Cambridge (CIE) IGCSE Chemistry

Your notes

Ions & Ionic Bonds

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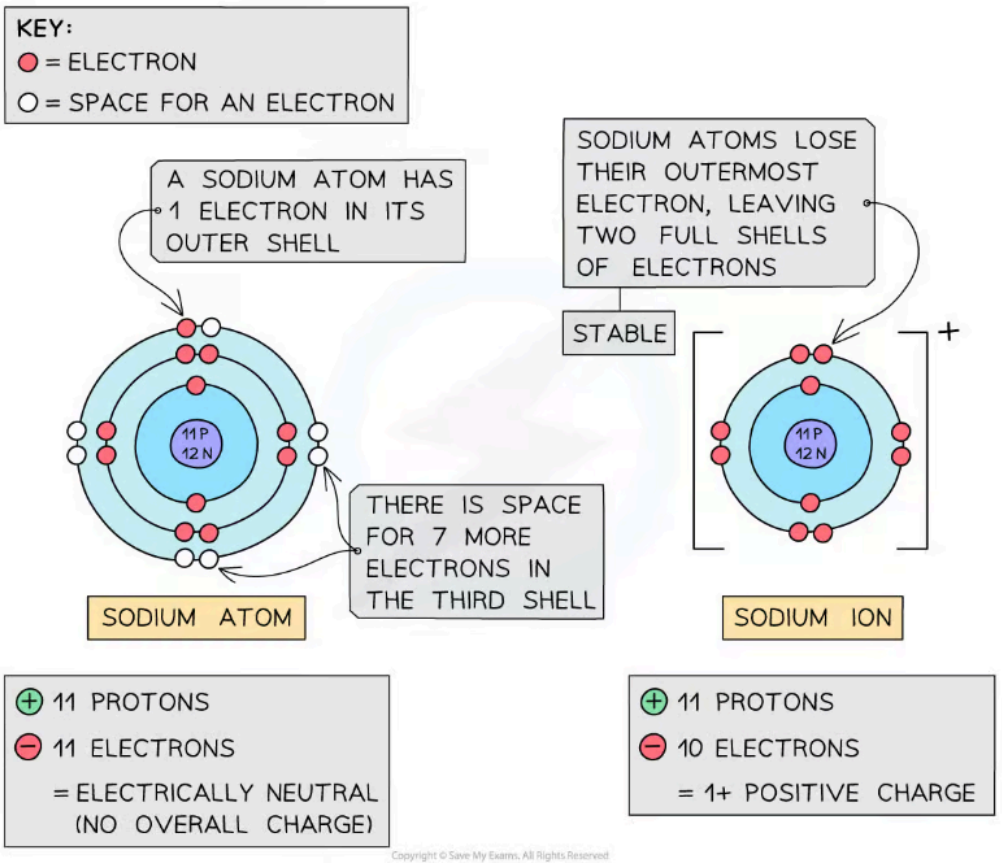
Your notes

The formation of ions

How are ions formed?

- An **ion** is an electrically charged atom or group of atoms formed by the **loss or gain of electrons**
- This loss or gain of electrons takes place to obtain a **full outer shell** of electrons
- The electronic structure of ions of elements in Groups 1, 2, 6 and 7 will be the same as that of a noble gas - such as helium, neon, and argon
- Negative ions are called **anions** and form when atoms **gain** electrons, meaning they have more electrons than protons
- Positive ions are called **cations** and form when atoms **lose** electrons, meaning they have more protons than electrons
- All metals **lose** electrons to other atoms to become positively charged ions
- All non-metals **gain** electrons from other atoms to become negatively charged ions

