Questions

Q1.

The nitrates of lithium, rubidium and strontium are all white solids. The compounds are held together by ionic bonds.

State the meaning of the term 'ionic bond'.

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(Total for question = 2 marks)

Q2.

This question is about catalytic converters.

Catalytic converters contain metals such as platinum.

Describe the bonding in platinum.
You may include a diagram in your answer.

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(Total for question = 2 marks)

Q3.

This question is about transition metals and transition metal complexes.

Describe the bonding in the element chromium and use your answer to justify why it has such a high melting temperature.

You may find it helpful to draw a labelled diagram.

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(Total for question = 4 marks)

Q4.

This question is about ionic bonding.

The strength of ionic bonding in different compounds can be compared by using the amount of energy required to separate the ions. Some values for this energy are given in the table.

Compound	Amount of energy required to separate the ions / $kJ\,mol^{-1}$
LiF	1031
KF	817
CaF_2	2957

Using the data provided, explain how changes in the cation affect the bond strength in an ionic compound.

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(Total for question = 2 marks)

Q5.

Magnesium bromide, $MgBr_2$, is an ionic compound.

(i) Draw a dot-and-cross diagram to show the bonding in magnesium bromide.
Only outer shell electrons are required.

(1)

(ii) State all the conditions under which magnesium bromide conducts electricity.

(1)

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(Total for question = 2 marks)

Q6.

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

Explain why the electrical conductivity of solid potassium bromide is poor but an aqueous solution of potassium bromide is a good electrical conductor.

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(Total for question = 2 marks)

Q7.

This question is about magnesium.

(i) Complete the electronic structure of a magnesium atom.

(1)

$1s^2$

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(ii) The bonding in magnesium results from

(1)

☒ **A** strong electrostatic attractions between oppositely charged ions

☒ **B** strong electrostatic attractions between the nuclei of magnesium atoms and a shared pair of electrons

☒ **C** strong electrostatic attractions between positively charged ions and a sea of delocalised electrons

☒ **D** weak dispersion forces between magnesium atoms

(Total for question = 2 marks)

Q8.

This question is about ionic bonding.

The elements sodium and fluorine react together to form an ionic compound.

(i) Select the correct equation for this reaction.

(1)

- ☒ **A** $Na(s) + F(g) \rightarrow NaF(s)$
- ☒ **B** $2Na(s) + F_2(g) \rightarrow 2NaF(s)$
- ☒ **C** $Na(s) + F_2(g) \rightarrow NaF_2(s)$
- ☒ **D** $2Na(s) + F(g) \rightarrow Na_2F(s)$

(ii) Draw dot-and-cross diagrams of the ions in sodium fluoride, showing all the electrons.

Use your diagram to explain why the ions are described as isoelectronic.

(3)

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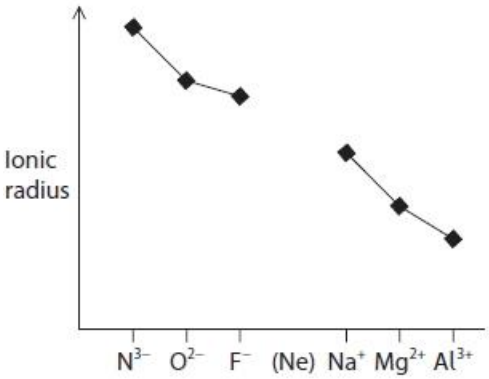
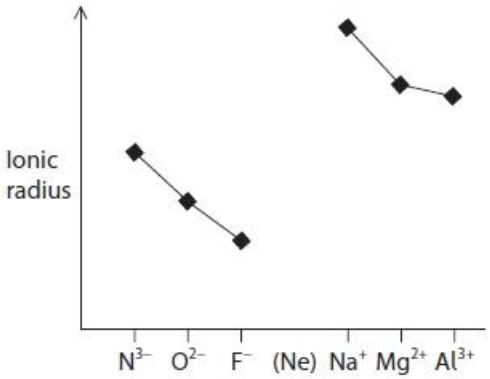
(iii) Which diagram shows the trend in ionic radius for the isoelectronic ions N^{3-} to Al^{3+}?

