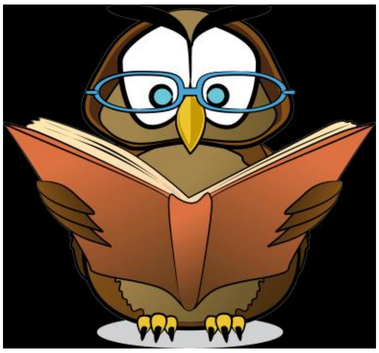


KNOWLEDGE

ST MARY'S SCIENCE DEPARTMENT:

CHEMISTRY

A LEVEL CHEMISTRY

BRIDGING COURSE

BONDING

WEEK 1

NAME	
CHEMISTRY CLASS	

VERSION 1.2

THIS MUST BE BROUGHT TO CHEMISTRY LESSONS AT THE START OF YEAR 12.

WEEK 1
Contents
5.2 Ionic and Covalent Bonding

This bridging course will provide you with a mixture of information about A-level Chemistry's fundamental topics, and what to expect from the course, as well as key work to complete.

Students who are expecting to study Chemistry at A-level, and are likely to meet the entry requirements, must complete the bridging course fully and thoroughly, to the best of their ability. You should complete all work on paper and keep it in a file, in an ordered way. You will submit it to your teacher in September.

All of the work will be reviewed and selected work will be formally assessed, and you will be given feedback on it. This work will be signalled to you. If you do not have access to the internet, please contact the school and appropriate resources will be sent to you.

If you are thinking about studying Chemistry at A-level you should attempt this work to see whether or not you think studying a subject like this is right for you. If you later decide to study Chemistry, you must ensure you complete this work in full. This work should be completed after you have read and completed the Study Skills work that all of Year 12 should complete.

Course outline

Assessment overview of A – level Chemistry

Content is in six modules:

Module 1 – Development of practical skills in chemistry
Module 2 – Foundations in chemistry
Module 3 – Periodic table and energy
Module 4 – Core organic chemistry
Module 5 – Physical chemistry and transition elements
Module 6 – Organic chemistry and analysis

Component	Marks	Duration	Weighting	[redacted]
Periodic table, elements and physical chemistry (01)	100	2 hour 15 mins	37%	Assesses content from modules 1, 2, 3 and 5
Synthesis and analytical techniques (02)	100	2 hour 15 mins	37%	Assesses content from modules 1, 2, 4 and 6
Unified chemistry (03)	70	1 hour 30 minute	26%	Assesses content from all modules (1 to 6)
Practical endorsement	-	-	-	Non-exam assessment

Component	Marks	Duration	Weighting	[redacted]
in chemistry (04)				

All components include synoptic assessment.

Students must complete all components (01, 02, 03, and 04) to be awarded the OCR A Level in Chemistry A.

The course in Year 12 will follow the OCR AS Chemistry as set out below (this leads onto Y13 work):

Assessment overview AS Chemistry

Content is in four modules:

Module 1 – Development of practical skills in chemistry
Module 2 – Foundations in chemistry
Module 3 – Periodic table and energy
Module 4 – Core organic chemistry

Component	Marks	Duration	Weighting	
Breadth in chemistry (01)	70	1 hour 30 mins	50%	Assesses content from all four modules
Depth in chemistry (02)	70	1 hour 30 mins	50%	Assesses content from all four modules

Both components include synoptic assessment.

Students will complete the OCR AS Level in Chemistry A at the end of Year 12 as a **MOCK EXAM** to gauge the students' progress in their first year of study.

Content overview

The four modules are each divided into key topics:

Module 1: Development of practical skills in chemistry

Practical skills assessed in a written examination

Module 2: Foundations in chemistry

Atoms, compounds, molecules and equations

Amount of substance

Acid–base and redox reactions

Electrons, bonding and structure

Module 3: Periodic table and energy

The periodic table and periodicity

Group 2 and the halogens

Qualitative analysis

Enthalpy changes

Reaction rates and equilibrium (qualitative)

Module 4: Core organic chemistry

Basic concepts

Hydrocarbons

Alcohols and haloalkanes

Organic synthesis

Analytical techniques (IR and MS)

Practical activities are embedded throughout the course to encourage practical activities in the laboratory, enhancing students’ understanding of chemical theory and practical skills.

