome them, so diamond has the highest melting point.

					This is a Level 2, (3 mark) response. Chlorine is identified as having the lowest melting point with weak intermolecular forces, which are most easily overcome. The candidate has also identified chlorine as a simple covalent molecule. Poly(ethene) is identified as a polymer, with stronger intermolecular forces than chlorine. Although the candidate appreciates that diamond is a giant covalent structure, its melting point is then discussed in terms of its intermolecular forces. This response has demonstrated clear knowledge and understanding of the structure and bonding in some of the structures but has not applied this to explain why diamond has the highest melting point.
	b	i	Idea that ionic compounds contain ions ✓ Idea that the ions cannot move in a solid/ions are held in fixed positions ✓ Idea that when ionic compounds are dissolved, the ions are free to move ✓	3 (3 x AO 1.1)	**DO NOT ALLOW** reference to (delocalised) electrons in the incorrect context – scores 0 for the question **ALLOW** ions are free **<u>Examiner's Comments</u>** Good responses to this question described that ionic compounds contain ions. In a solid the ions are held in fixed positions whereas when ionic compounds are dissolved the ions are free to move. **Misconception** A key misconception in this question was that electrical conductivity in ionic compounds is the result of the movement of electrons rather than ions. This led to many candidates gaining no marks for this question.

		ii	 Correct magnesium ion / 2.8 **OR** one shell showing 8 electrons **OR** empty outer shell ✓  Correct chloride ion / 2.8.8 **OR** correct chloride ion showing full outer shell only ✓	2 (2 x AO 1.2)	**DO NOT ALLOW** structures with shared electrons Two correct electronic structures but no charges award one mark Two correct charges with incorrect electronic structure award one mark The ionic charges must **not** be shown in the nucleus One electronic structure must be labelled in some way to indicate which ion is which in order to score two marks. **ALLOW** answers showing the transfer of electrons providing the same electrons are not shown twice All electrons can be dots or crosses If dots and crosses are used the number of each must be correct Inner shell electrons do not need to be shown but must be correct if they are shown. **<u>Examiner's Comments</u>** Many excellent dot and cross diagrams were seen by examiners. The most common mistake was showing 6 dots and 2 crosses (or vice versa) in the outer shell of a chloride ion or omitting the charges on the ions. There were however a significant proportion of candidates who drew diagrams showing sharing of electrons/covalent bonding.
			Total	**11**	
2			**D**	1 (AO 2.1)	
			Total	**1**	
3			**D**	1 (AO 1.1)	
			Total	**1**	

4	a		(Substance) 3 ✓ **And any two from:** Polymers have low melting points / substance 3 has a low melting point✓ Polymers do not conduct electricity / substance 3 does not conduct electricity ✓ Polymers can be flexible / substance 3 is flexible ✓	3 (3 × AO 2.1)	(Substance) 1 or 2 scores 0 for the question **IGNORE** references to boiling point **ALLOW** maximum 1 mark for a correct explanation if Substance 4 is chosen **<u>Examiner's Comments</u>** Many candidates correctly identified Substance 3 and were able to give two correct reasons for their choice. Some candidates, despite correctly selecting Substance 3 as the polymer, wrote about its melting point of 120°C being high. The most common incorrect choice was Substance 1 with the reasoning being that polymers have high melting points.
	b		Idea that polymer <u>chains</u> without cross-links can slide or move over each other / **ORA** ✓ The intermolecular forces holding polymer <u>chains</u> together are weaker than cross-links / **ORA** ✓	2 (2 × AO 1.1)	**Assume unqualified answer refers to polymers without cross-links** **IGNORE** references to the polymer chains stretching **ALLOW** idea that cross-links are covalent bonds **<u>Examiner's Comments</u>** The chemistry of polymer structures was not well known by candidates, with very few candidates referencing <u>chains</u> of polymers. Most candidates just wrote about layers being able to slide over each other. Some candidates did score 1 mark for recognising that the cross-links were covalent bonds. Many talked about the layers not being attached together so the polymer could easily be stretched. Exemplar 3

