

Theory Questions

Ions & Ionic Bonds

Ions & Ionic Bonds / Ionic Bonds & Lattice Structure / Properties of Ionic Compounds

Easy (6 questions)	/49
Medium (7 questions)	/59
Hard (5 questions)	/60
Total Marks	/168

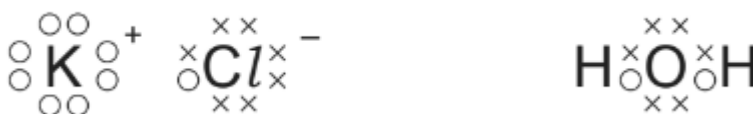
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Easy Questions

1 (a) Extended Only

The diagrams below show the electron arrangement in two compounds.



In a water molecule, each hydrogen atom is bonded to the oxygen atom by sharing a pair of electrons.

Why does an oxygen atom share two pairs of electrons rather than just one pair?

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(1 mark)

(b) Describe how a potassium atom becomes a potassium ion.

.....
(1 mark)

(c) Why is there a bond between the ions in potassium chloride?

.....
(1 mark)

(d) Extended Only

Solid potassium chloride is a poor conductor of electricity. When dissolved in water it is a good conductor. Explain

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.....
(2 marks)

2 (a) The following is a list of the electron distributions of atoms of unknown elements.

element	electron distribution
A	2,5
B	2,8,4
C	2,8,8,2
D	2,8,18,8
E	2,8,18,8,1
F	2,8,18,18,7

Choose an element from the list for each of the following descriptions.

- i) It is a noble gas.
- ii) It is a soft metal with a low density.
- iii) It can form a covalent compound with element A.
- iv) It has a giant covalent structure similar to diamond.
- v) It can form a negative ion of the type X^{3-} .

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(5 marks)

(b) Elements C and F can form an ionic compound.

i) Draw a diagram that shows the formula of this compound, the charges on the ions and the arrangement of the valency electrons around the negative ion. Use x to represent an electron from an atom of C. Use o to represent an electron from an atom of F.

[3]

ii) Predict **two** properties of this compound.

[2]

(5 marks)

3 (a) Magnesium reacts with bromine to form magnesium bromide.

Magnesium bromide is an ionic compound. Draw a diagram that shows the formula of the compound, the charges on the ions and the arrangement of outer electrons around the negative ion. The electron distribution of a bromine atom is 2, 8, 18, 7. Use x to represent an electron from a magnesium atom. Use o to represent an electron from a bromine atom.

(3 marks)

(b) **Extended Only**

In the lattice of magnesium bromide, the ratio of magnesium ions to bromide ions is 1:2.

i) Explain the term lattice.

[2]

ii) Explain why the ratio of ions is 1:2.

[1]

iii) The reaction between magnesium and bromine is redox. Complete the sentences.

Magnesium is the agent because it has electrons.

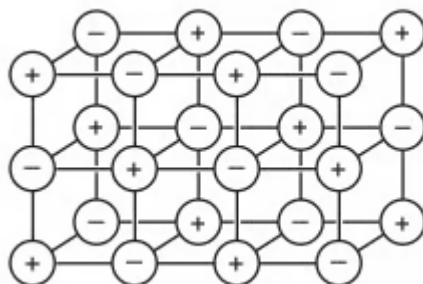
Bromine has been because it has electrons.

[4]

(7 marks)

4 (a) Extended Only

The structure of a typical ionic compound is a regular arrangement of positive and negative ions.



i) What is the name of this regular arrangement of particles?

[1]

ii) Give **two** physical properties of ionic compounds.

[2]

(3 marks)

(b) Extended Only

Ions are formed by electron loss or gain. The electron distribution of a magnesium atom is 2 + 8 + 2 and of a nitrogen atom is 2 + 5.

i) Give the formula of the magnesium ion.

[1]

ii) Give the formula of the nitride ion.

[1]

iii) What is the formula of the ionic compound, magnesium nitride?

[1]

iv) In this compound there is an ionic bond. Why are the two ions attracted to each other?

[1]

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(4 marks)

5 (a) The table below gives the number of protons, neutrons and electrons in atoms or ions.

