Questions

Q1.

The table shows some information about a selection of elements and compounds.

	Graphene	Graphite	Diamond	Magnesium oxide	Potassium bromide	Iron
Melting temperature / K	> 4000	3950	3820	3125	1007	1808
Density / g cm^{-3}	not measured	2.2 to 2.8	3.51	3.58	2.75	7.86
Compressive strength / GPa	not measured	2.3 and 15.3	443	152	15	170

The compressive strength is a measure of the energy required to break some of the bonds within a substance.

Deduce possible reasons why there are two widely different values for the compressive strength of graphite.
Both the values (2.3 and 15.3 GPa) are valid experimental results.

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(Total for question = 2 marks)

Q2.

The table shows some information about a selection of elements and compounds.

	Graphene	Graphite	Diamond	Magnesium oxide	Potassium bromide	Iron
Melting temperature / K	> 4000	3950	3820	3125	1007	1808
Density / g cm^{-3}	not measured	2.2 to 2.8	3.51	3.58	2.75	7.86
Compressive strength / GPa	not measured	2.3 and 15.3	443	152	15	170

Deduce **two** possible reasons why the density of iron (7.86 g cm^{-3}) is much greater than the density of graphite (2.2 to 2.8 g cm^{-3}).

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(Total for question = 2 marks)

Q3.

This question is about crystalline solids.

Graphite is also a crystalline solid at room temperature.
Unlike diamond, graphite conducts electricity.

Describe the key feature of the bonding of the carbon atoms in graphite that results in it being an electrical conductor.

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(Total for question = 2 marks)

Q4.

The table shows some information about a selection of elements and compounds.

	Graphene	Graphite	Diamond	Magnesium oxide	Potassium bromide	Iron
Melting temperature / K	> 4000	3950	3820	3125	1007	1808
Density / g cm^{-3}	not measured	2.2 to 2.8	3.51	3.58	2.75	7.86
Compressive strength / GPa	not measured	2.3 and 15.3	443	152	15	170

Graphene, graphite and diamond are all forms of solid carbon.
Explain, in terms of structure and bonding, why graphene and graphite are good electrical conductors but diamond is a poor electrical conductor.

You may include labelled diagrams in your answer.

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(Total for question = 6 marks)

Q5.

The table shows some information about the structure and bonding in four substances.

Substance	Structure	Bonding	Melting temperature / K
silicon(IV) oxide	giant	covalent	1883
potassium chloride			1043
iron		metallic	1808
iodine		covalent	387

Explain why the melting temperature of silicon(IV) oxide is much higher than that of iodine, even though the bonding in both is covalent.

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(Total for question = 3 marks)

Q6.

This question is about atomic structure and the Periodic Table.

The melting temperatures of two elements in Period 3 are given in the table.

Element	silicon	chlorine
Melting temperature / K	1683	172

Explain, in terms of the structure and bonding of each element, the difference between these values.

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(Total for question = 3 marks)

Q7.

This question is about crystalline solids.

Iodine and diamond are crystalline solids at room temperature.

Explain why diamond has a much higher melting temperature than iodine.

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(Total for question = 5 marks)

Mark Scheme

Q1.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An answer that makes reference to the following points: • Lower value relates to (weak) London / van der Waals' forces (between the layers) **(1)** • Higher value refers to (strong) covalent (C–C) bonds (within each layer) **(1)**	Allow 'pi-bonds (between layers)' Allow "(weak) intermolecular forces (between layers)" Allow (C–C) 'sigma bonds'	**(2)**

Q2.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An answer that makes reference to the following points: • iron atoms have greater mass than carbon atoms **(1)** • iron atoms pack closer than carbon atoms (in graphite) **(1)**	Allow weigh more / higher *Ar* / greater molar mass Allow idea of more space (between the layers of atoms) in graphite Award (0) overall if mention of iron molecules or graphite molecules	**(2)**

Q3.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following points: • one electron free to move / delocalised (within the layer to carry the current) (1) • each carbon is (covalently) bonded to three other carbons or the carbon atoms are arranged in layers which allow the flow of electricity through them (1)	Mark independently Marks could be scored in a diagram Ignore just 'free electrons' Allow uses three (outer shell) electrons in bonding	(2)

Q4.