Aim

In this bridging course, we will outline the basic principles of key topics covered in Year 12 Chemistry.

In each topic, we will start by reviewing the understanding which you gained in GCSE Chemistry and apply it to more advanced applications found in A-Level Chemistry.

This is not a comprehensive overview of the A-Level Chemistry specification, rather a taster on what is covered throughout the course.

Important

Please remember to look after your own wellbeing as you work through this bridging course.

Please take regular breaks as you go through this work.

This work should take approximately 5 hours, so should not be completed in one sitting.

Do not worry or panic if there is something challenging or which you do not understand at first. This is completely normal.

WEEK 1: BONDING

Instructions

The content that will be covered in this part of the course is mainly an extension of GCSE Chemistry Bonding and Structure work related to Topic 2 from the GCSE course.

There will be 2x PowerPoint booklets (see below) which will take you through Ionic and Covalent bonding.

There will be questions in the PowerPoint as you go that require completion.

At the end of the booklet on Covalent bonding it directs you to answer some further practice examination questions

Attempt these questions after you have also completed this study guide.

THESE WILL BE REQUIRED TO BE HANDED IN UPON YOUR RETURN TO SCHOOL FOR FORMAL MARKING.

Power Points [should be attached or available for download]

- Ppt 5.2 Ionic bonding
- Ppt 5.3 Covalent bonding

This information is also found in the attached PowerPoints.

The formally assessed questions are highlighted clearly in the appropriate PowerPoints.

5.2 Ionic bonding and structure

Introduction

Most of this topic will be familiar to you from Key Stage 4. It reminds you of the structure of ionic compounds and how to represent the electron arrangement in the ions by drawing dot-and-cross diagrams. From these ideas about structure and bonding you will be able to explain several important properties of ionic compounds.

Understand the nature of ionic bonding.

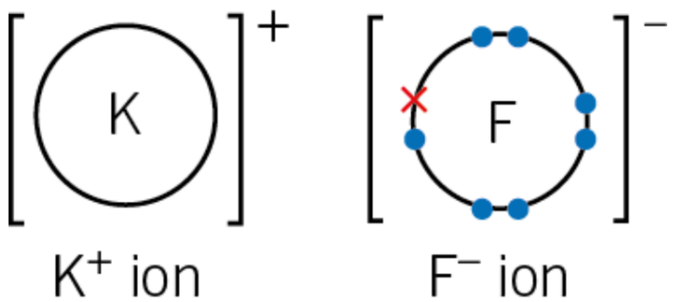
Draw dot-and-cross diagrams to represent the bonding in ionic compounds.

You will need to use the idea of electrostatic attraction to explain the bonding in ionic compounds.

The ions in these compounds are formed when electrons are transferred between atoms. You need to be able to draw dot-and-cross diagrams to show which electrons have been transferred and to indicate the charges on the ions.

There is a dot-and-cross diagram to complete in '5.3 Support: Ionic and covalent bonding', which also covers ideas about covalent bonding that you will meet in Topic 5.3.

In the dot-and-cross diagram for KF, only the outer-shell electrons are shown. Deduce the full electron configuration of the K^+ ions and F^- ions.



5.2 Ionic bonding and structure – properties

Describe the structure of ionic compounds.

Recall the typical physical properties of ionic compounds.

Understand how structure and bonding can be used to explain the physical properties of ionic compounds.

You need to understand that each ion attracts oppositely charged ions in all directions, which leads to the formation of a giant ionic lattice.

