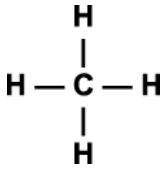
1. The surface of the planet Neptune is covered with clouds of dense material. The clouds contain substances in solid, liquid and gas states.

One of the compounds in the clouds is methane.



The table shows the melting point and boiling point of methane.

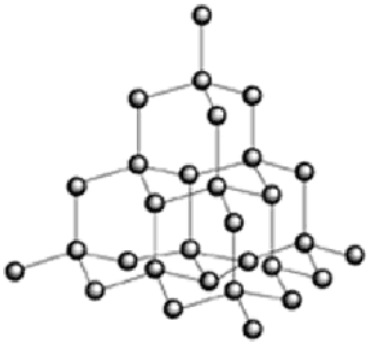
melting point (°C)	–182.5
boiling point (°C)	–161.5

What is the bonding and structure of methane at room temperature?

[2]

2(a). Diamond and silicon dioxide have similar properties.

Diamond



Silicon dioxide

Describe **two** similarities and **one** difference between the structures of diamond and silicon dioxide.

Similarity 1 _____

_____

Similarity 2 _____

_____

Difference _____

_____ [3]

(b). The structure of graphite can be used to explain its properties.

Draw straight lines to connect each **property** to the correct **explanation**.

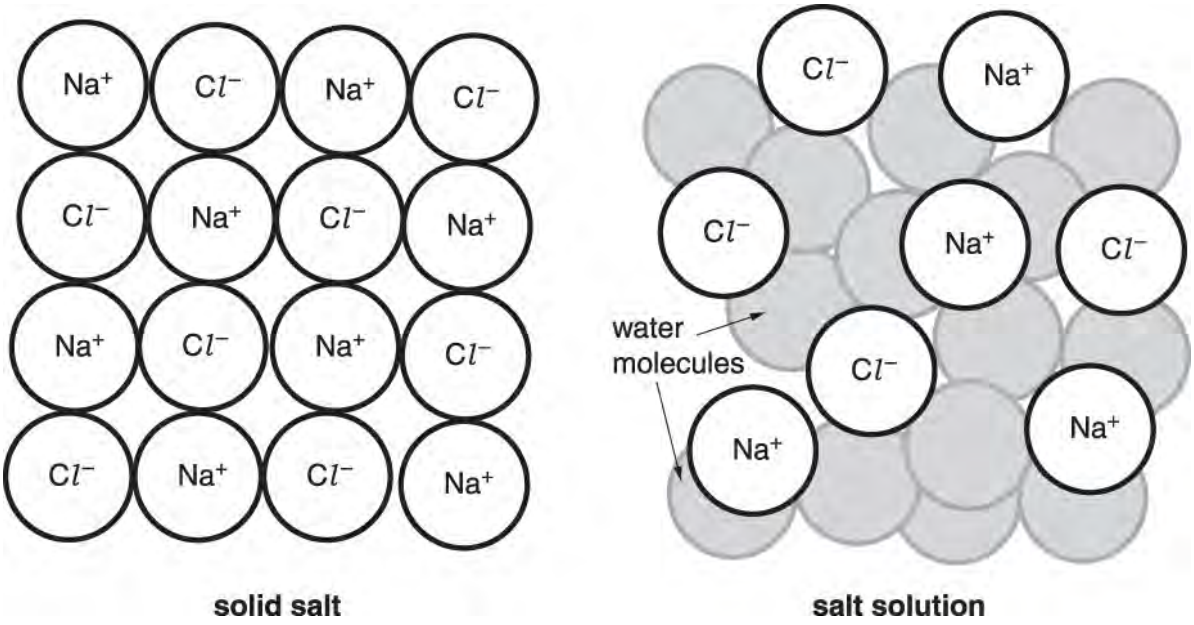
Property	Explanation
Conducts electricity.	Structure contains layers
High melting point.	Charged particles in structure can move.
Flaky and soft.	Strong giant structure.