Complete the table. The first line is given as an example.

You will need to use the Periodic Table.

particle	number of protons	number of electrons	number of neutrons	symbol or formula
A	4	4	5	${}^9_4\text{Be}$
B	19	18	20	
C	30	30	35	
D	8	10	8	
E	31	31	39	

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(6 marks)

(b) Using the data in the table, explain how you can determine whether a particle is an atom, a negative ion or a positive ion.

(3 marks)

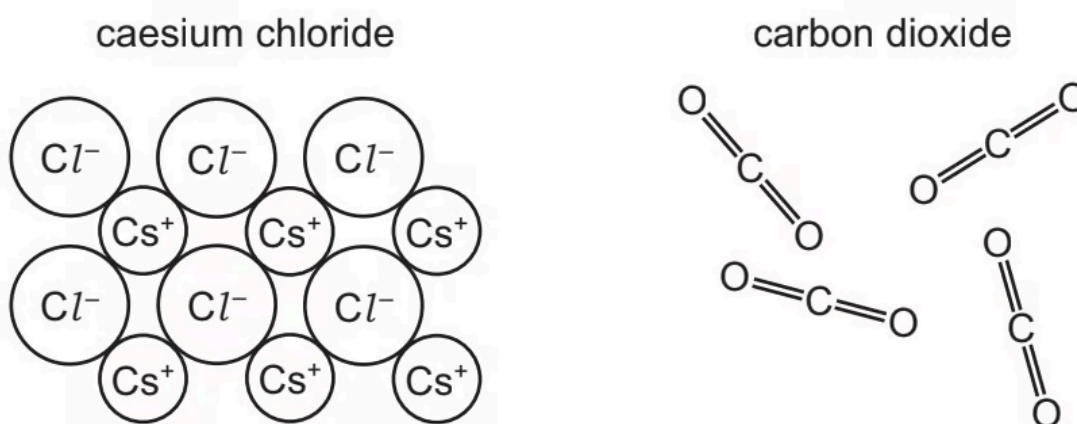
6 (a) A list of symbols and formulae is shown.

CH₄
Cl⁻
CO₂
Cr³⁺
Cu²⁺
Fe²⁺
H₂
K⁺
N₂
O₂
SO₂

Which symbol or formula represents an ion formed when an atom gains an electron?

.....
(1 mark)

(b) The diagram shows part of the structures of caesium chloride and carbon dioxide.

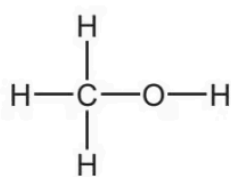


Describe both caesium chloride and carbon dioxide in terms of:

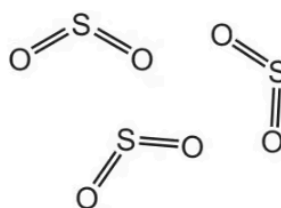
- bonding
 - arrangement of particles.
-

(5 marks)

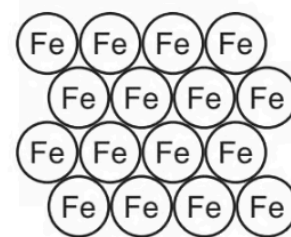
(c) The diagrams show part of the structures of five substances, A, B, C, D and E.



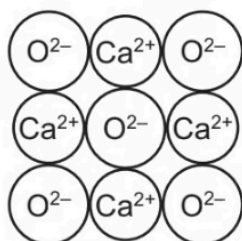
A



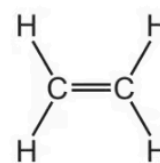
B



C



D



E

State which one of these structures, A, B, C, D or E is an ionic compound.

(1 mark)

(d) ${}^{22}_{11}\text{Na}$, ${}^{23}_{11}\text{Na}$ and ${}^{24}_{11}\text{Na}$ are isotopes of sodium. Why do sodium ions have a charge of +1?

(1 mark)

Medium Questions

1 (a) Extended Only

Potassium iodide is an ionic compound.

i) Describe what happens, in terms of electron loss and gain, when a potassium atom reacts with an iodine atom.