Formation of a cation



Formation of positively charged sodium ion

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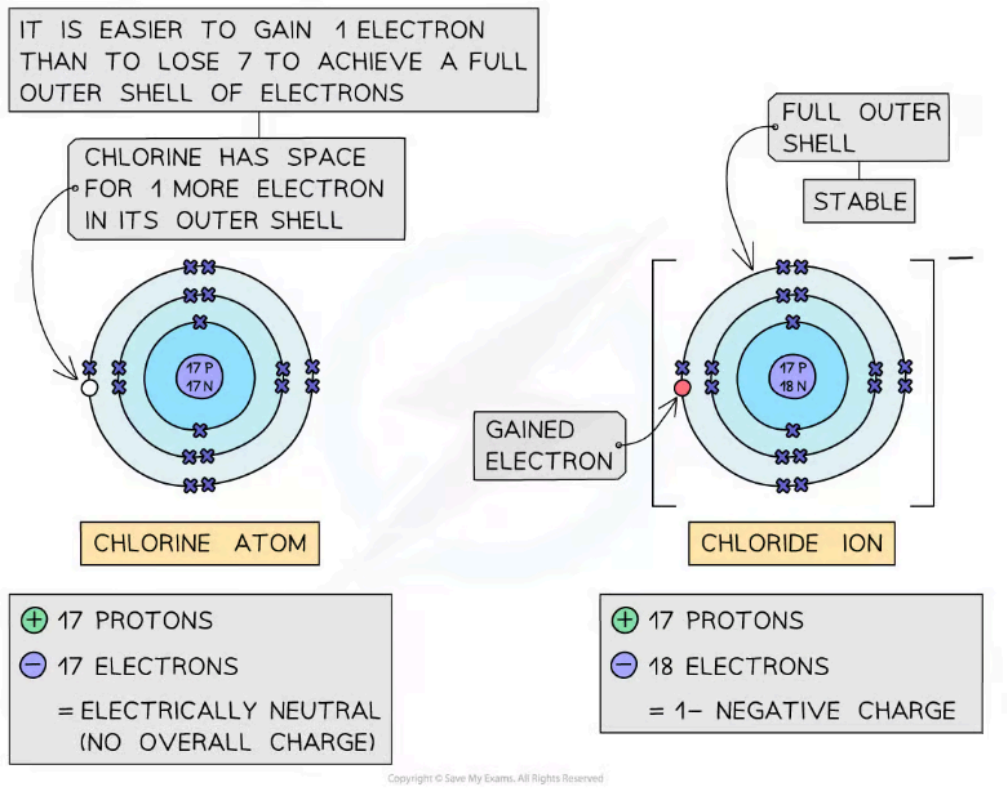
Formation of an Anion



Formation of negatively charged chloride ion

Examiner Tips and Tricks

- We can determine the charge an ion will have from the group the element is found in:
  - Elements in Group 1 form ions with a 1+ charge
  - Elements in Group 2 form ions with a 2+ charge
  - Elements in Group 6 form ions with a 2− charge
  - Elements in Group 7 form ions with a 1− charge

What is ionic bonding?

The Formation of Ionic Bonds

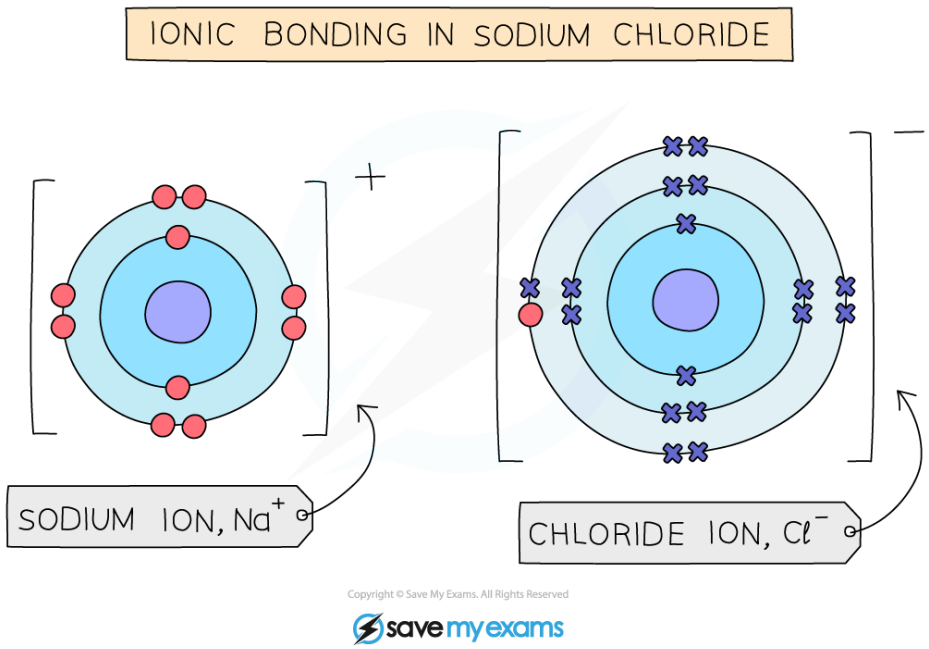
- Ionic compounds are formed when metal atoms react with non-metal atoms