					Cross links are really strong covalent bonds meaning the polymer structure is rigid. The other polymer has weak forces between chains so layers can slide over each other This response illustrates a correct, 2 mark response. The candidate has identified that cross-links are covalent bonds and realised that polymer chains without cross-links can slide over each other.
	c		(Part A) - substance 3 **AND** (Part B) – substance 1 ✓ **Explanations** Part A needs to be an insulator / Part A needs to protect from electrical shock / Part A needs to be flexible (so wire can bend) ✓ Part B needs to conduct electricity ✓	3 (3 × AO 3.2a)	**DO NOT ALLOW** named substances (e.g., plastic / metal) for MP1 **ALLOW** Part A does not conduct electricity MP2 and MP3 are independent of MP1 **Examiner's Comments** Most candidates selected the correct substances from the table and explained their answers. Some candidates selected Substance 1 for Part A and Substance 3 for Part B. Candidates should be encouraged to read questions carefully as a common error was not selecting substances from Table 21.1 but instead naming materials, e.g., rubber/plastic for Part A and copper/metal for Part B.
			Total	**8**	
5		i	**Any three from:** Particles move faster in gas / move slower in solid ✓ Particles have more energy in gas / less energy in solid ✓ Particles are further apart in gas / closer together in solid ✓ Particles are arranged more randomly in gas / arranged regularly in solid ✓ Forces between particles are weaker in gas / stronger in solid ✓	3 (3 × AO 1.1)	**Answers must be comparative** **ALLOW** atoms / molecules for particles **ALLOW** idea of particles (vibrating) in a fixed position for regular arrangement in a solid **Examiner's Comments** Many candidates, even higher attaining candidates, did not gain marks on this question usually

					because they did not give direct comparisons, choosing instead to make general statements, e.g. stating that particles are arranged regularly in a solid but then not stating their arrangement in a gas. Less successful responses saw candidates write about bulk properties of solids and gases such as referring to gas particles being able to take the shape of the container. Exemplar 1  they move from a closely packed, fixed position in a solid to a far apart position in a gas moving in all directions. This is because the particles gain kinetic energy to move further apart and move faster. This exemplar illustrates a clear response to this question in which the candidate has described what happens to the movement and arrangement of the particles when a solid changes to a gas. The answer is comparative, as required by the question.
		ii	**Temperature and pressure:** 1.0 MPa and a temperature value between −55 and −41 °C✓ **Reason:** Idea that the temperature selected is between the melting and boiling point (so will be a liquid) / Idea that lower than −56°C CO_2 is a solid and above −40°C CO_2 is a gas ✓ 1.0 MPa has a melting and boiling point (whereas 0.1 MPa does not) / 1.0 MPa does not have a sublimation point ✓	3 (3 × AO 3.2b)	MP dependent on correct temperature **ALLOW ORA** for 0.1MPa **ALLOW** idea that 1.0 MPa is the pressure when CO_2 can be a liquid (between −55 and −41 °C) **<u>Examiner's Comments</u>** Most candidates correctly selected a temperature and pressure at which carbon dioxide is a liquid, although a common misconception was that carbon dioxide is a liquid at its melting point of -56°C. Fewer candidates scored the marks for the explanation with many attempting to wrap up the

<table>
<tr><td></td><td></td><td></td><td></td><td></td><td>other 2 marks in a single sentence, hence not answering either condition in the detail required. Very few scored the mark for explanation of their choice of pressure.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>6</td><td></td></tr>
<tr><td>6</td><td></td><td></td><td>D</td><td>1
(AO 1.1)</td><td></td></tr>
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(AO 1.1)</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>1</td><td></td></tr>
<tr><td>8</td><td></td><td></td><td>D</td><td>1
(AO 2.1)</td><td><u>Examiner's Comments</u>

Misconception

B was a common misconception in this question, possibly because candidates saw 10^{-4} in relation to the human hair and made a link to an answer with four zeros.