The presence of charged ions in a lattice and the strength of the electrostatic attraction between the ions can be used to explain several physical properties including:

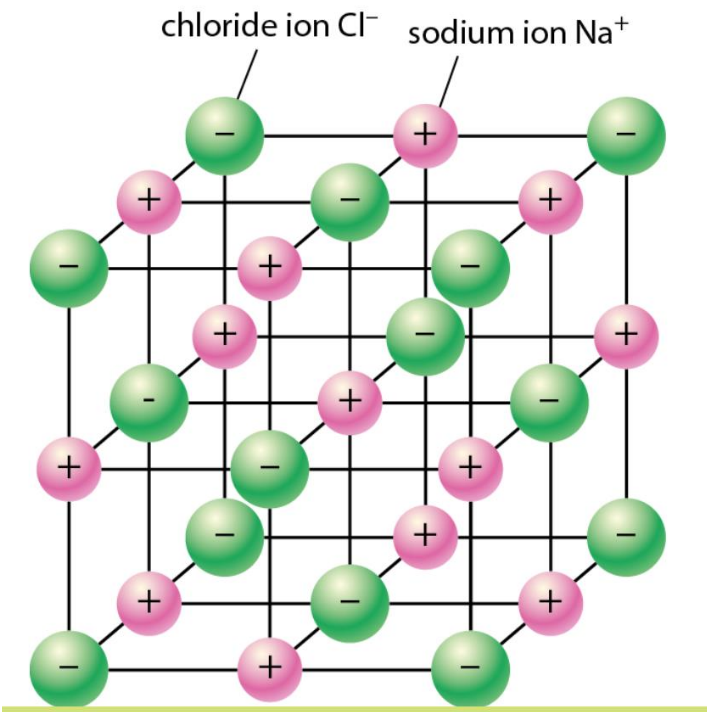
melting and boiling points

solubility

electrical conductivity.

'5.3 Support: Ionic and covalent bonding' gives you some practice explaining some of these properties. Use '5 Stretch and challenge: Structure and bonding in aluminium chloride' to apply these ideas to a substance with an unusual pattern of bonding.

The diagram shows part of the sodium chloride lattice. How many Cl^- ions surround the Na^+ ion in the centre of the lattice?

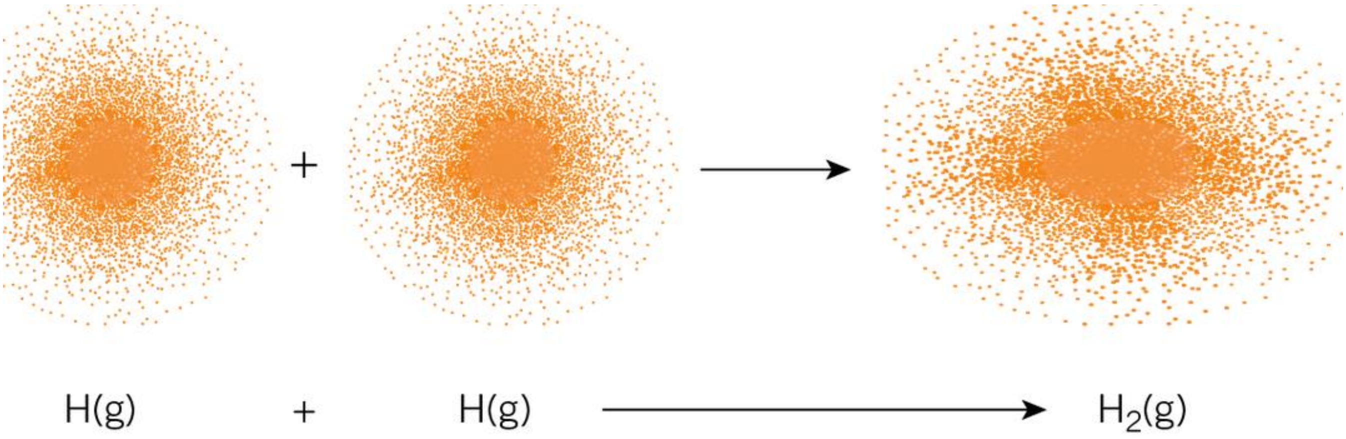


5.3 Covalent Bonding - Introduction

In this topic, you will be reminded of the difference between ionic and covalent bonding and will be introduced to the way in which chemists measure the strength of covalent bonds.