[2]

ii) Describe the structure of solid potassium iodide. You may draw a diagram.

[2]

iii) Explain why potassium iodide has a high melting point.

[2]

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(6 marks)

(b) Separate: Chemistry and Extended Only

Potassium iodide and lead nitrate are both soluble. Lead iodide is insoluble.

i) Describe how a pure dry sample of lead iodide could be made from solid potassium iodide and solid lead nitrate.

[4]

ii) Write an ionic equation for the formation of lead iodide, PbI_2 , when potassium iodide and lead nitrate react with each other. State symbols are **not** required.

[2]

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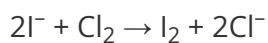
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(6 marks)

(c) Separate: Chemistry and Extended Only

When chlorine gas is bubbled through an aqueous solution of potassium iodide, a redox reaction takes place.



i) State the colour change expected in this reaction.

start colour

end colour

[2]

ii) Identify the reducing agent in this reaction. Explain your answer.

[2]

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(4 marks)

2 (a) Extended Only

Iron pyrite, FeS_2 , is known as Fool's Gold because it is a shiny yellow solid which is similar in appearance to gold. Iron pyrite is an ionic compound. Gold is a metallic element.

Iron pyrite, FeS_2 , contains positive and negative ions. The positive ion is Fe^{2+} .

Deduce the formula of the negative ion.

.....
.....
(1 mark)

- (b) A student is provided with a sample of iron pyrite and a sample of gold. Suggest how the student could distinguish between the two substances.

.....
.....
(2 marks)

(c) Extended Only

Sulfur dioxide is produced on a large scale by heating iron pyrite strongly in air. The iron pyrite reacts with oxygen in the air producing iron(III) oxide, Fe_2O_3 , and sulfur dioxide.

Construct a chemical equation for the reaction between iron pyrite and oxygen.

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.....
(2 marks)

3 (a) Nitrogen can form ionic compounds with reactive metals and covalent compounds with non-metals.

Nitrogen reacts with lithium to form the ionic compound lithium nitride, Li_3N .

i) Write the equation for the reaction between lithium and nitrogen.

[2]

ii) Lithium nitride is an ionic compound. Draw a diagram which shows its formula, the charges on the ions and the arrangement of the valency electrons around the negative ion. Use x for an electron from a lithium atom. Use o for an electron from a nitrogen atom.

[2]

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(4 marks)

(b) Nitrogen fluoride is a covalent compound.

i) Draw a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound nitrogen trifluoride, NF_3 . Use x for an electron from a nitrogen atom. Use o for an electron from a fluorine atom.

[2]

ii) Lithium nitride has a high melting point, $813\text{ }^\circ\text{C}$. Nitrogen trifluoride has a low melting point, $-207\text{ }^\circ\text{C}$. Explain why the melting points are different.

[2]

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(4 marks)

4 (a) The Group I metals show trends in both their physical and chemical properties.

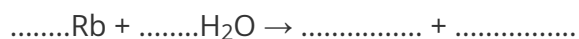
i) How do their melting points vary down the Group?

[1]

ii) Which element in the Group has the highest density?

[1]

iii) All Group I metals react with cold water. Complete the following equation.



[2]

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(4 marks)

(b) Extended Only

Lithium reacts with nitrogen to form the ionic compound, lithium nitride.

i) State the formula of the lithium ion.

[1]

ii) Deduce the formula of the nitride ion.

[1]

iii) In all solid ionic compounds, the ions are held together in a lattice. Explain the term *lattice*.

[1]

iv) What is the ratio of lithium ions to nitride ions in the lattice of lithium nitride? Give a reason for your answer.

[2]

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(5 marks)

5 (a) **Table 1.1** shows the properties of four substances.

Table 1.1

substance	boiling point	electrical conductivity of solid	electrical conductivity when molten	density in g / cm ³
aluminium	high	conducts	conducts	2.70
diamond				3.51
potassium bromide	high	does not conduct	conducts	2.75
sulfur	low	does not conduct		

State the meaning of the term ionic bonding.