[2]

3. Sodium chloride is the main compound in common salt.

Solid salt has very different properties compared to salt dissolved in water.

These diagrams show the structures of solid salt and salt dissolved in water (salt solution).



solid salt **salt solution**

State and explain how the properties and structure of solid salt change when it dissolves in water, using ideas from the diagrams to support your answer.

The quality of written communication will be assessed in your answer.

[6]

4. A company decides to make fence posts from a plastic.

The company decides that the plastic they have is too flexible and has too large a range of flexibility.

Technicians test small pieces of three other plastics.

All the samples used have exactly the same size.

They measure how far each sample bends under the same conditions.

Their results are shown in the table.

	Distance sample bends in mm						
Sample number	1	2	3	4	5	6	mean
Plastic A	35	33	35	34	34	33	34
Plastic B	2	4	3	2	4	3	3
Plastic C	14	13	14	15	13	15	14

Use your knowledge of the structure of polymers to suggest why these three plastics gave different results in the tests.

The quality of written communication will be assessed in your answer.

---

[6]

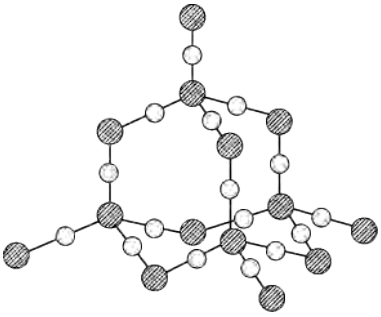
5. Aluminium is a metal but aluminium oxide is an ionic compound.

Aluminium metal and molten aluminium oxide conduct electricity in different ways.
Describe and explain the differences.

---

[3]

6. Carbon dioxide and silicon dioxide are compounds that occur naturally on Earth.
The table shows some information about the two compounds.

	carbon dioxide	silicon dioxide
formula	CO_2	SiO_2
structure		
melting point in °C	?78	1710
boiling point in °C	?57	2230
electrical conductivity	does not conduct	does not conduct

Use ideas about structure and bonding to explain the similarities and differences between the properties of carbon dioxide and silicon dioxide.

The quality of written communication will be assessed in your answer.

[6]

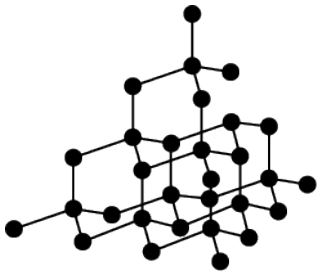
7. Sam does some research about the properties of diamond and graphite.

The table shows what he finds out.

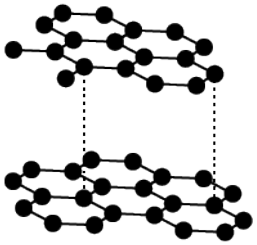
	Diamond	Graphite
Melting point in °C	3560	3650
Boiling point in °C	4830	4830
Solubility in water	insoluble	insoluble
Electrical conductivity	does not conduct	good conductor
Hardness	very hard	soft, flakes easily

Sam notices that some of the properties are similar and some are different.

He finds diagrams that show the structures of diamond and graphite.



diamond



graphite

The table shows some similarities and differences in the **properties** of diamond and graphite.

Use ideas about their **structures** to explain these similarities and differences.

The quality of written communication will be assessed in your answer.

---

[6]

8. One reason why copper is a useful material is because it is malleable.

Which statement explains why copper is malleable?

Put a tick (?) in the box next to the correct answer.

Copper is a good electrical conductor. ☐

Particles in copper can slide over each other. ☐

Bonds in the metal structure are strong. ☐

Metal particles are arranged in a regular crystal. ☐

[1]

9. The polymer used to make tennis balls has been modified to improve the performance in competitions. It reacts with sulfur to form cross-links. Plasticisers are added.

How do these modifications affect the properties of the polymer?

Complete the table. Choose from these words.

