Edexcel GCSE Chemistry

Your notes

Ionic Bonding

Contents

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Ions

What are ions?

- An ion is an **electrically charged** atom or group of atoms formed by the **loss** or **gain** of **electrons**
- 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

Deducing subatomic particles in ions

- An atom is **neutral** and has no overall charge
- Ions on the other hand have either **gained** or **lost** electrons causing them to become **charged**
- The number of **subatomic particles** in atoms and ions can be determined given their atomic (proton) number, mass (nucleon) number and charge
- Ions have a different number of electrons to the number of protons, depending on their charge
  - A positively charged ion has **lost** electrons and therefore has **fewer** electrons than protons
  - A negatively charged ion has **gained** electrons and therefore has **more** electrons than protons

Worked Example

Determine the number of protons, neutrons & electrons of the following ions:

1. Mg^{2+} ion
2. F^{-} ion

Answer 1:

- The atomic number of a magnesium atom is 12 and the mass number is 24
- Therefore, the number of protons in a **Mg^{2+} ion** is 12
  - **Remember:** The number of protons does not change when an ion is formed

- An atom of magnesium is electronically neutral, which means that the number of protons equals the number of electrons
  - However, the 2+ charge in an Mg^{2+} ion means it has **lost** two electrons
  - So, it has 12 - 2 = 10 electrons
- Number of neutrons = mass number – atomic (proton) number
  - Number of neutrons = 24 – 12
  - Number of neutrons = 12

Answer 2:

- The atomic number of a fluorine atom is 9 and the mass number is 19
- Therefore, the number of protons in an **F^- ion** is 9
  - **Remember:** The number of protons does not change when an ion is formed
- An atom of fluorine is electronically neutral, which means that the number of protons equals the number of electrons
  - However, the 1– charge in an F^- ion means it has **gained** one electron
  - So, it has 9 + 1 = 10 electrons
- Number of neutrons = mass number – atomic (proton) number
  - Number of neutrons = 19 – 9
  - Number of neutrons = 10

Examiner Tips and Tricks

- The number of electrons that an atom gains or loses is the same as the charge
- For example:
  - If a magnesium atom loses 2 electrons, then the charge will be 2+
  - If a bromine atom gains 1 electron then the charge will be 1–

Formation of Ions

- 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, 3, 5, 6 and 7 will be the same as that of a noble gas - such as helium, neon, and argon

Deducing Dot & Cross Diagrams for Ionic Compounds

- Sodium is a group 1 metal so will lose one outer electron to another atom to gain a full outer shell of electrons

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- A positive sodium ion with the charge 1+ is formed