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(2 marks)

(b) Identify which information in **Table 1.1** shows that potassium bromide is an ionic compound.

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(2 marks)

(c) Magnesium, calcium and strontium are Group II elements

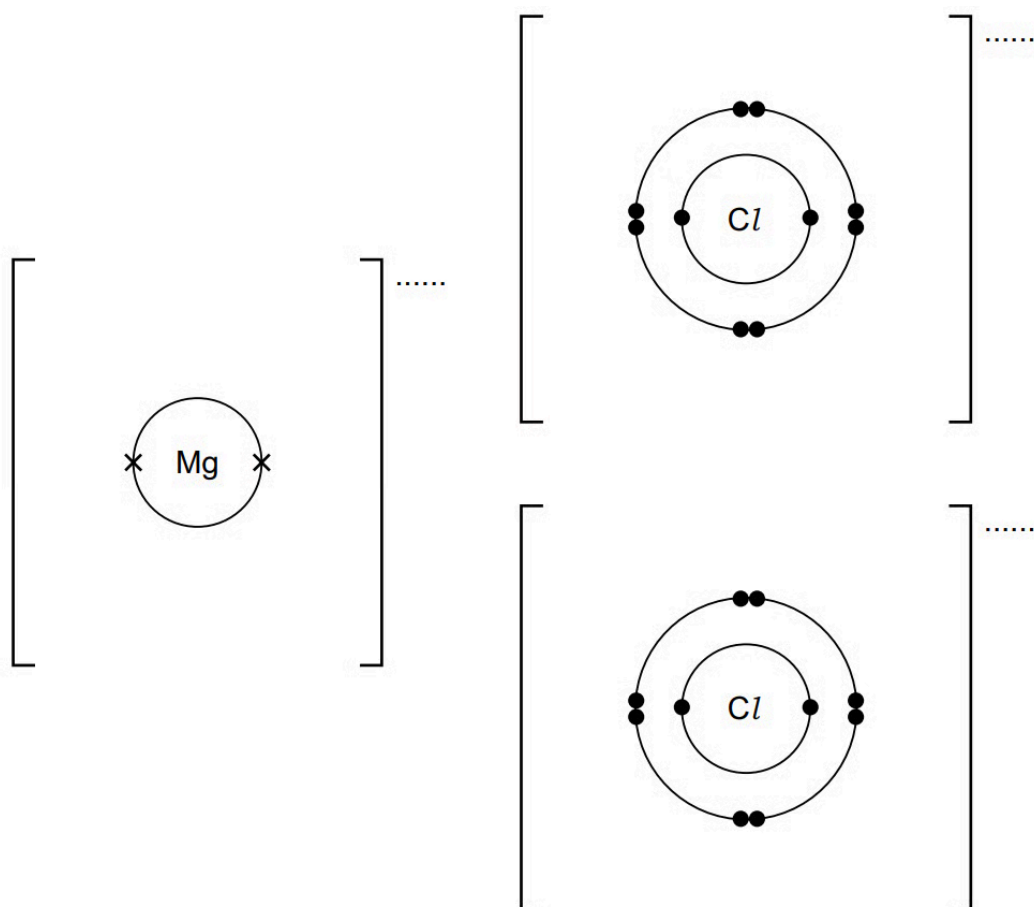
Magnesium reacts with chlorine to form magnesium chloride, MgCl₂.

Magnesium chloride is an ionic compound.

Complete the dot-and-cross diagram in **Figure 1.1** of the ions in magnesium chloride.

Show the charges on the ions.