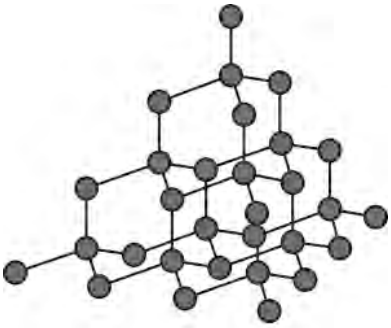
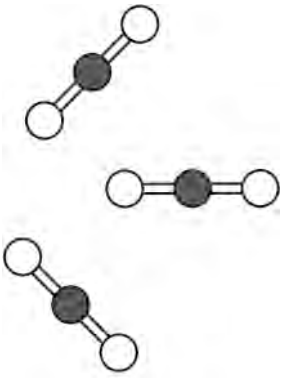
decreases
increases
stays the same

	Hardness	Melting point	Stiffness
Cross-linking			
Adding a plasticiser			

[2]

10(a) The table shows some information about diamond and carbon dioxide.

.

	Diamond	Carbon dioxide
Diagram of structure		
Type of structure	giant	simple
State at room temperature and pressure	solid	gas

The structures of diamond and carbon dioxide are different, but the bonds are similar.

Write down some similarities between the bonds in diamond and carbon dioxide.

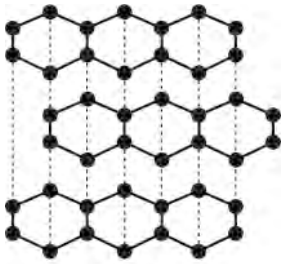
---[2]

(b). Explain why diamond is a solid and carbon dioxide is a gas at room temperature and pressure.

---[3]

(c). Diamond is an allotrope of carbon.

Graphite is another allotrope of carbon.



Graphite

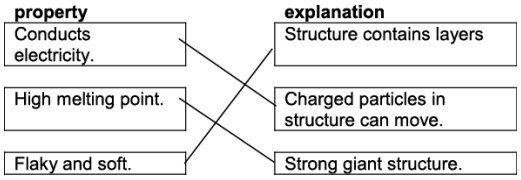
Carbon dioxide is not an allotrope of carbon.

Explain why diamond and graphite are allotropes but carbon dioxide is not.

---

[2]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1			covalent ✓ simple structure / single molecules ✓	2	
			Total	2	
2	a		similarities: • both covalently bonded ✓ • both giant structures ✓ one difference from: • silicon dioxide contains two elements but diamond only contains one (carbon) ✓ • all carbon atoms form four bonds in diamond but only silicon atoms form four bonds in silicon dioxide✓	3	IGNORE melting points / boiling points / electrical conductivity ALLOW both are giant covalent lattices / structures for 2 marks
	b			2	All three correct = (2) One or two correct = (1)
			Total	5	
3			[Level 3] Makes two statements about properties **and** two about structure, including one link between structure and a property. Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) [Level 2] Makes two statements about properties and/or structure OR Gives one link between structure and a property. Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) [Level 1]	6	This question is targeted at grades up to A Indicative scientific points may include: Properties • Solid has high MP and/or BP / solution MP below room temperature/low/lower • Solid does not change shape / is a fixed shape / solution can change shape/be poured • Solid does not conduct electricity / solution conducts electricity Structure • **Both** have ions/ionic bonding • Solid: arrangement of ions regular / Solution: not regular structure / solution has random arrangement of ions • Solid: is crystalline / forms a 3-D structure / forms a lattice

