

How ions bond: transfer and lattices

Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Lesson

Quick answer: Ionic bonding is the strong electrostatic attraction between oppositely charged ions, formed when metal atoms transfer electrons to non-metal atoms. The ions form a giant lattice, which gives high melting points, brittleness, and conduction only when molten or dissolved. Dot-and-cross diagrams show the electron transfer.

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How do ions form?

An atom is neutral, but it can gain a full outer shell by losing or gaining electrons. When this happens it becomes an **ion**: a particle with an overall charge. Metal atoms usually lose outer electrons and form positive ions. Non-metal atoms usually gain electrons and form negative ions.

Definition

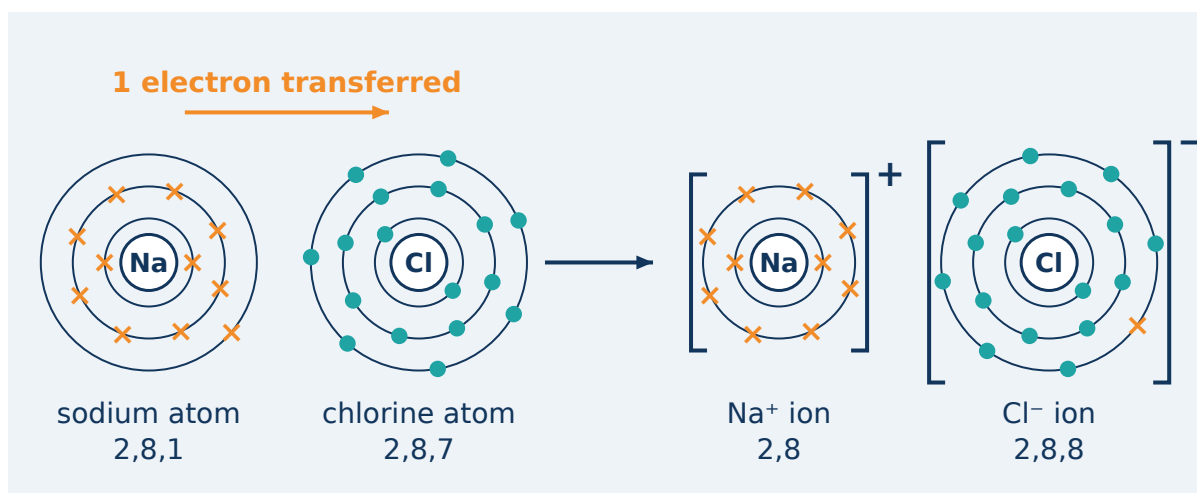
A **cation** is a positive ion, made by losing electrons. An **anion** is a negative ion, made by gaining electrons. **Ionic bonding** is the strong electrostatic attraction between oppositely charged ions.

Group	Outer electrons	Change	Ion formed	Example
1	1	Loses 1	1+	Na ⁺
2	2	Loses 2	2+	Mg ²⁺
3	3	Loses 3	3+	Al ³⁺
6	6	Gains 2	2-	O ²⁻
7	7	Gains 1	1-	Cl ⁻

Each ion ends up with the electron arrangement of a noble gas, which is stable. For example, Mg²⁺ is 2,8 like neon and O²⁻ is 2,8 like neon too.

How do dot-and-cross diagrams show ionic bonding?

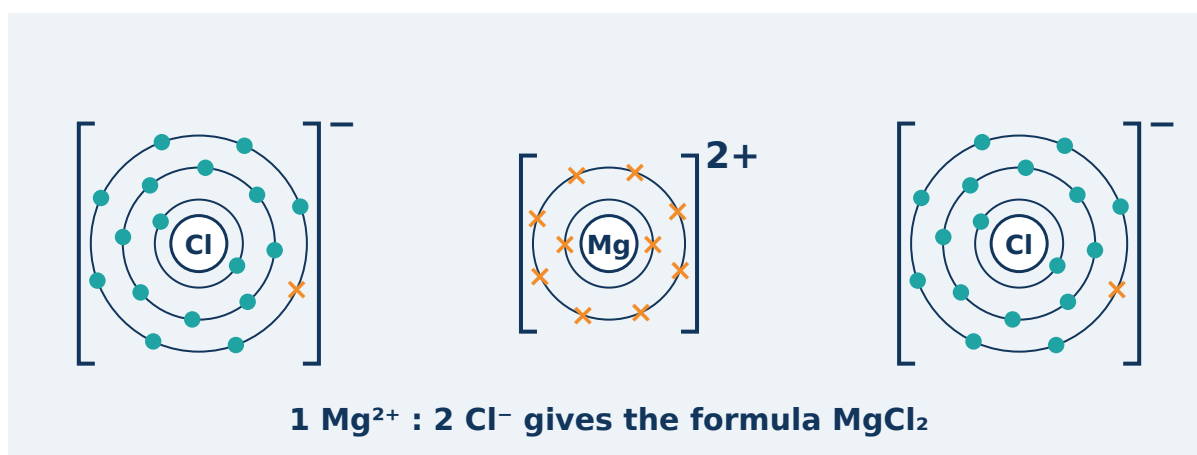
A dot-and-cross diagram follows the electrons. Electrons from one atom are drawn as dots and electrons from the other as crosses, so you can see where each one goes. Draw square brackets around each ion and write its charge at the top right.