Figure 1.1



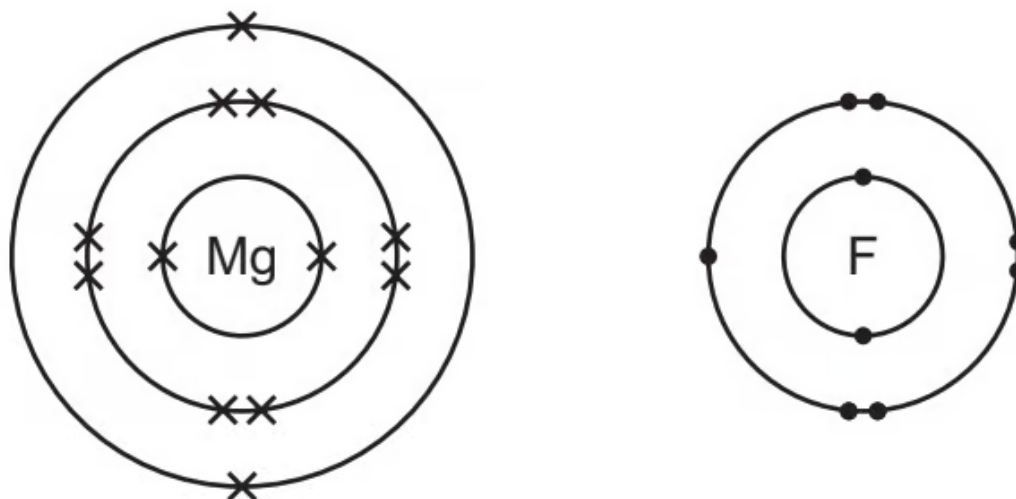
(3 marks)

(d) One physical property typical of ionic compounds, such as MgCl₂, is that they are soluble in water.

Give two other physical properties that are typical of ionic compounds.

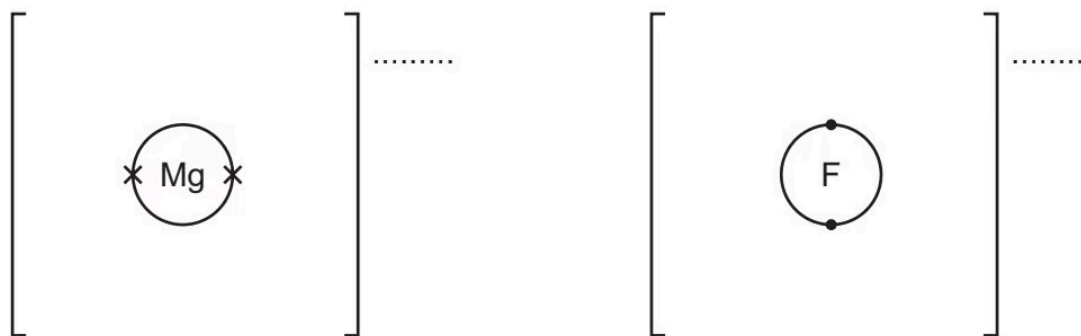
(2 marks)

6 (a) Fluorine forms both ionic and covalent compounds. Magnesium reacts with fluorine to form the ionic compound magnesium fluoride. The electronic structures of an atom of magnesium and an atom of fluorine are shown.



Complete the dot-and-cross diagrams to show the electronic structures of one magnesium ion and one fluoride ion.

Show the charges on the ions.



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(3 marks)

(b) Extended Only

Magnesium fluoride does not conduct electricity when it is solid.

What can be done to solid magnesium fluoride to make it conduct electricity?

In your answer explain why magnesium fluoride conducts electricity when this change is made.

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(2 marks)

(c) Extended Only

The melting points of magnesium fluoride and carbonyl fluoride are shown.

	melting point / °C
magnesium fluoride	1263
carbonyl fluoride	-111

Explain, using your knowledge of structure and bonding, why magnesium fluoride has a high melting point.

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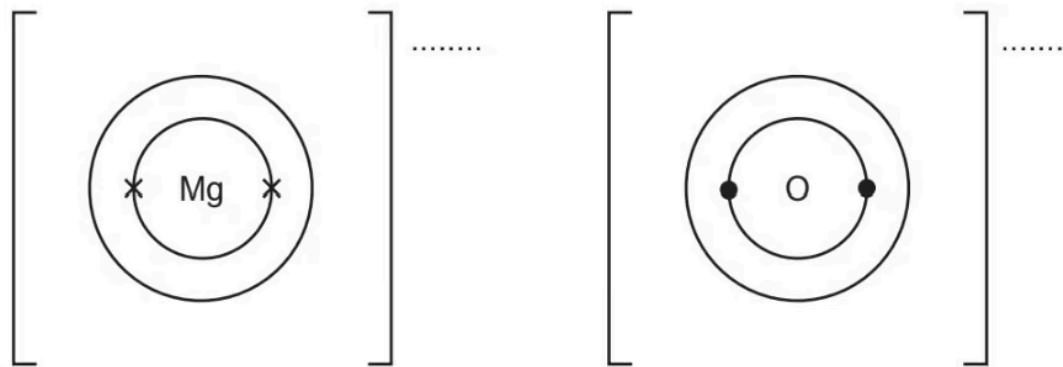
(2 marks)