Question			Answer/Indicative content	Marks	Guidance
			Makes a correct statement about a property or structure for solid or solution. Quality of written communication impedes communication of the science at this level. (1 – 2 marks) [Level 0] Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)		**Structure linked** to properties…. • (solid) strong bonds/attraction (linked to MP/BP) • (solid) ions can't move (linked to no conduction or shape) / (solution) ions in solution can move (linked to changes shape / conducts) **Allow** 'free ions' • (solution) forces/attraction between ions broken in solution (linked to changes shape / conducts) **At Level 1** only allow 1 mark for 'behaves like a liquid' **Consider QWC to be impeded** if incorrect terms are used e.g. molecules/atoms (for ions) or covalent (rather than ionic) or intermolecular forces **Do not allow** electrons move during conduction **Use the L1, L2, L3 annotations in RM Assessor; do not use ticks.** **Examiner's Comments** This level of response question was poorly answered, with about a third of candidates gaining no marks. The candidates were provided with diagrams of the structure of sodium chloride both as a solid and in solution. It was expected that they describe the changes on the diagrams and link these to the properties of each. In common with other questions, the logical links between structure and properties were not usually well expressed. In addition, most candidates made fundamental chemical errors, for example discussing covalent bonds, molecules, moving electrons or intermolecular forces. Many candidates made no mention of ions in their answers. Better answers discussed melting and/or boiling points and conductivity in terms of structure. About 10% of candidates gained a mark in the level 3 marking band.
			Total	**6**	

Question			Answer/Indicative content	Marks	Guidance
4			**Level 3 (5–6 marks)** Answer gives detailed explanation of different flexibility related to three or four relevant factors from chain length, plasticizers, cross-linking and crystallinity. Quality of the written communication does not impede communication of the science at this level. **Level 2 (3–4 marks)** Answer gives some description of different flexibility: related to two relevant factors from chain length, plasticizers, cross-linking and crystallinity. Quality of written communication partially impedes communication of the science at this level. **Level 1 (1–2 marks)** Answer recognises difference in flexibility of different polymers and relates to one relevant factor from chain length, plasticizers, cross-linking and crystallinity. Quality of written communication does impede communication of science at this level. **Level 0 (0 marks)** Insufficient or irrelevant science. Answer not worthy of credit.	6	**This question is targeted at grades up to A*** **Indicative scientific points may include:** • order of flexibility A, C, B (most to least) • the polymers have different flexibility • flexibility is affected by plasticizer / chain length / crosslinking / crystallinity • flexibility depends on size of force / attraction between polymer chains • more force / attraction between polymer chains less flexibility • force / attraction between chains lowered by addition of plasticizer • more plasticizer more flexible • force / attraction between chains depends on length of chains • longer chains less flexible • force / attraction between chains depends on crosslinking • more cross linking less flexible • force / attraction between chains depends on crystallinity • more crystalline less flexible **ignore** unqualified comparison of polymers in table **Use the L1, L2, L3 annotations in Scoris; do not use ticks.** **Examiner's Comments** Many candidates put the three polymers in correct order according to flexibility. Most of these quoted a factor thataffects polymer properties, eg plasticizer, and then made some attempt to explain how. Few could go beyond this. More able candidates suggested and tried to explain two or three factors, but only a few of the most able used ideas of forces between polymer chains in their answers. Some weaker candidates put the polymers in the wrong order of flexibility and many became confused between bonds in monomers and in polymers.

