Cambridge (CIE) A Level Chemistry

Your notes

Ionic Bonding

Contents

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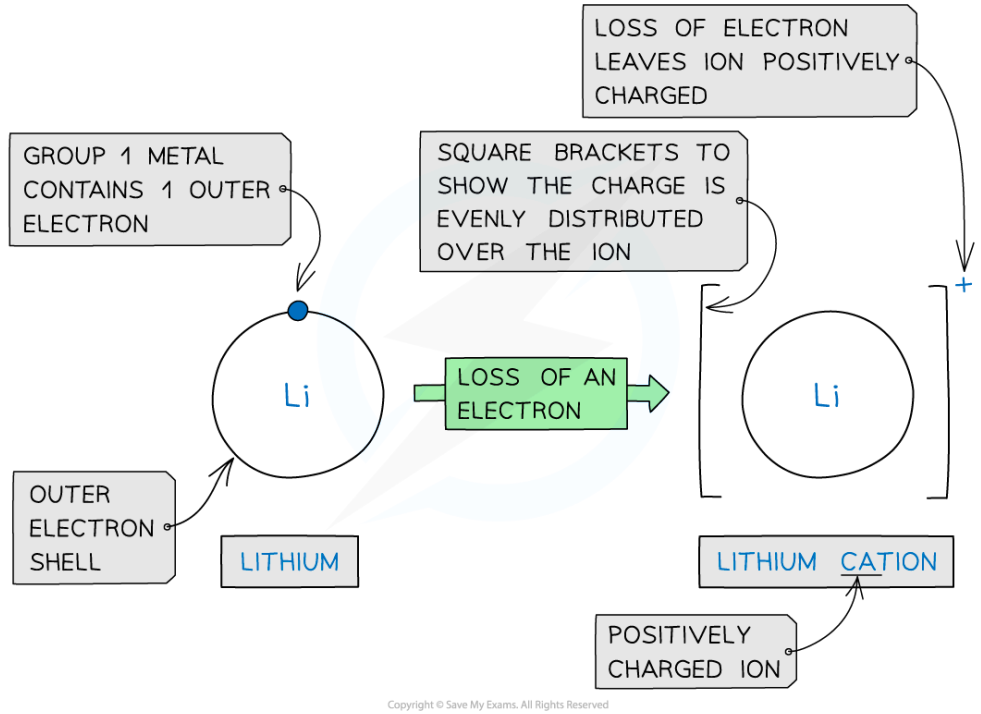
Defining Ionic Bonding

- As a general rule, **metals** are on the **left** of the Periodic Table and **non-metals** are on the **right-hand** side
- **Ionic bonding** involves the **transfer** of electrons from a **metallic** element to a **non-metallic** element
- Transferring electrons usually leaves the metal and the non-metal with a **full outer shell**
- Metals **lose** electrons from their valence shell forming **positively charged cations**