Sodium chloride: Na gives its outer electron (cross) to Cl, giving Na⁺ and Cl⁻ with full outer shells.

Worked example 1

Sodium (2,8,1) reacts with chlorine (2,8,7). Sodium has one outer electron to lose, and chlorine needs one more to complete its outer shell. Sodium transfers one electron to chlorine, forming Na⁺ (2,8) and Cl⁻ (2,8,8). One Na⁺ balances one Cl⁻. Answer: **NaCl**.



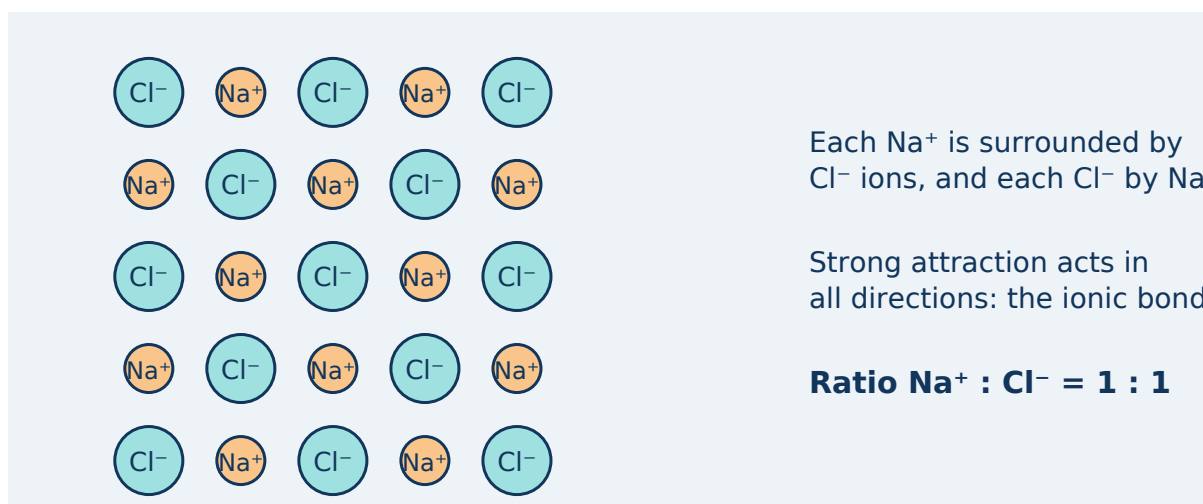
Magnesium chloride, MgCl₂: Mg gives one electron to each of two chlorine atoms.

Worked example 2

Magnesium (2,8,2) reacts with chlorine. Magnesium has 2 outer electrons to lose, but each chlorine atom can take only 1. So two chlorine atoms are needed. The result is Mg²⁺ and two Cl⁻ ions. Answer: **MgCl₂**.

What is a giant ionic lattice?

An ionic compound is not made of separate molecules. The ions form a **giant ionic lattice**, a regular three-dimensional pattern in which every positive ion is surrounded by negative ions and the other way round.



A giant ionic lattice: a regular, repeating pattern of alternating positive and negative ions.

Key rule

The total positive charge must equal the total negative charge. To find a formula, balance the charges: swap the numbers in the ion charges, then simplify.