Question			Answer/Indicative content	Marks	Guidance
			Total	6	
5			any 3 from: idea that in the metal / Al conduction due to electrons ; idea that in molten Al_2O_3 conduction due to ions ; both ions and electrons move ; idea that ionic compounds are broken down when they conduct / changes happen at the electrodes / chemical change / oxygen is made / metals are not changed when they conduct	3	**Allow** alternative wording for 'move'. **Examiner's Comments** Again, this part question was very difficult for candidates with only about a third gaining any marks. Some knew that electrical conductivity in metals is linked to the electrons, but few linked conduction in aluminium oxide to moving electrons.
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
6			**Level 3 (5–6 marks)** Makes statements about a similarity and a difference and links both properties to structure or bonding. Quality of written communication does not impede communication of the science at this level. **Level 2 (3–4 marks)** Makes one clear link between a property and structure or bonding for a compound OR makes statements about a similarity and a difference in properties and makes a correct statement about structure or bonding (not necessarily clearly linked to a property). Quality of written communication partly impedes communication of the science at this level. **Level 1 (1–2 marks)** Makes statements about a similarity and a difference in properties OR makes a correct statement about structure or bonding for a compound. Answer may only contain information given in the table. Quality of written communication impedes communication of the science at this level. **Level 0 (0 marks)** Insufficient or irrelevant science. Answer not worthy of credit.	6	This question is targeted at grades up to A* Indicative scientific points may include: Similarities and differences in properties. • both have similar formulae / two oxygen atoms • neither conduct electricity. • carbon dioxide has a low MPT / BPT and silicon dioxide has a high MPT / BPT • carbon dioxide has a lower MPT / BPT / less heat or energy to melt / boil ora • carbon dioxide is a gas and silicon dioxide is a solid Ignore 'MPT and / or BPT are different' Structure and bonding • bonding (in both) is covalent / no electrons or ions available to conduct electricity • carbon dioxide has a simple structure / carbon dioxide molecule contains a small number of atoms / is a small molecule • silicon dioxide has a giant structure / structure of silicon dioxide contains many atoms bonded together / 3D / lattice • (all) atoms in silicon dioxide held together by strong bonds / bonds require large amounts of energy / heat to break • weak forces between molecules in carbon dioxide / forces do not require large amounts of energy / heat to break • carbon dioxide has double bonds • silicon dioxide had only single bonds • each silicon atom is bonded to four oxygen atoms in silicon dioxide / is a tetrahedral structure • each carbon atom is bonded to two oxygen atoms in carbon dioxide Use the L1, L2, L3 annotations in Scoris; do not use ticks.

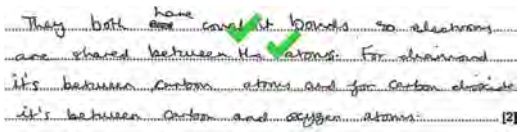
Question			Answer/Indicative content	Marks	Guidance
					Examiner's Comments This six-mark extended-writing question provided candidates with data about the properties of carbon dioxide and silicon dioxide. The task demanded that the candidates compare the similarities and differences between the compounds. A relatively common barrier to scoring was that some candidates discussed either the similarities or the differences between the compounds, but did not address both. It is important that candidates check that they have accessed all parts of the task before moving on. The question information did not give any information about structure. A correct discussion of structural similarities and differences was demanded at Level 2 or above. Most candidates made correct comments about structure, sometimes, but not always, clearly linked to the properties, but often the exposition was confused with incorrect points expressed alongside correct explanations. Common misconceptions included that the bonding in silicon dioxide is ionic and that the bonds between atoms in carbon dioxide are weak.
			Total	6	

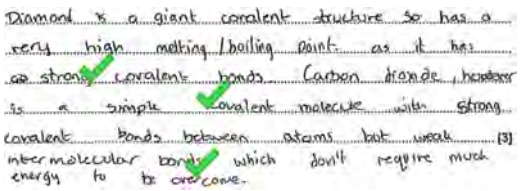
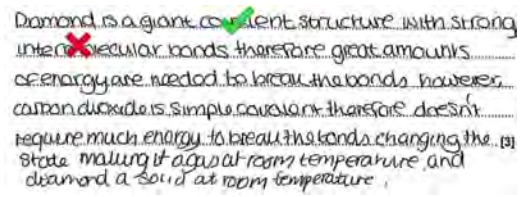
Question			Answer/Indicative content	Marks	Guidance
7			**Level 3 (5–6 marks)** Links a similar and a different property to both structures. Quality of written communication does not impede communication of the science at this level. **Level 2 (3–4 marks)** Links a property to the structure for diamond or graphite. Quality of written communication partially impedes communication of the science at this level. **Level 1 (1–2 marks)** Compares **properties** and / or makes points about **structures**. Quality of written communication impedes communication of the science at this level. **Level 0 (0 marks)** Insufficient or irrelevant science. Answer not worthy of credit.	6	**This question is targeted at grades up to C** **Relevant points include:** **Properties** (look for comparison) • both have high / similar melting points • both have high / similar boiling points • both are insoluble in water • graphite conducts but diamond does not • diamond is harder (than graphite) (needs comparison) • Graphite flakes / marks paper' and diamond does not (needs comparison) • Appearance of diamond and graphite is different **Structures** • Both have strong bonds • Both have covalent bonds • Both have giant structure / lattice structure / lots of bonds / macromolecule • Both contain carbon atoms • graphite has layers • diamond has four bonds / tetrahedral • graphite has three bonds • graphite has delocalised electrons (**accept** 'free' electrons) • graphite has weak bonds / intermolecular forces between layers • graphite has rings / hexagonal structure **Similar properties linked to structure** • (both) high melting / boiling point because strong bonds / giant structure • (both) insoluble because covalently bonded **Different properties linked to structure** • (diamond) hard because strong bonds / each atom bonded to 4 others and (graphite) Soft / flakes because of layers / weak bonds between layers