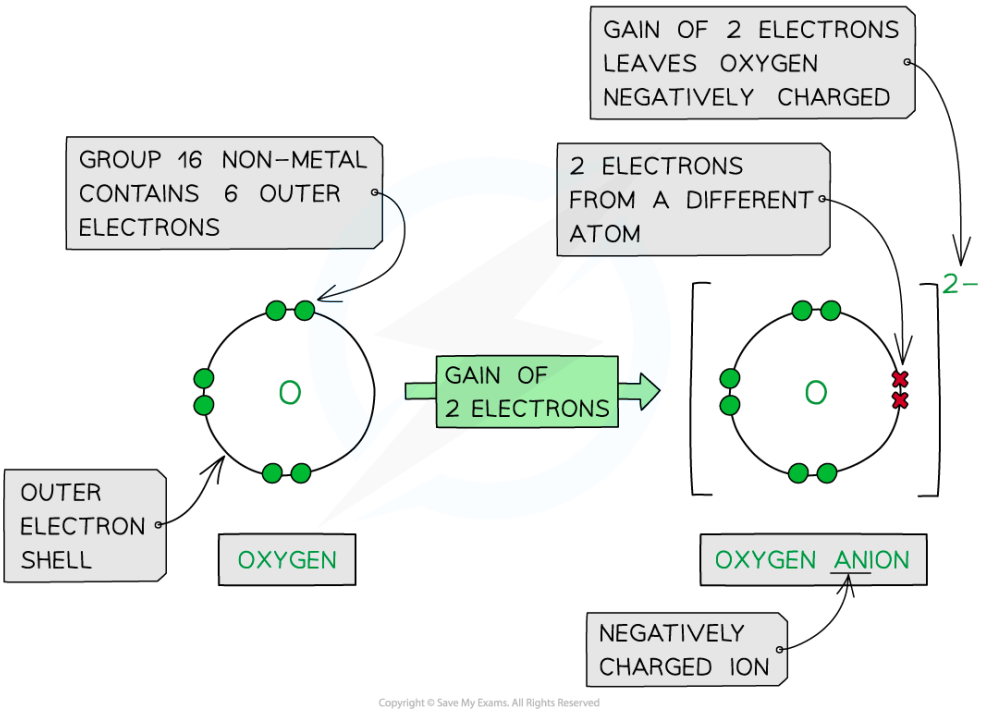
Formation of cations



Cations are formed by the removal of electrons from metals

- Non-metal atoms **gain** electrons, forming **negatively charged anions**
- Once the atoms become ions, their electronic configurations are the same as a stable noble gas.
  - A potassium ion (K^+) has the same electronic configuration as argon: $[2,8,8]^+$
  - A chloride ion (Cl^-) also has the same electronic configuration as argon: $[2,8,8]^-$

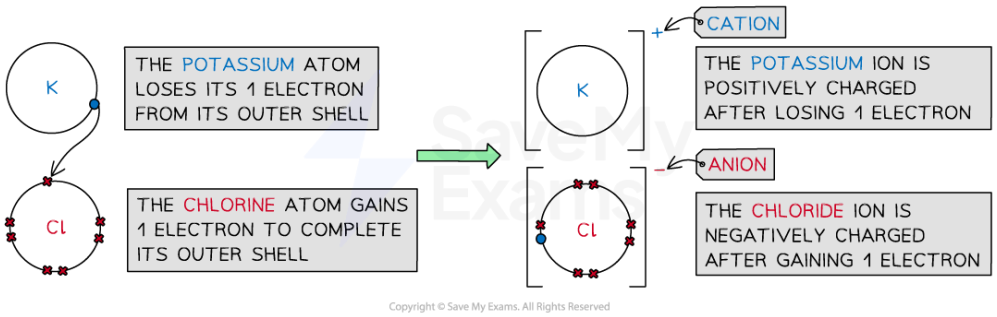
Formation of anions



Anions are formed by the addition of electrons to non-metals

- **Cations** and **anions** are oppositely charged and therefore attracted to each other
- **Electrostatic attractions** are formed between the oppositely charged ions to form **ionic compounds**
- The **ionic bond** is the **electrostatic attraction** formed **between the oppositely charged ions**, which occurs in all directions
- This form of attraction is **very strong** and requires a **lot of energy** to overcome
  - This causes high melting points in ionic compounds

Using cations and anions to form ionic compounds



Cations and anions bond together using strong electrostatic forces, which require a lot of energy to overcome

- The ions form a **lattice structure** which is an evenly distributed **crystalline** structure

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- Ions in a lattice are arranged in a **regular repeating pattern** so that positive charges cancel out negative charges
- The attraction between the cations and anions is occurring in all directions
  - Each ion is attracted to all the oppositely charged ions around it
- Therefore, the final lattice is overall electrically **neutral**