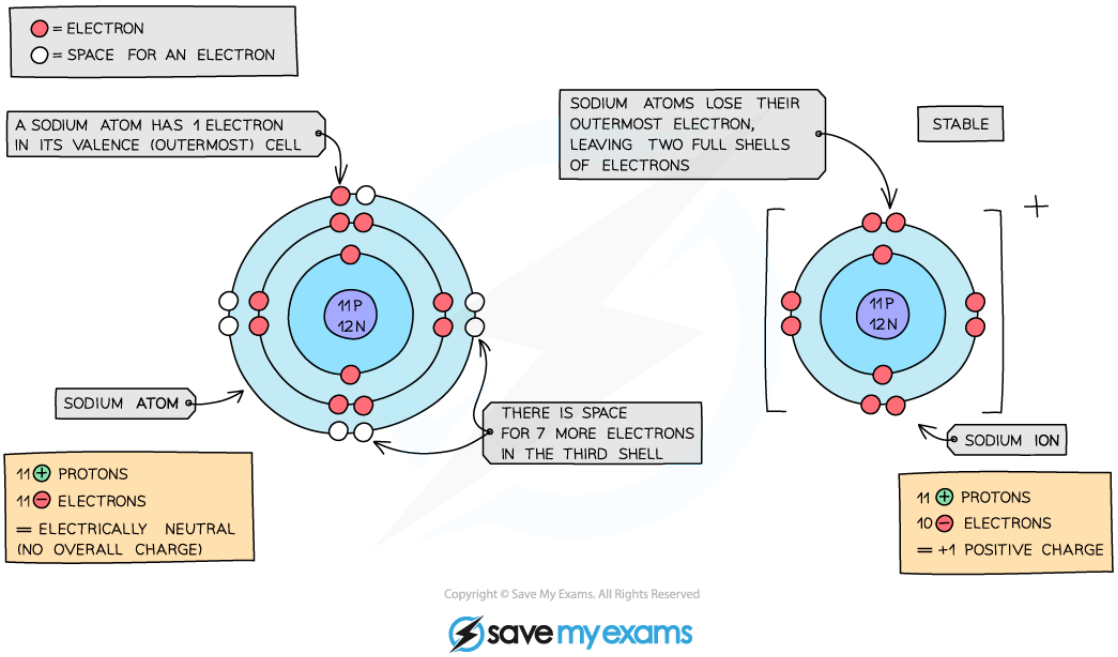

Diagram showing the formation of the sodium ion

- Chlorine is a group 7 non-metal so will need to gain an electron to have a full outer shell of electrons
- One electron will be transferred from the outer shell of the sodium atom to the outer shell of the chlorine atom
- A chlorine atom will gain an electron to form a negatively charged chloride ion with a charge of -1

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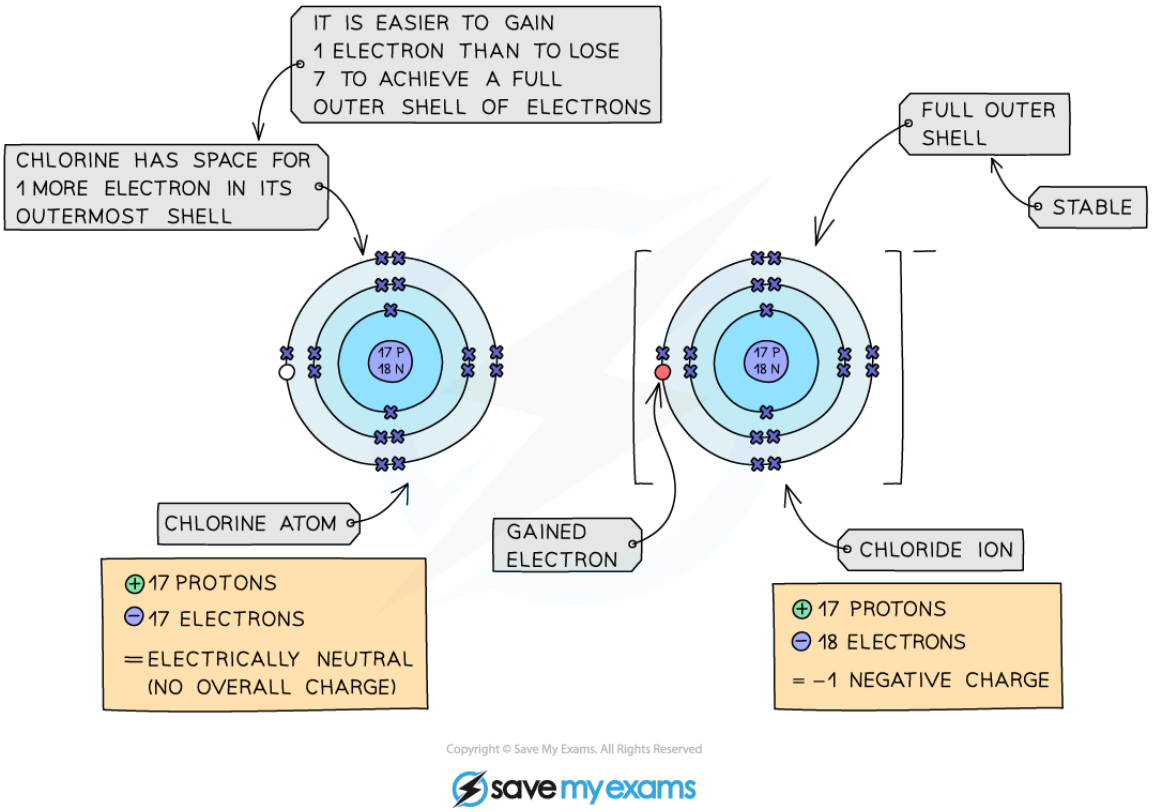