- Metal atoms **lose** their outer electrons which the non-metal atoms **gain** to form positive and negative ions
- The positive and negative ions are held together by strong **electrostatic forces of attraction** between **opposite** charges
- This force of attraction is known as an **ionic bond** and they hold ionic compounds together

Your notes

Dot-and-cross diagrams

- **Dot and cross diagrams** are diagrams that show the arrangement of the outer-shell electrons in an **ionic** or **covalent** compound or element
- The electrons are shown as dots and crosses
- In a dot and cross diagram:
  - Only the outer electrons are shown
  - The charge of the ion is spread evenly which is shown by using brackets
  - The charge on each ion is written at the top right-hand corner



Electrostatic forces between the positive Na ion and negative Cl ion

Ionic bonds between Group I & Group VII elements

Group I & Group VII Ions

- Sodium is a Group 1 metal so **loses** one outer electron to another atom to gain a full outer shell of electrons
- A positive sodium ion with the charge 1+ is formed, Na^+
- Chlorine is a Group 7 non-metal so gains one electron to have a full outer shell of electrons
- A negative chloride ion with a charge of 1– is formed, Cl^-
- The ions are then attracted to one another and held together by **electrostatic forces**
- The formula of the ionic compound is thus NaCl
- The large square brackets should encompass each atom and the charge should be in superscript and on the right-hand side, outside the brackets

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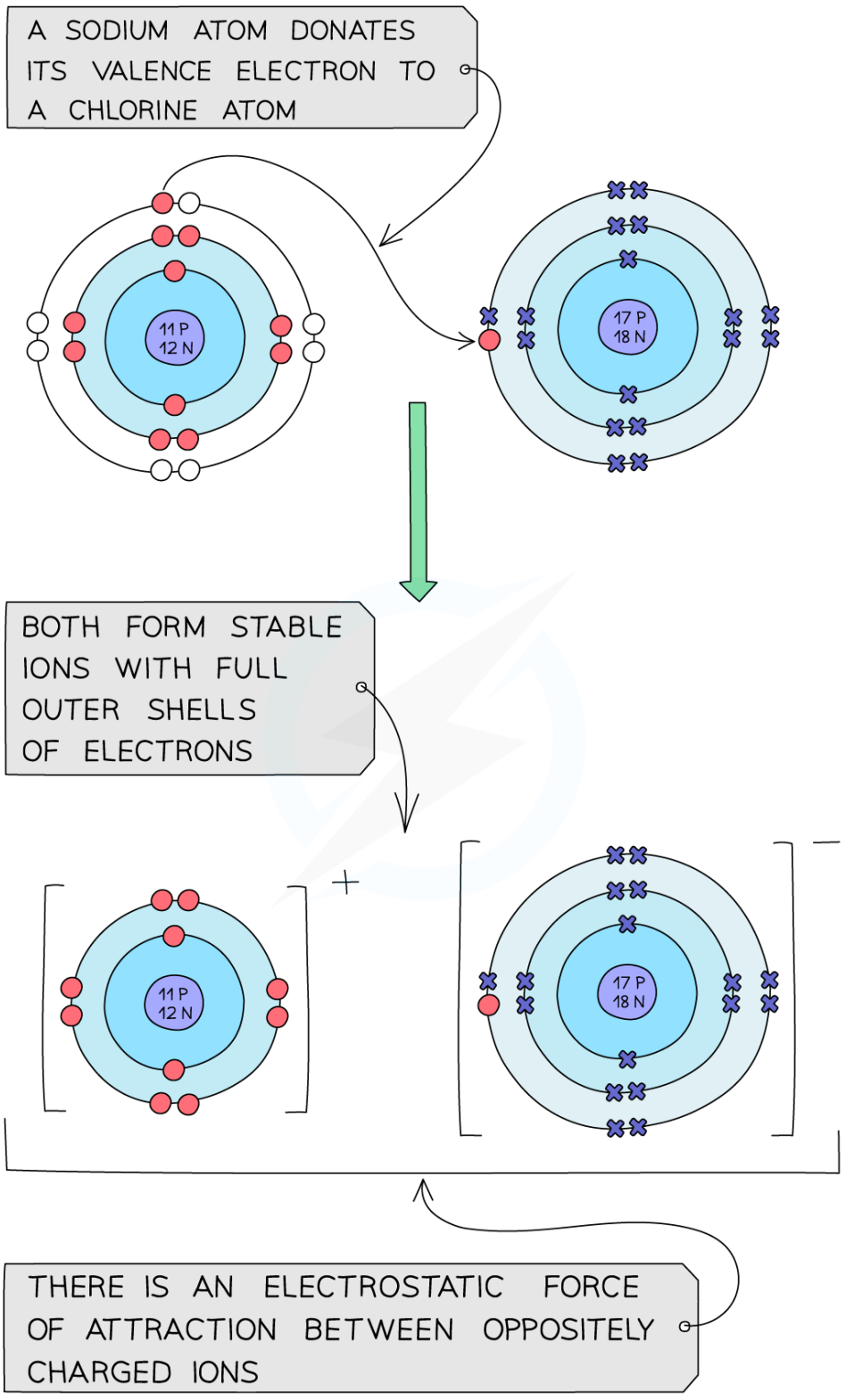
Diagram representing the formation of the ionic bond in sodium chloride