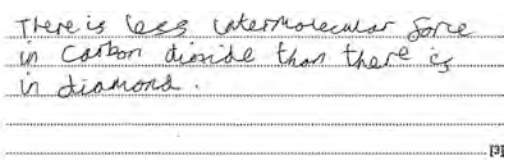
Question			Answer/Indicative content	Marks	Guidance
					• (diamond) does not conduct because electrons cannot move and (graphite) conducts because electrons move / are 'free' / delocalised Use the L1, L2, L3 annotations in Scoris; do not use ticks. Examiner's Comments This six mark question was shared with the foundation tier paper; it was designed to differentiate candidates working at standard demand (grades C and D). A full range of achievement was seen. Again, some information was presented in table and diagram form to support candidates in answering the question. The question asked the candidates to 'use ideas about structure to explain the similarities and differences in the properties of diamond and graphite'. About 40% of candidates achieved Level 3 by accessing this task very well. Common reasons why Level 3 did not score included making incorrect statements about structures (for example conduction in graphite linked to moving ions, or the bonding in both being ionic), or for only discussing differences between the structures and omitting any discussion of similarities. Some candidates quoted incorrectly from the table, for example referring to diamond as 'strong' rather than 'hard' and graphite as 'weak' rather than 'soft'.
			Total	6	
8			particles in copper can slide over each other	1	Examiner's Comments Almost two thirds of candidates knew that copper particles slide over one another.
			Total	1	

Question			Answer/Indicative content	Marks	Guidance
9			increases / increases / increases (1) decreases / decreases / decreases (1)	2	each complete row = 1 mark Examiner's Comments Understanding of how modifications affect the properties of polymers was weak with few candidates gaining marks. Weak candidates guessed answers randomly and some good candidates lacked the confidence to go with one statement per line: correct answers were crossed out so that an incorrect mix of statements was given.
			Total	2	

Question			Answer/Indicative content	Marks	Guidance
10	a		Similarities: both contain covalent bonds ✓ (which form from) shared electrons / both have 4 bonds around the carbon atom ✓	2 (AO 2× 1.1)	DO NOT ALLOW MP1 for <u>both</u> have single covalent bonds/<u>both</u> have double covalent bonds NOT intermolecular forces IGNORE structure <u>Examiner's Comments</u> This whole question is a typical 'depth' question. Through the question, candidates are asked to compare and contrast diamond and carbon dioxide. Question (a) is about the bonding; (b) is about the state of each (linked to ideas about structure) and (c) is about allotropes. Candidates who scored high marks in this question read each question carefully, considered what it was asking about and answered clearly. Candidates who did less well typically wrote long responses which sometimes included contradictions (for example confusion between bonds and intermolecular forces) and did not clearly address the question (for example by discussing structure or state when asked about bonding). In part (a) the mark scheme allowed a range of similarities. A relatively common shortcoming was to only give one. Some candidates stated that the bonds were 'all single' or 'all double' in both, which is incorrect. Exemplar 3 Both diamond and carbon dioxide have covalent bonds which means they have non-metallic atoms. They both have bonds between carbon atoms [2] This answer is succinct and clear. It answers the question by stating that both bonds are covalent. 1 mark. As only one similarity is stated, a second mark cannot be given.