Question Number	Acceptable Answer	Additional Guidance	Mark
	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content.	Guidance on how the mark scheme should be applied: The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points that is partially structured with some linkages and lines of reasoning, scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning). If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).	(6)

Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points
6	4
5-4	3
3-2	2
1	1
0	0

The following table shows how the marks should be awarded for structure and lines of reasoning.

	Number of marks awarded for structure and sustained lines of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout.	2
Answer is partially structured with some linkages and lines of reasoning.	1
Answer has no linkages between points and is unstructured.	0

In general it would be expected that 5 or 6 indicative points would get 2 reasoning marks, and 3 or 4 indicative points would get 1 mark for reasoning, and 0, 1 or 2 indicative points would score zero marks for reasoning.

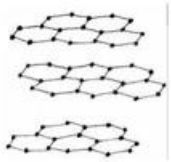
If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s).
Comment: Look for the indicative marking points first, then consider the mark for the structure of the answer and sustained line of reasoning.

Indicative content:

- **IP1** graphene has a **single** layer / **single** sheet (of hexagons / rings)
- **IP2** graphene has delocalised electrons / electrons which are mobile
- **IP3** graphite has layers / sheets / planes **and** each carbon bonded to **three** others
- **IP4** graphite has delocalised electrons / electrons which are mobile (between the layers)
- **IP5** diamond has each carbon bonded to four other carbons / diamond has a tetrahedral arrangement (around each C atom) / tetrahedral structure
- **IP6** diamond's C atoms have all their outer / valence / fourth electrons involved in bonding **OR** diamond has no delocalised electrons / all electrons are localised

Allow annotated diagrams for all marking points

graphite



diamond

graphene

Allow 'free' for delocalised or mobile

Q5.

Question Number	Acceptable Answer		Additional Guidance	Mark
	An explanation that makes reference to the following points:			(3)
	• silicon(IV) oxide/ silicon dioxide (is a giant structure therefore) contains many (strong covalent) bonds	(1)	Allow silicon oxide	
	• iodine – (only) weak intermolecular / London forces/bonds must be broken	(1)	Do not award covalent bonds are broken Accept dispersion force / instantaneous dipole-induced dipole / van der Waals	
	• more **energy** is required to break the stronger bonds in silicon(IV) oxide/ silicon dioxide (hence higher melting temperature)	(1)	Allow reverse argument M3 can be awarded even if M2 is incorrect	

Q6.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following points: • silicon – giant atomic / giant covalent / giant molecular / macromolecular **and** contains covalent bonds **(1)** • chlorine - (simple) molecular / molecules / diatomic / Cl_2 **and** contains London forces **(1)** • (covalent) bonds in silicon are stronger than London forces/ intermolecular forces in chlorine **or** covalent bonds take more energy to break than London forces / intermolecular forces **(1)**	Do not allow just 'silicon is a covalent molecule' Do not allow reference to ions or metallic bonding Allow dispersion forces / van der Waals' / attractions between temporary dipole and induced dipole/ attractions between instantaneous dipole (- induced dipole) for London forces Do not award covalent bonds being broken in chlorine Ignore silicone for silicon as correct spelling is given in the paper	**(3)**

Q7.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following points: • iodine is (simple) molecular (1) • diamond is a giant (covalent / lattice) structure (with 4 covalent bonds per carbon atom) (1) • iodine molecules are held together by weak London forces / dispersion forces / van der Waal's forces / instantaneous induced dipole-dipole attractions (1) • carbon atoms in diamond are held together by (strong) covalent bonds (1) • strong covalent bonds require more energy to break than intermolecular forces	Allow iodine is made up of (I_2) molecules Do not award diamond molecules Allow weak intermolecular forces Do not award strong intermolecular forces Award converse argument for less energy need to break intermolecular forces Single sentences may contain more than one marking point. For example 'iodine molecules are held together by weak intermolecular forces' scores (2)	(5)