Sodium loses one electron and chlorine gains an electron

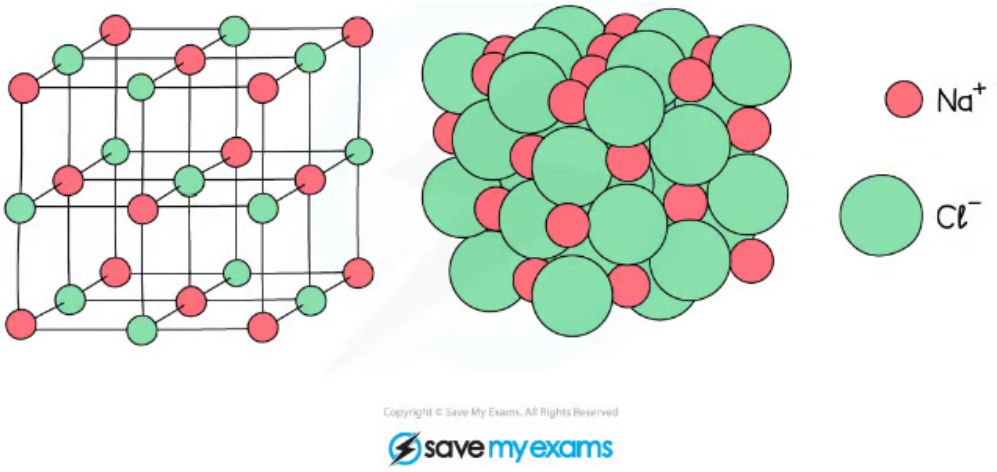
Your notes

The lattice structure of ionic compounds

Extended tier only

Lattice structure

- Ionic compounds have a **giant lattice** structure
- Lattice structure refers to the arrangement of the atoms of a substance in 3D space
- In lattice structures, the atoms are arranged in an **ordered** and **repeating** fashion
- The lattices formed by ionic compounds consist of a **regular arrangement** of **alternating** positive and negative ions



The lattice structure of NaCl

Ionic bonds between metallic & non-metallic elements

Extended tier only

Ionic compounds

- Ionic compounds are formed when metal atoms and non-metal atoms react
- The ionic compound has **no** overall charge

Example; magnesium Oxide, MgO

- Magnesium is a Group II metal so will lose two outer electrons to another atom to have a full outer shell of electrons
- A positive ion with the charge 2+ is formed
- Oxygen is a Group VI non-metal so will need to gain two electrons to have a full outer shell of electrons
- Two electrons will be transferred from the outer shell of the magnesium atom to the outer shell of the oxygen atom
- Oxygen atom will gain two electrons to form a negative ion with charge 2–
- Magnesium oxide has no overall charge
  - MgO