Diagram showing the formation of the chloride ion

Examiner Tips and Tricks

For exam purposes you need only show the outer electrons in dot & cross diagrams.When writing about ions, we use the notation 1−, 2+ etc. to describe the charge of the ion, with the number first followed by the sign (+/-). It is incorrect to write them the other way around as this refers to the oxidation state, not the charge.

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Ionic Bonds

Sodium Chloride Dot & Cross Diagram

- The process of ion formation does not happen in isolation; sodium atoms want to lose electrons and chlorine atoms want to gain electrons
- We can use dot & cross diagram to show this as one continuous process
- The positive and negative charges are held together by the strong **electrostatic forces of attraction** between **oppositely** charged ions
- This is what holds ionic compounds together

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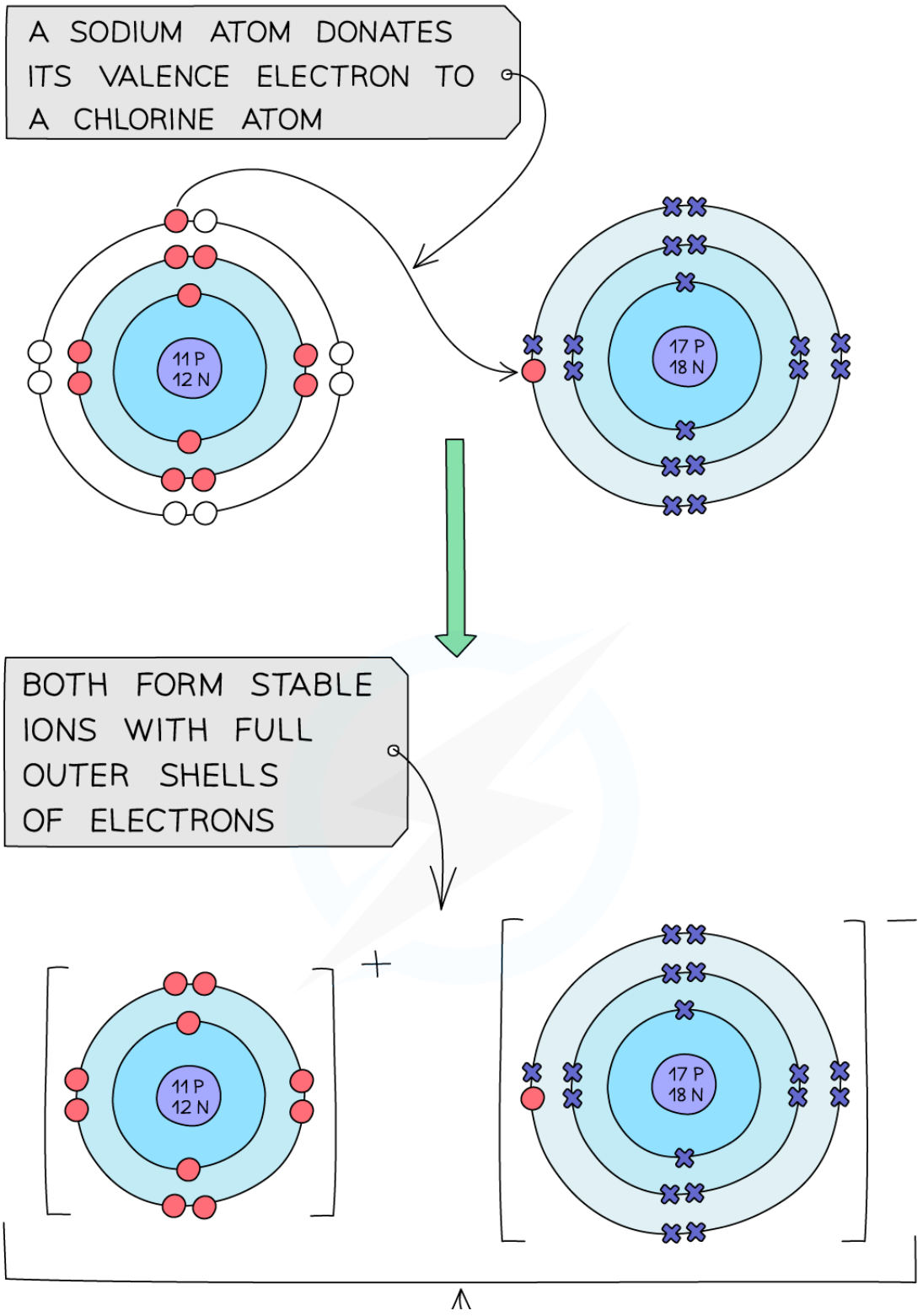