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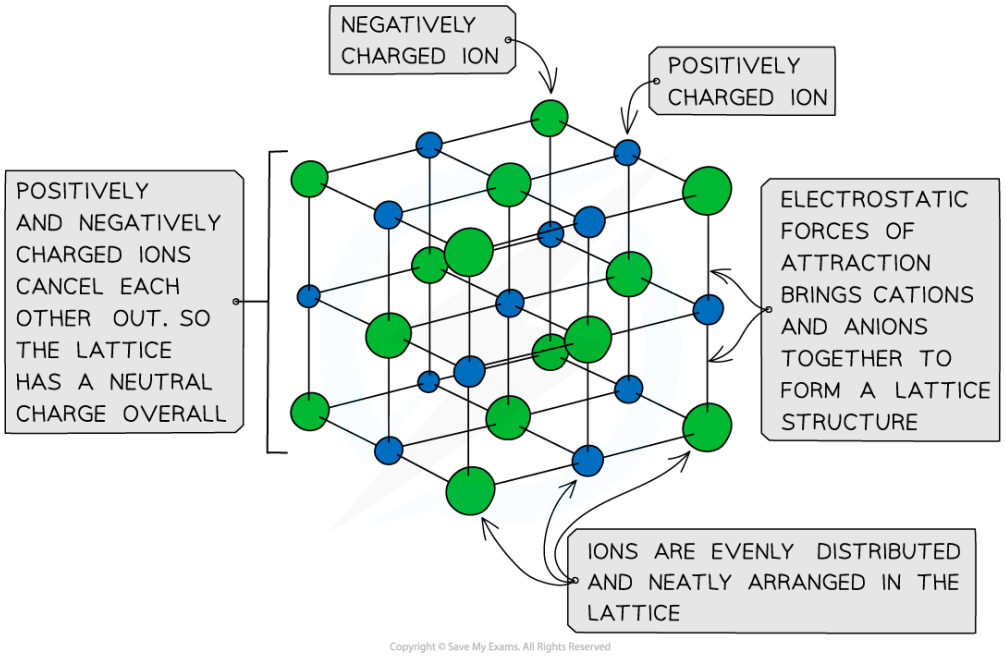
A general ionic lattice



Ionic solids are arranged in lattice structures with alternating cations and anions

Examiner Tips and Tricks

- **Metals** usually **lose** all electrons from their outer valence shell to become **cations**.
- You can make use of the groups on the Periodic Table to work out how many electrons an atom is likely to lose or gain by looking at the **group** an atom belongs to.
- The electrostatic attraction between oppositely charged ions is the ionic bond.

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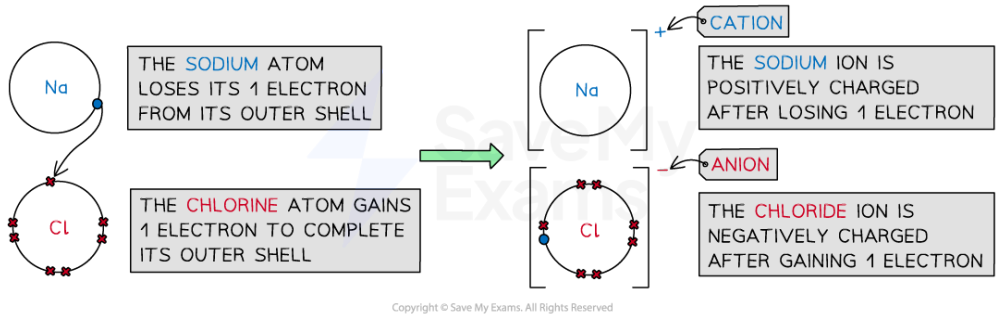
Examples of Ionic Bonding

Sodium chloride

- Sodium is a Group 1 **metal**
  - It **loses** its outer electron to form a sodium ion with a +1 charge (Na^+)
- Chlorine is a Group 7 **non-metal**
  - It **gains** 1 electron to form a chloride ion with a -1 charge (Cl^-)
- The oppositely charged ions are attracted to each other by **electrostatic forces** to form NaCl (ionic bonds)
- The final ionic solid is **neutral** in charge