(1)

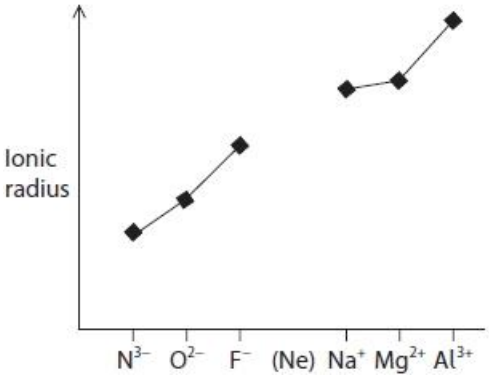
☐ **A**



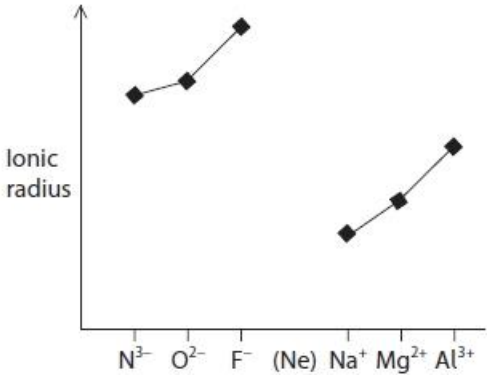
☐ **B**



☐ **C**



☐ **D**



(iv) Explain your answer to (iii) in terms of the structure of the ions.

(2)

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(Total for question = 7 marks)

Q9.

Give the formula of a stable **ion** that is isoelectronic with the magnesium ion, Mg^{2+}.

(1)

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(Total for question = 1 mark)

Q10.

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

Explain the difference in the melting temperatures of magnesium oxide and potassium bromide.

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(Total for question = 3 marks)

Q11.

The properties of elements and their compounds are determined by their structure and bonding.

Element **X** has the typical appearance of a metal.

Predict **two** other distinct physical properties that element **X** would exhibit if it is a metal. Explain your choices in terms of structure and bonding.

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(Total for question = 4 marks)

Q12.

This question is about the thermal stability of Group 1 and Group 2 nitrates and carbonates.

Calcium carbonate is thermally decomposed during the manufacture of cement.

(i) Write an equation, including state symbols, for the thermal decomposition of calcium carbonate.

(1)

(ii) Name all the types of bond present in calcium carbonate.

(1)

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(iii) Give a reason, in terms of the bonding, why a high decomposition temperature is required.

(1)

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(Total for question = 3 marks)

Mark Scheme

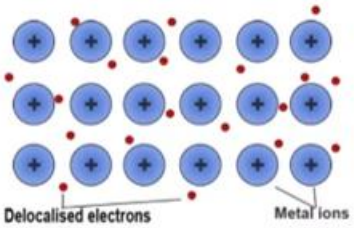
Q1.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following points: • (strong) electrostatic attraction • between oppositely charged ions		(2)

Q2.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following points • metal cations in a 'sea' of delocalised electrons (1) • (metallic bonding is the strong) **electrostatic** attraction between (cations and electrons) (1)	ACCEPT suitable annotated diagram ALLOW reference to metal ions IGNORE 'free' electrons/positive nucleus Do not award reference to molecules Example diagram  Approximately equal numbers of positive ions and negative electrons	(2)

Q3.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following points (Structure consisting of) • lattice of positive ions / regular arrangement of positive ions **(1)** • (in sea of) delocalised electrons **(1)** • strong forces of attraction between ions and delocalised electrons (so high melting temperature) **(1)** • so lots of (heat) energy needed to break attraction between ions and delocalised electrons / metallic bonds **(1)**	M1 and M2 can be scored by use of a labelled diagram, but if both given both must be correct For example  Allow charge on ion of 2+ or 3+ Diagram should show at least 4 ions (for M1) a number of electrons roughly consistent with charge on ions and random (for M2) The attraction between ions and delocalised electrons only needs to be mentioned once in M3 and M4 Allow 'lots of energy needed to separate the ions'	**(4)**

Q4.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An explanation that makes reference to the following points: • the higher the charge on the cation the stronger the attraction between ions **and** mention of a 2+ cation in CaF_2 compared to a 1+ cation in LiF / KF **(1)** • the smaller the radius of the cation the stronger the attraction between ions **and** mention of Li^+ being smaller than K^+ **(1)**	Allow "stronger bonding" for stronger attraction between ions Both charges should be stated Allow calcium ions have twice the charge of potassium / lithium ions. Do not award 'lithium has a smaller radius than potassium' unless it is clear ions are being considered, for example the use of Li^+ and K^+ in the answer. If no other marks awarded, allow a discussion of charge density without reference to charge or radius of one pair of ions for (1) If no other mark awarded, allow a correct statement about the effect of charge and ionic radius without justification from table of data for (1)	**(2)**

Q5.

