1(a). Lithium atoms react with fluorine atoms to form lithium ions and fluoride ions.

Draw dot and cross diagrams to show the arrangement of electrons and charge for a lithium ion and a fluoride ion.

[3]

(b). The table shows some information about fluorine and lithium fluoride.

Substance	Structure	Melting point in °C	Boiling point in °C
Fluorine	simple covalent	–220	–188
Lithium fluoride	giant ionic	845	1680

Explain why the melting point and boiling point of the two substances are different.

-- **[3]**

2(a). Kay is a geologist. She takes samples of minerals from a range of rocks.

She tests their melting points and electrical conductivity so that she can work out the bonding and structure of each mineral.

The table shows her results.

Mineral	Melting point in °C	Electrical conductivity of solid	Electrical conductivity when molten	Electrical conductivity when dissolved in water
A	1083	good	good	insoluble
B	1600	does not conduct	does not conduct	insoluble
C	801	does not conduct	good	good
D	373	does not conduct	good	insoluble

Kay thinks minerals **C** and **D** are both ionic compounds with a giant structure.

Explain why Kay thinks this.

--- [2]

(b). Compare minerals **A** and **B.** What type of structure and bonding do minerals **A** and **B** have?

Explain your answer.

--- [4]

3(a). Chlorine reacts with metals in many groups of the Periodic Table to make metal chlorides.

Table 1 shows some information about metals and metal chlorides.

Metal	Number of electrons in outer shell of atom	Formula of metal ion	Formula of metal chloride
lithium	1	Li^{+}	$LiCl$
sodium	1	Na^{+}	$NaCl$
beryllium	2	Be^{2+}	$BeCl_2$
magnesium	2	Mg^{2+}	$MgCl_2$
aluminium	3	Al^{3+}	$AlCl_3$

Table 1

There are links between the information in the columns in the table.

Describe **two** of these links.

-- [2]

(b). Table 2 shows information about other metals and metal chlorides.

Complete the table by filling in the boxes.

Metal	Number of electrons in outer shell of atom	Formula of metal chloride
potassium	1	
calcium	2	$CaCl_2$
gallium	3	

Table 2

[2]

4.

Magnesium oxide, MgO, is an ionic compound.

Draw a 'dot and cross' diagram for the ions in magnesium oxide.

Show the outer electron shells only.

[2]

5.

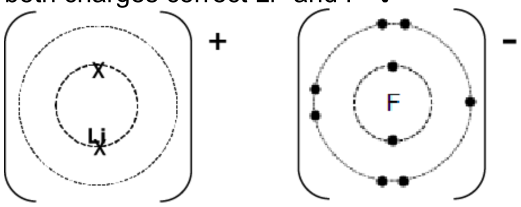
Aluminium oxide does not conduct electricity when it is solid.

It conducts electricity when it is molten.

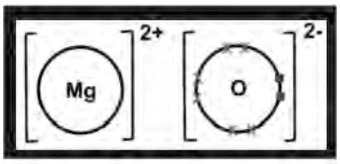
Explain why.

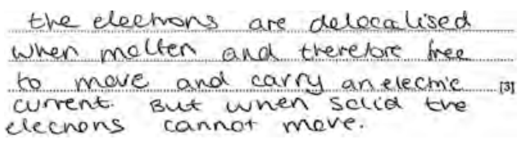
--- **[3]**

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1	a		lithium: 2 electrons ✓ fluoride ion: 10 electrons in the arrangement 2, 8 ✓ both charges correct Li^+ and F^- ✓ 	3	
	b		simple covalent substances have lower MP and BP than ionic compounds ✓ idea that forces between molecules of simple covalent substances are weak ✓ idea that attraction between ions in ionic compounds are strong ✓	3	**IGNORE** reference to size
			Total	6	
2	a		do not conduct when solid but do when molten so ionic ✓ have a high melting point so giant structure ✓	2	
	b		both have giant structures as both have high melting points ✓ **A** conducts electricity when solid or molten, **B** does not conduct electricity ✓ therefore **A** is a metal with a giant structure ✓ **B** is a covalent compound with a giant structure ✓	4	
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
3	a		**Any 2 from** the number of electrons is the same as the number of (positive) charges on the ion / the more electrons the higher the charge; the number of electrons is the same as the number of chlorine (atoms) in the formula / the more electrons the higher the number of chlorines in the formula; the (positive) charge on the ion is the same as the number of chlorine (atoms) in the formula;	2	**Accept** Number of electrons = number of electrons in the outer shell Answer must compare numbers in general or use examples of elements with different numbers of electrons e.g. 'Li has one electron and has a charge of +1' alone = 0 **Allow** 'number of chlorides' **Examiner's Comments** Some candidates gave answers that were too close to a restatement of the question. For example stating 'the number of electrons in the outer shell is linked to the formula of the metal ion'. This does not describe the links, which is what the question demands. A better answer would be 'the positive charge on the ion is the same as the number of electrons in the outer shell' or 'as the number of electrons in the outer shell increases, so does the positive charge on the ion'.
	b		KCl (1) $GaCl_3$ (1)	2	Do not accept incorrect case in symbol e.g. GA / GA or CL **Examiner's Comments** This was well answered, showing that writing formulae is something that candidates are skilled at doing. Over 80% gained both marks.
			Total	**4**	

Question			Answer/Indicative content	Marks	Guidance
4			 Ions with correct electrons ✓ Charges ✓	2 (AO 1.2 × 2)	**ALLOW (1)** for one correct ion **ALLOW** eight electrons in outer shell of Mg **ALLOW** all oxygen electrons with same symbol **IGNORE** correct inner shells **DO NOT ALLOW** incorrect inner shells <u>Examiner's Comments</u> Candidates found this difficult and did not typically draw charged ions. They did usually try to show complete outer shells. Many attempted to draw covalent shared electrons to hold the atoms together. Others showed the atoms before bonding with arrows to show that electrons would be transferred, without showing the final arrangements of electrons in the ions. Some who drew correct ion arrangements of electrons omitted the charges on the ions.
			Total	2	

Question			Answer/Indicative content	Marks	Guidance
5			ions / charged particles✓ can't move in solid / held in lattice / do not move / in fixed positions ✓ can move in liquid/when molten ✓	3 (AO 3 × 1.1)	DO NOT ALLOW electrons/'particles' alone <u>Examiner's Comments</u> This question links with 8b in that it requires candidates to a model of a molten ionic compound instead of a metal. Almost all candidates knew that movement of particles was important to conduction and that particles can move in aluminium oxide only when it is molten. Answers which earned three marks correctly identified that these particles are ions, which cannot move in solids but can when molten. It was very common that candidates discussed 'moving electrons' in the context of conduction in the molten compound. **AfL** Candidates need to be able to 'compare and contrast' models of metals and in ionic compounds and to state clearly the similarities and differences between them, in particular in relation to the nature of the particles in each model and that the moving particles which enable conduction in each are different. Exemplar 7  the electrons are delocalised when molten and therefore free to move and carry an electric current. But when solid the electrons cannot move. [3] This answer gained no credit because rather than describe conduction in a molten ionic compound it gives a partial but confused description of conduction in metals. This confusion between ionic and metallic models for conduction was very

Question			Answer/Indicative content	Marks	Guidance
					common.
			Total	3	