7 (a) Magnesium exists as three isotopes, ${}^{24}_{12}\text{Mg}$, ${}^{25}_{12}\text{Mg}$ and ${}^{26}_{12}\text{Mg}$.

Magnesium reacts with oxygen to form the ionic compound magnesium oxide.

Complete the dot-and-cross diagrams to show the electronic structures of the ions in magnesium oxide.

Show the charges on the ions.



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(3 marks)

(b) **Extended Only**

Magnesium oxide melts at 2853 °C.

Why does magnesium oxide have a high melting point?

.....

(1 mark)

(c) **Extended Only**

Explain why molten magnesium oxide can conduct electricity.

(1 mark)

Hard Questions

- 1 (a) The first three elements in Period 6 of the Periodic Table of the Elements are caesium, barium and lanthanum.

How many more protons, electrons and neutrons are there in one atom of lanthanum than in one atom of caesium. Use your copy of the Periodic Table of the Elements to help you.

Number of protons =

Number of electrons =

Number of neutrons =

(3 marks)

(b) **Extended Only**

All three metals can be obtained by the electrolysis of a molten halide. The electrolysis of the aqueous halides does not produce the metal.

- i) Complete the equation for the reduction of lanthanum ions at the negative electrode (cathode).



[1]

- ii) Name the three products formed by the electrolysis of aqueous caesium bromide.

[3]

(4 marks)

(c) All three metals react with cold water. Complete the word equation for these reactions.



(2 marks)

(d) Barium chloride is an ionic compound.

Draw a diagram that shows the formula of the compound, the charges on the ions and gives the arrangement of the valency electrons around the negative ion.

The electron distribution of a barium atom is 2.8.18.18.8.2 Use x to represent an electron from a barium atom. Use o to represent an electron from a chlorine atom.

(2 marks)

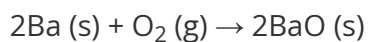
(e) Extended Only

Describe, by means of a simple diagram, the lattice structure of an ionic compound, such as caesium chloride.

(2 marks)

(f) Extended Only

The reactions of these metals with oxygen are exothermic.



i) Give an example of bond forming in this reaction.

[1]

ii) Explain using the idea of bond breaking and forming why this reaction is exothermic.

[3]

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(4 marks)

2 (a) Calcium reacts with nitrogen to form the ionic compound calcium nitride, Ca_3N_2 .

Draw a diagram, based on the correct formula, which shows the charges on the ions and the arrangement of the electrons around the negative ion.

Use o to represent an electron from a calcium atom. Use x to represent an electron from a nitrogen atom.

(3 marks)

(b) **Extended Only**

In the lattice of calcium nitride, the ratio of calcium ions to nitride ions is 3 : 2.

i) What is meant by the term lattice?

[2]

ii) In terms of ionic charges, explain why the ratio of ions is 3 : 2.

[2]

(4 marks)

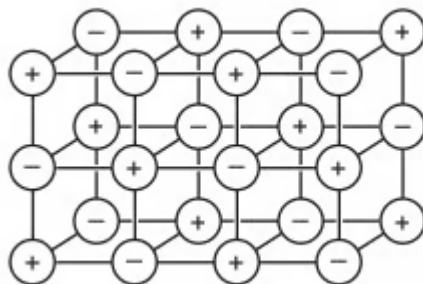
(c) **Extended Only**

The reaction between calcium and nitrogen to form calcium nitride is a redox reaction. In terms of electron transfer, explain why calcium is the reducing agent.