You will build on your knowledge of dot-and-cross diagrams, drawing diagrams to show the features of electron arrangement and bonding in a range of covalent molecules.

The diagram shows the overlap of the 1s orbitals of two hydrogen atoms when they form a hydrogen molecule. Suggest where the nuclei are located in this diagram.



Covalent Bonding - Bonding

Understand the nature of covalent bonding.

Recall that average bond enthalpy is a measure of covalent bond strength.

You need to be able to describe how a covalent bond is the strong electrostatic attraction between a shared pair of electrons and the nuclei of the bonded atoms. You should be able to recall the types of atoms that are involved in covalent bonding. You need to be able to use average bond enthalpy data to discuss the strength of bonds and describe patterns in bond strength.

The table shows the average bond enthalpy for some different covalent bonds. Bromine is much larger than the other atoms included in the table. Use the data to suggest how bond strength might be affected by the size of the atoms involved.

Bond	Average bond enthalpy / kJ mol^{-1}	Relative strength
Br–Br	193	Increasing bond strength
C–Br	290	
C–O	358	
O–H	464	

Covalent Bonding – Dot and Cross Diagrams

Construct dot-and-cross diagrams to describe covalent bonding, including multiple bonds and dative covalent bonds.

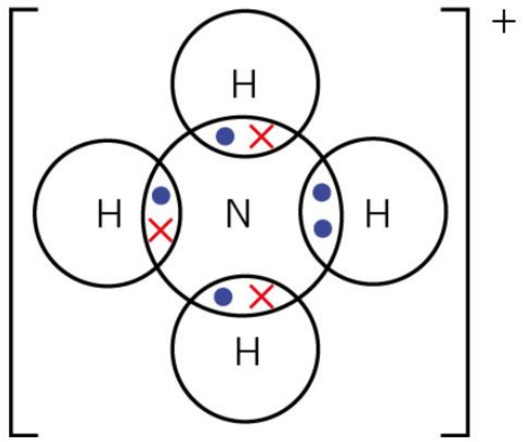
You need to be able to draw dot-and-cross diagrams for covalently-bonded substances and understand the difference between lone pairs of electrons and bonded pairs. Dot-and-cross diagrams make it clear how many covalent bonds there are between atoms – the number of bonds is equal to the number of shared electrons divided by 2.

You also need to understand that a dative covalent bond, or coordinate bond, is a covalent bond in which the shared pair of electrons has been supplied by one of the bonding atoms only. You need to be able to show this using a dot-and-cross diagram.

'5.3 Support: Ionic and covalent bonding' gives you some practice drawing dot-and-cross diagrams for covalent compounds. You can use

'5 Stretch and challenge: Structure and bonding in aluminium chloride' includes some questions involving dot-and-cross diagrams for a substance with an unusual pattern of bonding.

In the dot-and-cross diagram of the ammonium ion, how can you tell that one of the bonds is a dative covalent bond?



Summary

In this chapter you have developed your understanding of the nature of ionic and covalent bonding, and how dot-and-cross diagrams are used to describe the arrangement of electrons in ionic and covalent compounds.

You can now check how well you can apply your skills and knowledge from Chapter 5, using the following resources:

5 Electrons and bonding: Checklist

5.3 Support: Ionic and Covalent Bonding

Ionic and covalent bonding

Learning outcomes

After completing this worksheet you should be able to:

- describe the bonding in ionic and covalent compounds and the properties resulting from these
- compare the bonding in ionic compounds and simple molecular substances.