OCR support

The Mathematical Skills Handbook provides both teachers and students support on the use of mathematical skills in GCSE Science, including the use of standard form. It can also be used in conjunction with the Mathematical skills check in to assess student skills.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>1</td><td></td></tr>
<tr><td>9</td><td></td><td>i</td><td><table><tr><td>Name</td><td>Melting point (°C)</td><td>Boiling point (°C)</td><td>State at room temperature</td></tr><tr><td>Phosphorus trichloride</td><td>- 94</td><td>76</td><td>Liquid</td></tr><tr><td>Phosphorus pentachloride</td><td>161</td><td>167</td><td>Solid</td></tr><tr><td>Phosphorus trifluoride</td><td>- 152</td><td>-102</td><td>Gas</td></tr></table>✓ ✓</td><td>2(2 × 2.1)</td><td>All 3 correct = 2 marks

1 or 2 correct = 1 mark

<u>Examiner's Comments</u>

Most candidates correctly interpreted the melting and boiling point data to determine that state at room</td></tr>
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					temperature of the three phosphorus compounds.
		ii	Phosphorus trifluoride ✓ **Any two from**: Idea that the weakest intermolecular forces require the least energy to break / the least energy to separate the molecules ✓ Idea that less energy to break the forces means a lower melting point and/or boiling point ✓ Idea that the weakest intermolecular forces mean a lower melting and/or boiling point ✓	3(1 × 2.1)(2 × 1.1)	**ALLOW** phosphorus trifluoride circled in the table **DO NOT ALLOW** references to covalent bonds or intermolecular forces between atoms **ALLOW** idea that phosphorus trifluoride is a gas (at room temperature) **Examiner's Comments** Most candidates correctly identified phosphorus trifluoride as the compound with the weakest intermolecular forces and realised that the evidence is the low melting point and boiling point. More successful responses then described that the weakest intermolecular forces require the least energy to break and that less energy to break the forces means a lower melting and/or boiling point. **Misconception** A common misconception was to refer to the energy needed to break the bonds rather than the intermolecular forces. **OCR support** Extra support with terminology and challenging common misconceptions with candidates can be found in our Multiple choice topic quizzes. Instructions for setting these self-marking assessments can be found in the Digital MCQ quiz – Instructions resource.
		iii	Idea that giant covalent compounds have high melting points / high boiling points ✓	2(2 × 3.1b)	**ALLOW** idea that giant covalent compounds have many strong covalent bonds (which need to be broken)

			Phosphorus trichloride does not have a high melting point / boiling point **or** Phosphorus trichloride has a low melting point / boiling point ✓		**DO NOT ALLOW** references to breaking intermolecular forces in giant covalent compounds **ALLOW** phosphorus trichloride is a liquid (at room temperature) **DO NOT ALLOW** references to strong intermolecular forces OR strong covalent bonds between molecules **<u>Examiner's Comments</u>** This question was well answered with many candidates gaining 2 marks. Candidates needed to discuss both phosphorus trichloride and giant covalent compounds to gain both marks. **Assessment for learning** Candidates should be encouraged to use correct terminology. Examiners frequently saw references to strong intermolecular forces in giant covalent compounds.
			Total	**7**	
10		i	B and D ✓	1(AO2.1)	BOTH required for the mark **<u>Examiner's Comments</u>** Many candidates correctly identified B and D as nanoparticles. The most common incorrect answer was the combination of A and C. This was possibly because candidates had not learnt the definition of a nanoparticle and simply selected the two values which look similar because they were both values × 10^{-7}.
		ii	B ✓ (B is) a nanoparticle so it has a large surface area to volume ratio ✓	3(3 ×AO3.2a)	**No marks awarded if B not given** **ALLOW** B (is the smallest particle so) has the <u>largest</u> surface area to volume ratio

			Idea that (B is) cheap and has a high purity ✓		**Examiner's Comments** Good responses correctly identified particle B, stating that B has the largest surface area to volume ratio, is cheap and has a high purity. Less successful candidates did not use the term nanoparticles in their explanation or did not refer to B having the larg**est** surface area to volume ratio. Candidates that didn't choose B usually chose A or C.
			Total	**4**	
11			B ✓	1(AO1.1)	
			Total	**1**	
12			D ✓	1(AO1.1)	
			Total	**1**	