(3 marks)

3 (a) Extended Only

The diagram shows the lattice of a typical ionic compound.



i) Explain the term *ionic lattice*.

[2]

ii) In this lattice, the ratio of positive ions to negative ions is 1:1. In the lattice of a different ionic compound, the ratio of positive ions to negative ions is 1:2. Suggest why this ratio varies in different ionic compounds.

[1]

iii) Give **three** physical properties of ionic compounds.

[3]

(6 marks)

(b) Extended Only

Strontium oxide is an ionic compound.

Draw a diagram which shows its formula, the charges on the ions and the arrangement of the valency electrons around the negative ion.

The electron distribution of a strontium atom is $2 + 8 + 18 + 8 + 2$. Use o to represent an electron from a strontium atom. Use x to represent an electron from an oxygen atom.

(3 marks)

4 (a) **Extended Only**

The structure of an element or compound determines its physical properties. Scandium fluoride and silicon(IV) oxide have giant structures.

Scandium fluoride is an ionic compound.

i) The valency of scandium is three. Draw a diagram which shows the formula of the compound, the charges on the ions and the arrangement of the valency electrons around the negative ion.

Use x to represent an electron from a scandium atom. Use o to represent an electron from a fluorine atom.

[3]

ii) The melting point of scandium fluoride is 1552 °C. Explain why scandium fluoride has a high melting point.

[1]

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(4 marks)

(b) Separate: Chemistry and Extended Only

Silicon(IV) oxide has a macromolecular structure.

i) Describe the structure of silicon(IV) oxide. You may use a diagram.

[3]

ii) How does the electrical conductivity of these two compounds differ?

[1]

iii) Explain the difference in conductivity.

[2]

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(6 marks)

5 (a) Extended Only

Both strontium and sulfur have chlorides of the type XCl_2 . The table below compares some of their properties.

	strontium chloride	sulfur chloride
appearance	white crystals	red liquid
formula	$SrCl_2$	SCl_2
melting point / $^{\circ}C$	874	-120
boiling point / $^{\circ}C$	1250	59
conductivity of liquid	good	poor
solubility in water	dissolves to form a neutral solution	reacts to form a solution of pH 1

i) Use the data in the table to explain why sulfur chloride is a liquid at room temperature, $25^{\circ}C$.

[2]

ii) Strontium is a metal and sulfur is a non-metal. Explain why both have chlorides of the type XCl_2 . The electron distribution of a strontium atom is $2 + 8 + 18 + 8 + 2$.

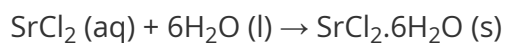
[2]

iii) Explain the difference in the electrical conductivity of liquid strontium chloride and liquid sulfur chloride.

[3]

(7 marks)

(b) Strontium chloride-6-water can be made from the insoluble compound, strontium carbonate, by the following reactions.



The following method was used to prepare the crystals.

1. Add excess strontium carbonate to hot hydrochloric acid.
2. Filter the resulting mixture.
3. Partially evaporate the filtrate and allow to cool.
4. Filter off the crystals of $\text{SrCl}_2 \cdot 6\text{H}_2\text{O}$.
5. Dry the crystals between filter papers.

i) How would you know when excess strontium carbonate had been added in step 1?

[1]

ii) Why is it necessary to filter the mixture in step 2?

[1]

iii) In step 3, why partially evaporate the filtrate rather than evaporate to dryness?

[1]

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(3 marks)

(c) Separate: Chemistry and Extended Only

In the above experiment, 50.0 cm^3 of hydrochloric acid of concentration 2.0 mol / dm^3 was used. 6.4 g of $\text{SrCl}_2 \cdot 6\text{H}_2\text{O}$ was made.

Calculate the percentage yield.

number of moles of HCl used =

number of moles of $\text{SrCl}_2 \cdot 6\text{H}_2\text{O}$ which could be formed =

mass of one mole of $\text{SrCl}_2 \cdot 6\text{H}_2\text{O}$ is 267 g

theoretical yield of $\text{SrCl}_2 \cdot 6\text{H}_2\text{O}$ =g

percentage yield =%

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(4 marks)