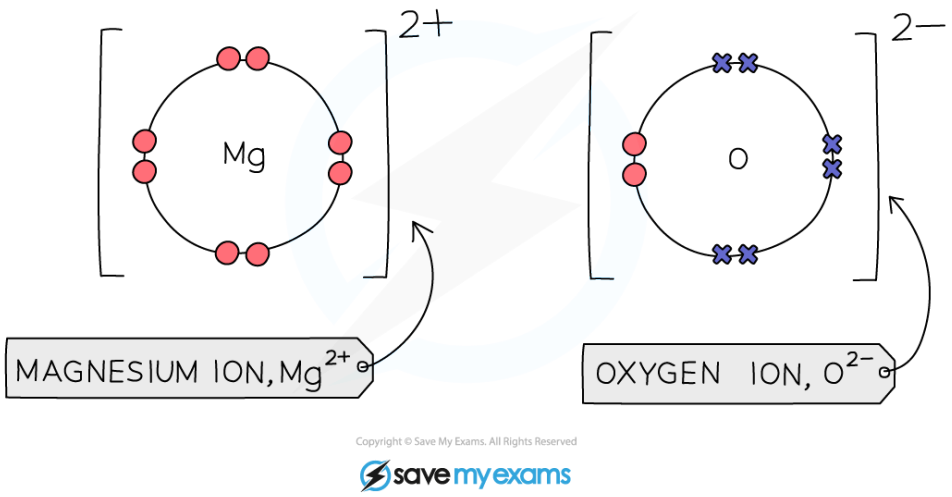


Diagram showing the dot-and-cross diagram of magnesium oxide

Examiner Tips and Tricks

When drawing dot and cross diagrams, you only need to show the outer shell of electrons. Remember to draw square brackets and include a charge for each ion. Make sure the overall charge is 0; you may need to include more than one positive or negative ion to ensure the positive and negative charges cancel each other out.

Your notes

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Properties of ionic compounds

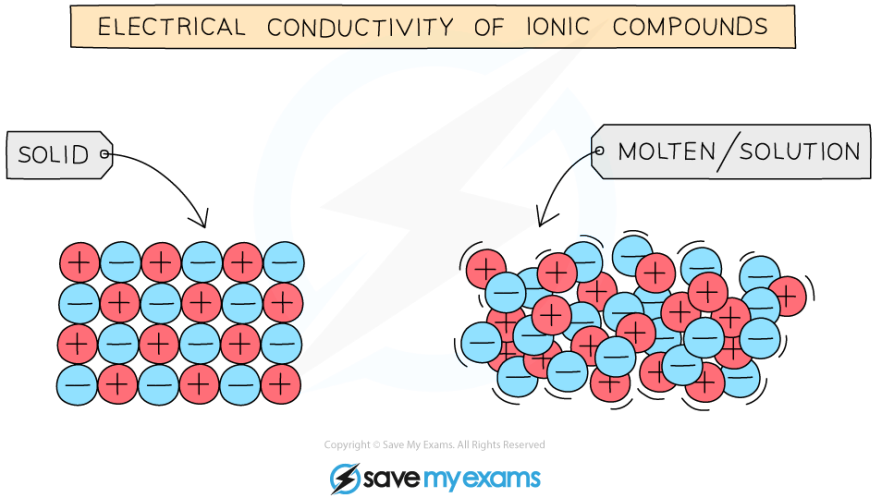
- Ionic compounds are usually **solid** at room temperature
- They have **high** melting and boiling points
- Ionic compounds are good conductors of electricity in the **molten** state or in **solution**
- They are poor conductors in the solid state

Explaining the properties of ionic compounds

Extended tier only

- Ionic compounds have **high melting** and **boiling points**
  - They have giant structures
  - There are strong electrostatic forces of attraction between oppositely charged ions in all directions
  - The forces need lots of energy to overcome them
- Ionic compounds are **poor conductors in the solid state**
  - The ions are in fixed positions in the lattice
  - They are therefore unable to move and carry a charge
- Ionic compounds are **good conductors of electricity in the molten state or in solution**
  - When the ionic compound is melted or dissolved in water, the ions are able to move and carry a charge
- The greater the charge on the ions, the stronger the electrostatic forces and the higher the melting point will be
  - For example, magnesium oxide consists of Mg^{2+} and O^{2-} so will have a higher melting point than sodium chloride which contains the ions, Na^{+} and Cl^{-}

Diagram to show the electrical conductivity of ionic compounds



Molten or aqueous ions move freely but cannot in solid form

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