Questions

1 Ionic bonding involves the transfer of electrons. The electrons are transferred from metal atoms to non-metal atoms. The metal atoms become positively charged ions and the non-metal atoms become negatively charged ions. Upon transfer, both sets of ions have a full outer shell of electrons. Ionic bonding is therefore the electrostatic attraction between the oppositely charged ions.

a Sodium reacts with chlorine to form the ionic compound sodium chloride. Construct a balanced symbol equation for this reaction. *(1 mark)*

b Copy and complete the dot-and-cross diagram in Figure 1 to show the sodium ions and chloride ions in this compound. *(4 marks)*

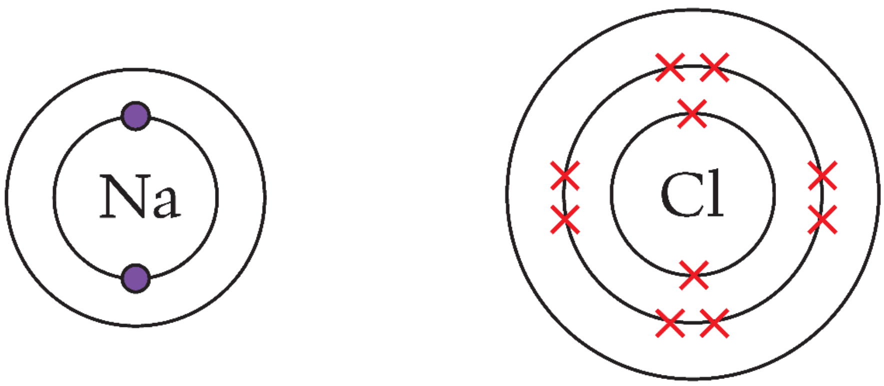


Figure 1 *Incomplete dot-and-cross diagram for sodium chloride*

c Explain why sodium chloride has a high melting point. *(3 marks)*

d Explain why solid sodium chloride **does not conduct** electricity. *(1 mark)*

e Explain why molten sodium chloride **does conduct** electricity. *(1 mark)*

2 **Covalent bonding** occurs between non-metal atoms. The atoms share pairs of electrons so that all the atoms have a full outer shell of electrons. Carbon, for example, reacts with hydrogen to form methane, CH_4. Methane is a simple molecule formed when a small number of non-metal atoms are joined together by covalent bonds.

a Construct a balanced symbol equation for the formation of methane from carbon and hydrogen. *(1 mark)*

b Copy and complete the dot-and-cross diagram in Figure 2 to show the bonding in a molecule of methane, CH_4. *(2 marks)*

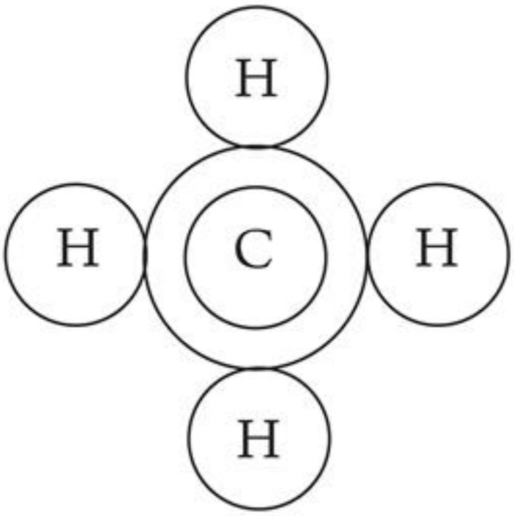


Figure 2 *Incomplete dot-and-cross diagram for methane*

c Explain why methane **does not conduct** electricity. *(1 mark)*

d Compare the bonding in **ionic compounds** and in simple molecular substances. *(4 marks)*

ANSWERS

Answers

1

a $2Na + Cl_2 \rightarrow 2NaCl$ *(1 mark)*

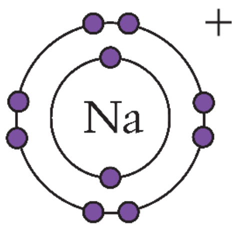
b Students should copy and complete the diagrams from the student sheet, so produce the following. Award a maximum of four marks from the following:

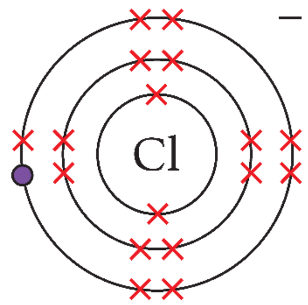
electrons drawn correctly on sodium *(1 mark)*

'plus' sign indicating positive charge on sodium *(1 mark)*

electrons drawn correctly on chlorine *(1 mark)*

'minus' sign indicating negative charge on chloride *(1 mark)*





c Sodium chloride is an ionic compound. *(1 mark)*

The sodium and chloride ions are held together by strong electrostatic forces. *(1 mark)*

A large amount of energy is required to break these forces of attraction so sodium chloride will only melt at a high temperature. *(1 mark)*

d Solid sodium chloride does not conduct electricity because the ions are held in a lattice and cannot move. *(1 mark)*

e In molten sodium chloride, the ions can move. *(1 mark)*

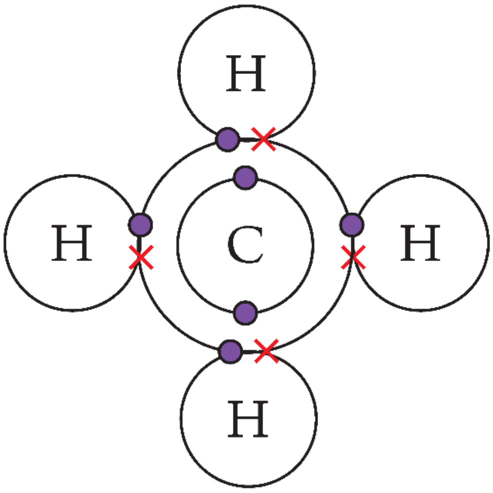
2

a $C + 2H_2 \rightarrow CH_4$ *(1 mark)*

b Students should copy and complete the diagrams from the student sheet, so produce the following. Award one mark for each of the following:

six electrons from carbon all placed correctly *(1 mark)*

one electron from each hydrogen, placed correctly. *(1 mark)*



c Methane does not conduct electricity because it has no overall electrical charge. *(1 mark)*

d In ionic compounds, electrons are transferred from metal atoms to non-metal atoms to form positively and negatively charge ions. *(1 mark)*

These ions are then held together by strong electrostatic charges. In simple molecular substances, non-metal atoms are held together by shared pairs of electrons. *(1 mark)*

There are strong covalent bonds between the atoms within a simple molecule but only very weak forces of attraction between the molecules. *(1 mark)*

Little energy is required to break the forces of attraction between the molecules so methane melts and boils at low temperatures and is a gas at room temperature. *(1 mark)*

5 Stretch and Challenge
Structure and bonding in aluminium chloride

Specification reference

- *2.2.2 a) b) c) d) e) (i) g) h) j) (i)*

Introduction

Aluminium chloride ($AlCl_3$) is an unusual compound. Aluminium, in Group 3 of the periodic table is a metal and chlorine is a non-metal, so you would expect the bonding in aluminium chloride to be ionic; however this is not always the case.
In this activity you will investigate the bonding of aluminium chloride in its different states, applying knowledge that you have gained throughout 'Chapter 5: Electrons and bonding'.

Learning outcomes

After completing the worksheet you should be able to:

- construct dot-and-cross diagrams for ionic and covalent compounds
- explain the structure of giant ionic lattices, resulting from oppositely charged ions strongly attracted in all directions
- explain the effect of structure and bonding on the physical properties of ionic and covalent compounds
- predict and explain the shapes of molecules, using electron pair repulsion theory
- draw 3-D diagrams of molecules.

Background

In solid aluminium chloride ionic bonding is observed, and solid aluminium chloride shows the expected properties of an ionic solid. However, when aluminium chloride is heated to temperatures above 180 °C, it sublimes (turns directly from a solid to a gas) and the structure and bonding changes dramatically. Covalent bonds now exist between aluminium and chlorine atoms. As a result, molecules of aluminium chloride are formed. These are found to have the formula Al_2Cl_6, and are also found in liquid aluminium chloride. At higher temperatures still, molecules of $AlCl_3$ are formed.