Question			Answer/Indicative content	Marks	Guidance
					Exemplar 4  They both ~~are~~ have covalent bonds so electrons are shared between the atoms. For diamond it's between carbon atoms and for carbon dioxide it's between carbon and oxygen atoms. [2] Another clear answer. Notice in this case the candidate has stated two similarities (bonds are covalent and electrons are shared) leading to two marks.
	b		diamond has a giant structure/every atom is bonded to 4 others / carbon dioxide contains simple molecules/small molecules/simple covalent structure ✓ (all) bonds in diamond are strong / need a lot of energy/high temperatures to break bonds ✓ (intermolecular) forces/<u>intermolecular</u> bonds between carbon dioxide molecules are weak/do not need a lot of energy to break ✓	3 (AO 3× 1.1)	DO NOT ALLOW ionic (this statement contradicts MP1) DO NOT ALLOW intermolecular forces linked to diamond (this statement contradicts MP2) DO NOT ALLOW bonds in carbon dioxide are weak (this statement contradicts MP3) <u>Examiner's Comments</u> There are three marks to be earned. Firstly, candidates need to identify that diamond has a giant structure and that carbon dioxide has a simple structure. Either of these, clearly stated earns marking point 1 on the mark scheme. The next important point is that when diamond changes state bonds must break (and these are very strong) whereas when carbon dioxide changes state only (weaker) intermolecular forces break (the bonds do not). These last two ideas proved challenging for all but the most able candidates. There was a great deal of confusion between bonds and intermolecular forces across most of the answers seen. Misconception A very common misconception is that 'intermolecular forces' is a term that can be used interchangeably with 'bonds'. It was common

Question	Answer/Indicative content	Marks	Guidance
			to see 'strong intermolecular forces in diamond'. It was also common to see candidates talking about 'breaking bonds' in carbon dioxide (without any mention of intermolecular). The explanation for the change of state in giant and simple covalent structures is not well understood. Exemplar 5  Diamond is a giant covalent structure so has a very high melting / boiling point as it has as strong covalent bonds. Carbon dioxide, however is a simple covalent molecule with strong covalent bonds between atoms but weak intermolecular bonds which don't require much energy to be overcome. [3] This is another very good example of a fully scoring answer.3 marks. Notice how clear and unambiguously the candidate has described the structure of each and correctly explained its effect on the state of each. Exemplar 6  Diamond is a giant covalent structure with strong intermolecular bonds therefore great amounts of energy are needed to break the bonds however carbon dioxide is simple covalent therefore doesn't require much energy to break the bonds changing the state making it a gas at room temperature and diamond a solid at room temperature. [3] This candidate has stated correctly that diamond has a giant covalent structure and that carbon dioxide has simple structure (one mark). However notice the contradiction; the candidate has gone on to confuse bonding with intermolecular forces in diamond. Intermolecular forces have not been mentioned at all in relation to carbon dioxide.

Question			Answer/Indicative content	Marks	Guidance
					Exemplar 7  This candidate earned no marks. The misconceptions discussed above are evident in this response. The answer states that intermolecular forces are broken in both.
	c		diamond and graphite are both elements / both contain <u>only</u> carbon / are pure carbon / contain all the same atoms ✓ carbon dioxide is a compound / contains (carbon and) oxygen / contains different atoms ✓	2 (AO 2× 1.1)	<u>Examiner's Comments</u> Almost all candidates identified the pertinent point that carbon dioxide is a compound of carbon and oxygen. The question also asks why diamond and graphite are allotropes. Some missed out this part and so did not state that they contain atoms which are all of the same element (carbon).
			Total	7	