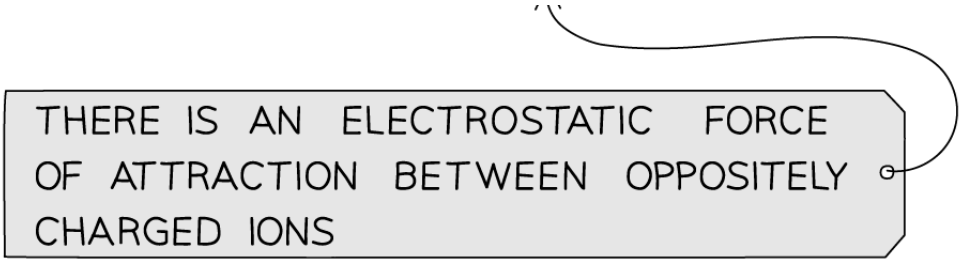

Sodium chloride ionic bonding

Magnesium Oxide Dot & Cross Diagram

- Magnesium is a group 2 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 6 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
- The oxygen atom will gain the two electrons
  - A negative ion with charge 2– is formed

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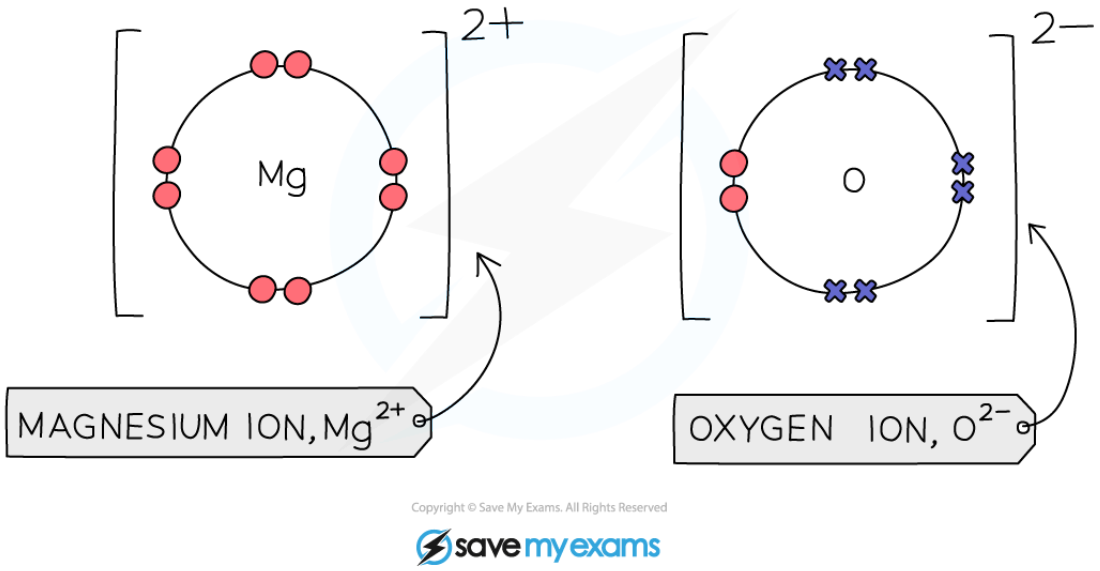

Diagram showing the dot-and-cross diagram of magnesium oxide

Examiner Tips and Tricks

You should be able to draw dot & cross diagrams for combinations of ions from groups 1,2, 6 and 7.