Dot and cross diagram to show the ionic bonding in sodium chloride

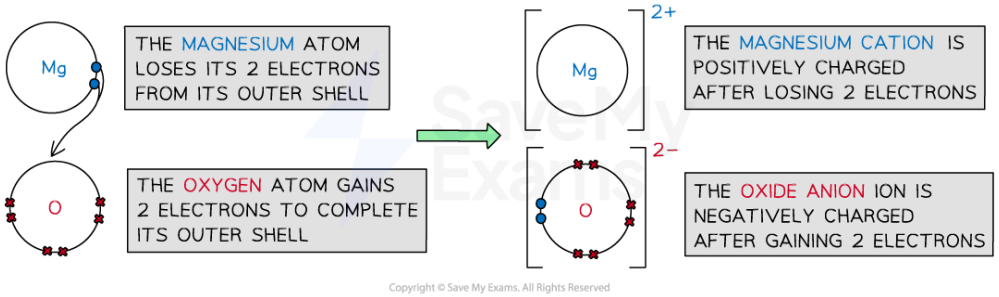


Sodium gives its one outer electron to chlorine forming the ionic compound, sodium chloride

Magnesium oxide

- Magnesium is a Group 2 **metal**
  - It **loses** its 2 outer electrons to form a magnesium ion with a +2 charge (Mg^{2+})
- Oxygen is a Group 6 **non-metal**
  - It **gains** 2 electrons to form an oxide ion with a -2 charge (O^{2-})
- The oppositely charged ions are attracted to each other to by **electrostatic forces** to form MgO (ionic bonds)
- The final ionic solid is **neutral** in charge

Dot and cross diagram to show the ionic bonding in magnesium oxide

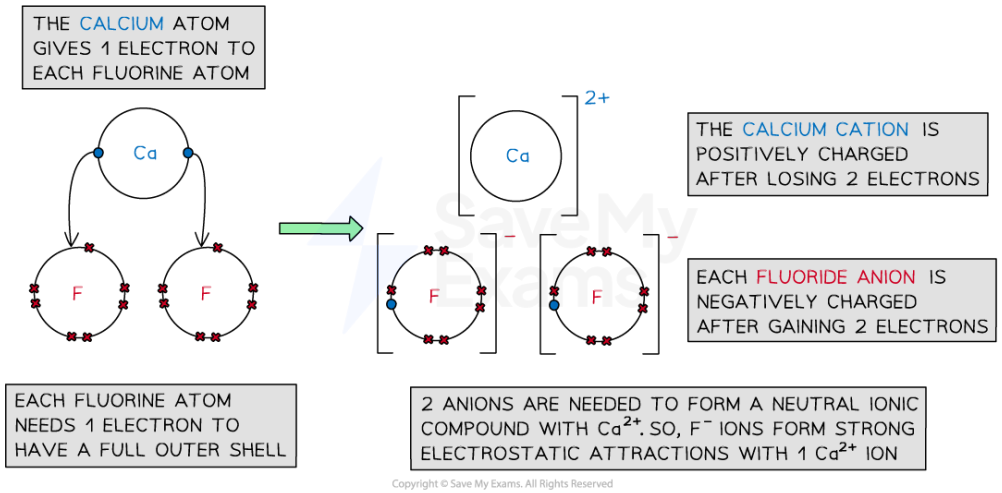


Magnesium gives both outer electrons to oxygen forming the ionic compound, magnesium oxide

Calcium fluoride

- Calcium is a Group 2 **metal**
  - It **loses** its 2 outer electrons to form a calcium ion with a +2 charge (Ca^{2+})
- Fluorine is a Group 7 **non-metal**
  - It **gains** 1 electron to form a fluoride ion with a -1 charge (F^-)
- As before, the positive and negative ions are attracted to each other via an ionic bond
- However, to cancel out the 2+ charge of the calcium ion, 2 fluorine atoms are needed
  - Each fluorine atom can only accept 1 electron from the calcium atom
  - 2 fluoride ions will be formed
- Calcium fluoride is made when 1 calcium ion and 2 fluoride ions form ionic bonds, CaF_2
- The final ionic solid of CaF_2 is **neutral** in charge

Dot and cross diagram to show the ionic bonding in calcium fluoride



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Calcium gives away both outer electrons. Each fluorine receives one of those electrons forming the ionic compound, calcium fluoride