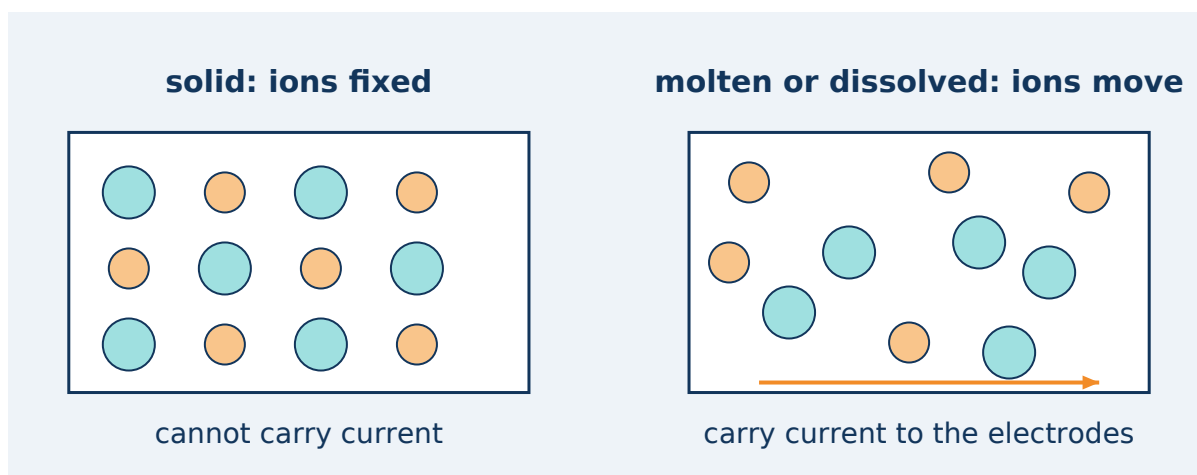
Worked example 3

Aluminium forms Al^{3+} and oxygen forms O^{2-} . The lowest common multiple of 3 and 2 is 6. Two Al^{3+} give +6 and three O^{2-} give -6. Answer: **Al_2O_3** .

What are the properties of ionic compounds?

The strong attraction between ions in all directions explains their properties.

Property	Explanation
High melting and boiling points	Much energy is needed to break the strong ionic bonds throughout the lattice. NaCl melts at 801 °C and MgO at 2852 °C.
Do not conduct when solid	The ions are held in fixed positions and cannot move.
Conduct when molten or dissolved	The ions are free to move and carry charge.
Brittle	A blow shifts a layer so that like charges meet and repel, and the crystal splits.
Often soluble in water	Water molecules attract and surround the ions, pulling them out of the lattice.



Ions must be free to move to carry charge.

Magnesium oxide melts at a much higher temperature than sodium chloride because its ions have charges of 2+ and 2– instead of 1+ and 1–. The attraction between the ions is stronger.

Common mistake

Do not draw or describe a “molecule of sodium chloride”. Ionic compounds are giant lattices, so the formula NaCl only gives the simplest ratio of ions. Also, ionic compounds do not conduct as solids, but this is because the ions cannot move, not because they have no charge.

Lina's tip

Check every formula by adding charges. If the positives and negatives do not cancel to zero, the formula is wrong. For Al_2O_3 : $(2 \times 3+) + (3 \times 2-) = +6 - 6 = 0$.

Key points to remember

- Metals lose electrons to form cations; non-metals gain electrons to form anions.
- Ions have noble-gas electron arrangements, such as Na^+ (2,8) and Cl^- (2,8,8).
- Ionic compounds form giant lattices; total positive charge equals total negative charge (Al_2O_3).
- High melting points: NaCl 801 °C; MgO 2852 °C because of 2+ and 2– charges.
- They conduct only when molten or dissolved, because ions must be free to move.

How ions bond: transfer and lattices: frequently asked questions

What is ionic bonding?

Ionic bonding is the strong electrostatic attraction between positive and negative ions. It forms when a metal atom transfers electrons to a non-metal atom. Both ions end with full outer shells.

Why do ionic compounds have high melting points?

The ions in a giant lattice attract each other strongly in every direction. A great deal of energy is needed to overcome these forces and let the ions move past each other. Compounds with higher ion charges, like MgO , melt at even higher temperatures.

Why can ionic compounds conduct electricity only when molten or dissolved?

Conduction needs charged particles that can move. In the solid the ions are fixed in the lattice. When molten or dissolved, the ions are free to move, so they carry charge between the electrodes.

How do you work out the formula of an ionic compound?

Write the charge of each ion, then choose the numbers of ions so that the total positive and negative charges are equal. Al^{3+} and O^{2-} need 2 aluminium and 3 oxygen ions to give +6 and -6, so the formula is Al_2O_3 .

Why are ionic crystals brittle?

A force can shift one layer of ions by one position. Then ions with the same charge sit next to each other and repel. The repulsion splits the crystal along that layer.