Chemists have found that the Al_2Cl_6 is a dimer – that is, it consists of two $AlCl_3$ molecules joined together. The structure is thought to be that shown in Figure 1.

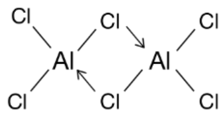


Figure 1 *The structure of the aluminium chloride dimer*

The ability of aluminium to bond covalently under certain circumstances means that aluminium chloride can show some unusual chemical reactions. It reacts violently with water releasing HCl gas and eventually forming hydrated aluminium ions, $Al(H_2O)_6^{3+}$. It is also a very important catalyst in a reaction called the Friedel–Crafts reaction, which is used in the synthesis of organic molecules, allowing carbon chains to join onto benzene rings.

Questions

1 **a** Draw a dot-and-cross diagram to show the structure of the ions in solid aluminium chloride (outer shell only). (*2 marks*)

b The ionic lattice has a structure in which six chloride ions surround one aluminium ion, in an octahedral arrangement. Draw a 3D diagram to show this arrangement. (*2 marks*)

c Solid aluminium chloride has the empirical formula $AlCl_3$. Use the information in part **b** to suggest how many aluminium ions surround each chloride ion in the ionic lattice. Explain your answer. (*2 marks*)

2 At high temperatures, molecules of $AlCl_3$ are formed.

a) Draw a dot-and-cross diagram to show the bonding in an $AlCl_3$ molecule, showing outer electrons only. (*2 marks*)

b) Predict, using your dot and cross diagram, the shape of the $AlCl_3$ molecule, and suggest a value for the bond angle. (*1 mark*)

3 When solid $AlCl_3$ is heated just above 180 °C, molecules of Al_2Cl_6 are formed.

a) Look at the diagram of the Al_2Cl_6 molecule shown in Figure 1. Explain the meaning of the arrows pointing from some of the chlorine atoms to the aluminium atom. (*2 marks*)

b) Draw a dot-and-cross diagram to show the bonding in the molecule Al_2Cl_6. (*2 marks*)

c) Using information from your dot-and-cross diagram, draw the 3D structure of the Al_2Cl_6 molecule, making a prediction for any bond angles in the molecule. (*3 marks*)

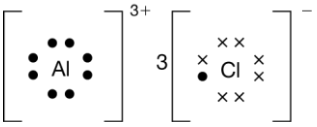
4 Aluminium chloride has a relatively low melting point compared to other ionic compounds.

a) Discuss one way in which you would expect aluminium chloride to be similar to, and one way in which you would expect it to differ from, the typical properties of ionic compounds, other than its melting and boiling points. (*6 marks*)

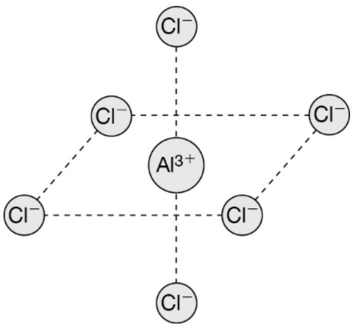
b) The bonding in aluminium chloride is sometimes described as 'ionic with some covalent character'. The bonding in magnesium chloride does not have significant covalent character. Suggest two differences between aluminium and magnesium ions that might explain the different types of bonding observed in these compounds. (*2 marks*)

Answers

1 a Both ions correct (*1 mark*)
charges correct on both ions (*1 mark*)

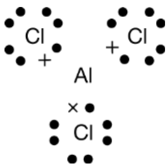


b 6 Cl^- ions around Al^{3+} (*1 mark*)
arrangement is clearly 3-dimensional and octahedral (*1 mark*)



c There are six Cl^- ions around each Al^{3+}. (*1 mark*)
So two Al^{3+} ions surround each Cl^- ion, giving an Cl : Al ratio of 3 : 1 (*1 mark*)
Students may find this difficult to visualise; please see the first bullet point in Teacher notes for guidance.