Question Number	Answer	Additional Guidance	Mark
(i)	• dot-and-cross diagram **and** charges	Example of diagram  Circles are not needed Allow no electrons or 8 electrons on outer shell of Mg Allow dots or crosses for all electrons Allow diagrams without square brackets, provided charges are shown Allow alternative ways of showing that there are 2 bromide ions Ignore inner shell electrons	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	• (conducts electricity when) molten / liquid **and** dissolved in water / (in) aqueous (solution)	Both needed for the mark Ignore gaseous Allow 'in solution / dissolved'	(1)

Q6.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An explanation that makes reference to the following points: • (solid potassium bromide does not conduct because) the **ions** are in fixed positions / **ions** are not free to move **(1)** • it does conduct in solution because the **ions** are free to move (and carry charge) **(1)**	Do not award any marks if reference to movement of **electrons** or **free electrons** when conduction occurs Do not award any marks if 'molecules'/ London forces mentioned	(2)

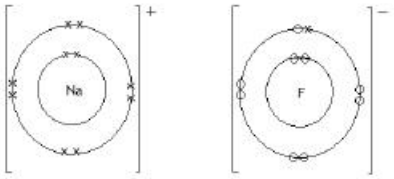
Q7.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	$(1s^2)\ 2s^2\ 2p^6\ 3s^2$	ALLOW $1s^2$ repeated	(1)

Question Number	Answer	Mark
(ii)	**The only correct answer is C** ***A*** *is not correct because this describes ionic bonding and magnesium has metallic bonding* ***B*** *is not correct because this describes covalent bonding and magnesium has metallic bonding* ***D*** *is not correct because this describes intermolecular forces and magnesium has metallic bonding*	(1)

Q8.

Question Number	Answer	Mark
(i)	**The only correct answer is B** ***A*** *is not correct because fluorine is diatomic* ***C*** *is not correct because sodium is* 1^+ *ion* ***D*** *is not correct because fluorine is diatomic*	(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	A diagram which shows the first two points: • electronic configuration for Na is 2.8 and +1 charge **(1)** • electronic configuration for F is 2.8 and -1 charge **(1)** • isoelectronic ions have the same electronic configuration **(1)**	Example of diagram  Allow one mark if both ions have eight electrons in their outer shell if M1 and M2 not scored OR Both with correct charge if M1 and M2 not scored. Do not award either mark for a covalent bond Ignore balancing numbers Allow same number of electrons	(3)

Question Number	Answer	Mark
(iii)	**The only correct answer is A** ***B*** *is not correct because diagram has cations larger than anions* ***C*** *is not correct because diagram has cations larger than anions* ***D*** *is not correct because trends in wrong direction*	(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(iv)	• increase in number of protons (in the nucleus) **(1)** • increases the attraction for the electrons (bringing them closer to the nucleus) **(1)**	Allow increasing nuclear charge For explanations of graph B allow max (1) for a correct explanation for any downward trend for three ions Allow max (1) for an explanation of the smallest or largest ion without an explanation of the trend e.g. Al^{3+} has the most protons so electrons most attracted to nucleus so smallest scores (1) Discussion of atomic radius max (1)	**(2)**

Q9.

Question Number	Answer	Additional Guidance	Mark
	• N^{3-} / O^{2-} / F^- / Na^+ / Al^{3+}	Do not award Ne, C^{4-}, Si^{4+}	**(1)**

Q10.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An explanation that makes reference to the following points: • comparison of ionic charges **(1)** • comparison of ionic radii **(1)** • comparison of **energy** required **(1)**	Examples of explanations MgO has doubly charged ions **and** KBr has singly charged ions Allow reference to just one ion in each compound Mg^{2+} smaller than K^+ and/or O^{2-} smaller than Br^- Ignore references to **atomic** radii More **energy** needed to overcome the electrostatic attractions/bonds (between ions) in MgO (than in KBr) Ignore references to 'electronegativity' / (ion) polarisation Award **(0)** overall if any mention of any of the following: London Forces **Molecules** / intermolecular forces Hydrogen bonding Covalent bonding	**(3)**

Q11.

Question Number	Acceptable Answers	Additional Guidance	Mark
	Any **two** of the following pairs of physical properties and explanations: • high melting/ boiling temperature **(1)** • **strong** (electrostatic) attraction between metal ions and delocalised electrons **(1)** • (good) electrical conductivity/ thermal conductivity **(1)** • mobile **delocalised** electrons **(1)** • malleability/ ductility **(1)** • the layers of ions/ atoms can easily slide over each other **(1)**	Explanation mark is dependent on stating the relevant physical property Ignore references to reactivity with water Allow references to hardness/strength Do not award if attraction to the nucleus is mentioned as this may imply ionisation Some reference to movement needed Allow 'carry charge' for movement / 'free to move'	**(4)**

	• high density **(1)** • the ions/ atoms are tightly packed due to the strong attraction between them **(1)**	Ignore any comment referring to the appearance of a metal eg lustrous If more than two properties are given, incorrect chemistry negates correct answers	

Q12.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	• correct formulae and state symbols of each species	$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$	(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	• ionic **and** covalent (bonding)	Ignore reference to single/double/dative	(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(iii)	• strong bonds within the carbonate ion / CO_3^{2-} /C-O bond / C=O bond	Ignore bonds between the ions / (Ca^{2+} and CO_3^{2-}) are strong	(1)