Ionic Lattices

- Ionic compounds are made of charged particles called ions which form a **giant lattice** structure
- A lattice is a regular repeating arrangement of particles, in this case, ions
- Ionic substances have **high** melting and boiling points due to the presence of **strong electrostatic forces** acting between the oppositely charged ions
- These forces act in all directions and a lot of energy is required to overcome them

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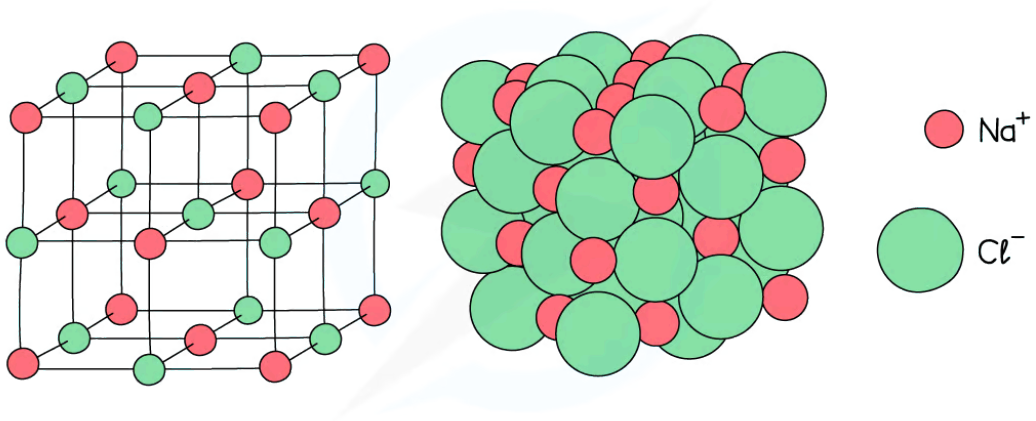

Strong electrostatic forces act in all directions in an ionic solid such as sodium chloride

Examiner Tips and Tricks

Ions with higher charge have stronger electrostatic forces and will thus have higher melting and boiling points.

Names & Formulae of Ionic Compounds

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Naming Ionic Compounds

- Ionic compounds contain metal and non-metal elements joined together as particles called ions
- The metal element's symbol is always written first
- The non-metal element always takes on the name ending '– ide' **unless oxygen is also present,**
  - For example, PbS is called lead sulfide and $MgCl_2$ is called magnesium chloride
- When oxygen is present the name ending is usually '-ate'
  - For example, $CuSO_4$ is copper sulfate, $KClO_3$ is potassium chlorate and Na_2CO_3 is sodium carbonate

Deducing Formulae

- The formulae of simple ionic compounds can be calculated if you know the charge on the ions
- Below are some common ions and their charges:

Common Ions & Their Charges Table

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Ion	Formula and charge
Oxide	O^{2-}
Chloride	Cl^{-}
Bromide	Br^{-}
Iodide	I^{-}
Hydroxide	OH^{-}
Nitrate	NO_3^{-}
Sulfate	SO_4^{2-}
Carbonate	CO_3^{2-}

- For ionic compounds you have to balance the charge of each part by multiplying each ion until the sum of the charges = 0
- Example: what is the formula of aluminium sulfate?
  - Write out the formulae of each ion, including their charges
  - Al^{3+} SO_4^{2-}
- Balance the charges by multiplying them out:

  Al^{3+} x **2** = +6 and SO_4^{2-} x **3** = -6; so +6 – 6 = 0
- So the formula is $Al_2(SO_4)_3$

Examiner Tips and Tricks

Another method that also works is to 'swap the numbers'. In the example above the numbers in front of the charges of the ions (3 and 2) are swapped over and become the multipliers in the formula (2 and 3). Easy when you know how!


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