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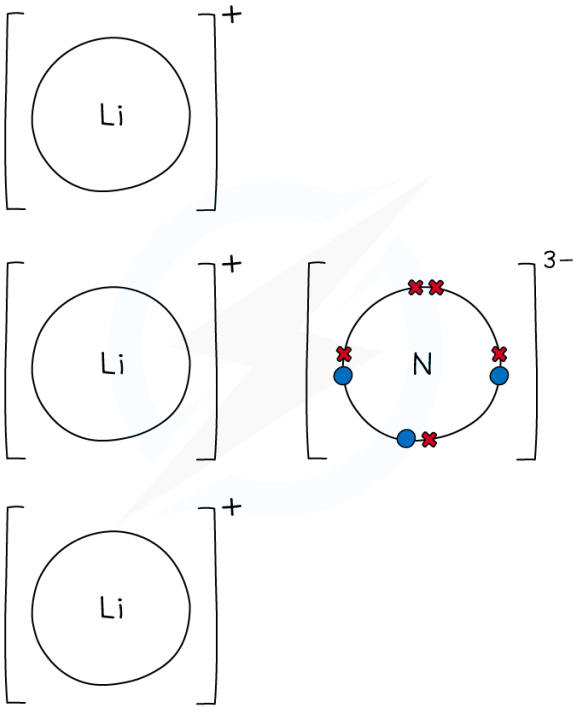
Worked Example

Dot & cross lithium nitride

Draw a dot and cross diagram for lithium nitride, Li_3N.

Answer

- Lithium is a Group 1 **metal**
  - It **loses** its outer electron to form a lithium ion with a +1 charge (Li^+)
- Nitrogen is a Group 5 **non-metal**
  - It **gains** 3 electrons to form a nitride ion with a -3 charge (N^{3-})
- To cancel out the -3 charge of the nitride ion, 3 lithium atoms are needed and 3 lithium ions will be formed
  - Lithium nitride is made when 1 nitride ion and 3 lithium ions form ionic bonds
- The final ionic solid of Li_3N is **neutral** in charge:



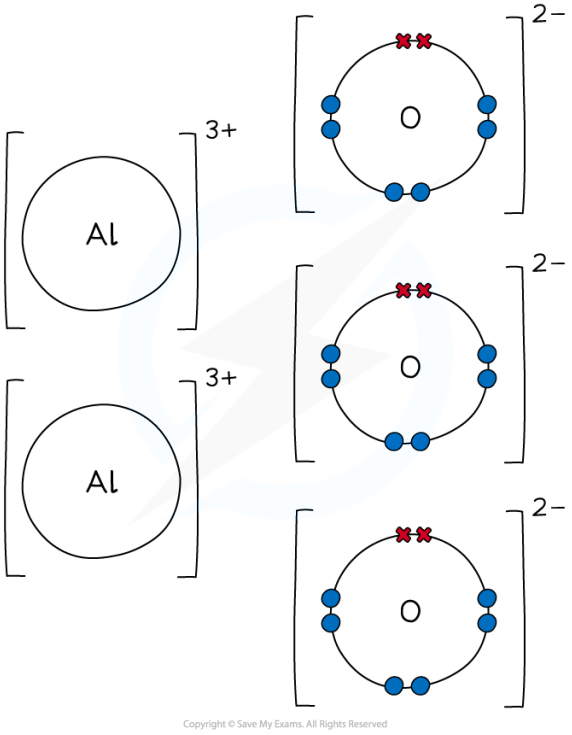
Worked Example

Dot & cross aluminium oxide

Draw a dot and cross diagram for aluminium oxide, Al_2O_3.

Answer

- Aluminium is a Group 3 **metal**
  - It **loses** its outer electrons to form an aluminium ion with a +3 charge (Al^{3+})
- Oxygen is a Group 6 **non-metal**
  - It **gains** 2 electrons to form an oxide ion with a -2 charge (O^{2-})
- To cancel out the negative and positive charges, 2 aluminium and 3 oxygen atoms are needed
  - Aluminium oxide is made when 2 aluminium ions and 3 oxygen ions form ionic bonds
- The final ionic solid of Al_2O_3 is **neutral** in charge:



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