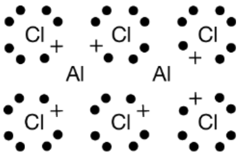
2 a Al outer shell correct (*1 mark*)
all Cl atoms correct (*1 mark*)



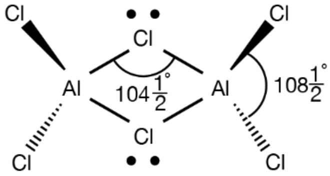
b Trigonal / triangular planar (*1 mark*)
120° (*1 mark*)

3 **a** Dative (or co-ordinate) bond. (*1 mark*)
A covalent bond in which both electrons are provided by the chlorine atom. (*1 mark*)

b Dative bonds shown correctly from chlorine to aluminium. (*1 mark*)
Rest of structure correct. (*1 mark*)



c Bonds around Al drawn to look tetrahedral (*1 mark*)
one Cl–Al–Cl bond angle marked in range 100–115° (*1 mark*)
one Al–Cl–Al bond marked in range 95–110° (smaller than Cl–Al–Cl angle). (*3 marks*)



4 a

Question	Answer	Marks	Guidance
4 a	**Level 3 (5–6 marks)** One similarity and one difference clearly identified. AND For each difference there is clear link to the behaviour of ions or covalent molecules. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3-4 marks)** One similarity or difference clearly identified. AND Reference to the behaviour of ions / covalent molecules, with an attempt to link to the property under discussion. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1-2 marks)** Reference is made to a similarity or difference, but some details may be missing. AND Some relevant mention of the behaviour of ions / covalent molecules but this is not clearly linked to the similarity / difference. *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** *No response or no response worthy of credit*	6	Similar to other ionic compounds: solid soluble in water (as described in passage) OR will conduct when in solution different to other ionic compounds: will not conduct electricity when molten) Discussion: Charged ions are present in solid; Ions will be attracted to water molecules; Ions will move in response to electric field; Covalent molecules / No charged ions present in liquid Will not attract water Will not move in response to electric field

b Aluminium ions (3+) have a higher charge than magnesium ions (2+). (*1 mark*)
Aluminium ions are smaller than magnesium ions. (*1 mark*)

This high 'charge density' means that electrons in the chloride ion can be attracted towards the aluminium ion, causing a distortion of the chloride ion (called polarisation of the ion). As a result, there is some electron density between the aluminium and chloride ions and this creates some covalent character in the bond.

5 Electrons and Bonding: Checklist
Electrons and bonding

Specification reference	Checklist questions	
2.2.2 a	Can you describe ionic bonding as electrostatic attraction between positive and negative ions, and the construction of '*dot-and-cross*' diagrams?	☐
2.2.2 b	Can you explain the solid structures of giant ionic lattices, resulting from oppositely charged ions strongly attracted in all directions (e.g. NaCl)?	☐
2.2.2 c	Can you explain the effect of structure and bonding on the physical properties of ionic compounds, including melting and boiling points, solubility and electrical conductivity in solid, liquid and aqueous states?	☐
2.2.2 d	Can you describe covalent bond as the strong electrostatic attraction between a shared pair of electrons and the nuclei of the bonded atoms?	☐
2.2.2 e	Can you construct '*dot-and-cross*' diagrams of molecules and ions?	☐
2.2.2 e i	Can you construct '*dot-and-cross*' diagrams of molecules and ions to describe single covalent bonding?	☐
2.2.2 e ii	Can you construct '*dot-and-cross*' diagrams of molecules and ions to describe multiple covalent bonding?	☐
2.2.2 e iii	Can you construct '*dot-and-cross*' diagrams of molecules and ions to describe dative covalent (coordinate) bonding?	☐
2.2.2 f	Can you use the term *average bond enthalpy* as a measurement of covalent bond strength?	☐