

# Ionic bonding

5.2.1.2 · Chemistry · revision notes

How metal atoms and non-metal atoms form ions by transferring electrons, how to show this with a dot and cross diagram, and how to work out the charge on an ion from its group. Expect 'describe what happens, in terms of electrons' questions (3 to 4 marks), dot and cross diagrams to draw or complete, and formulae to work out.

## Key facts

- Metal atoms lose electrons → positive ions; non-metal atoms gain electrons → negative ions
- Ions from Groups 1, 2, 6 and 7 have a noble gas electronic structure (full outer shell)
- $\text{Mg } 2,8,2 \rightarrow \text{Mg}^{2+} 2,8$      $\text{O } 2,6 \rightarrow \text{O}^{2-} 2,8$
- Formula: total positive charge = total negative charge
- Group 1: 1+    Group 2: 2+    Group 6: 2-    Group 7: 1-
- $\text{Na } 2,8,1 \rightarrow \text{Na}^{+} 2,8$      $\text{Cl } 2,8,7 \rightarrow \text{Cl}^{-} 2,8,8$
- Dot and cross: each ion in square brackets, charge at the top right

## Notes

### Forming ions

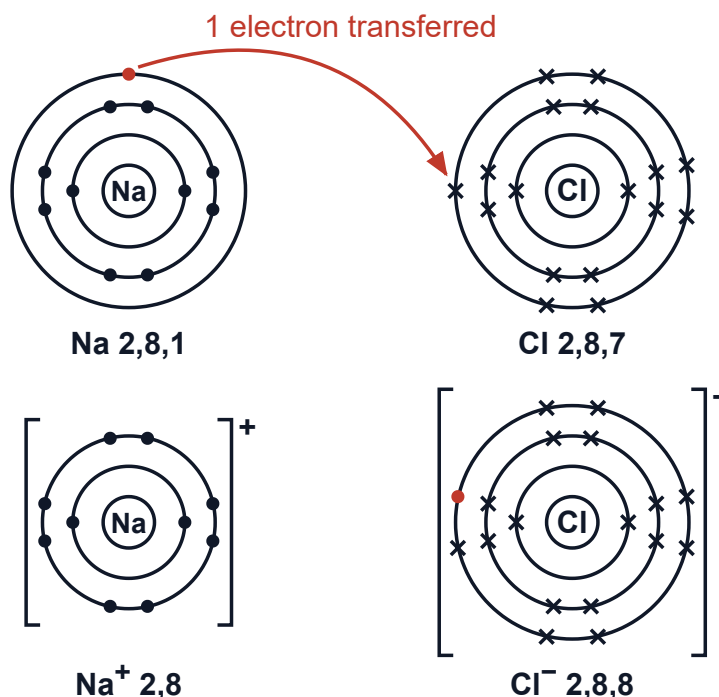
- When a metal reacts with a non-metal, electrons in the outer shell of the metal atom are **transferred** to the non-metal atom.
- The metal atom **loses** electrons and becomes a **positive ion**. The non-metal atom **gains** electrons and becomes a **negative ion**.
- An ion is charged because it now has unequal numbers of protons and electrons. The number of protons never changes.
- The ions formed by metals in Groups 1 and 2 and by non-metals in Groups 6 and 7 have the electronic structure of a **noble gas** (Group 0): a full outer shell.

### Charge from the group number

- Group 1 atoms lose 1 electron → **1+** ions, e.g.  $\text{Na}^{+}$ ,  $\text{K}^{+}$ .
- Group 2 atoms lose 2 electrons → **2+** ions, e.g.  $\text{Mg}^{2+}$ ,  $\text{Ca}^{2+}$ .
- Group 6 atoms gain 2 electrons → **2-** ions, e.g.  $\text{O}^{2-}$ ,  $\text{S}^{2-}$ .
- Group 7 atoms gain 1 electron → **1-** ions, e.g.  $\text{F}^{-}$ ,  $\text{Cl}^{-}$ .
- Negative ions made from one atom end in **-ide**: oxide, sulfide, fluoride, chloride.

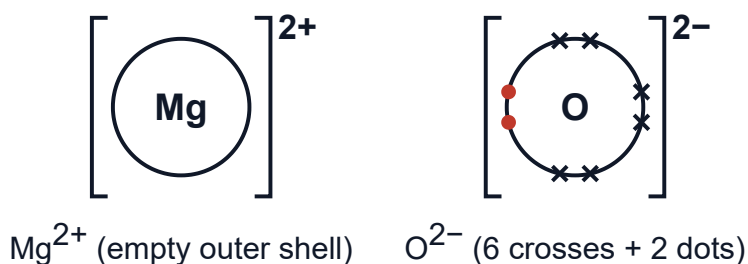
## Dot and cross diagrams

- Use dots for the electrons of one atom and crosses for the electrons of the other, so you can see where each electron came from.
- Sodium chloride: Na (2,8,1) transfers its outer electron to Cl (2,8,7). You get  $[\text{Na}]^+$  (2,8) and  $[\text{Cl}]^-$  (2,8,8). If sodium's electrons are crosses, the outer shell of the chloride ion has 7 dots and 1 cross.



Sodium's electrons are dots, chlorine's are crosses. The transferred electron is red.

- Draw each ion in **square brackets** with its charge at the top right. If you draw outer shells only, show the metal ion with an empty outer shell (or with the full shell below it) and the non-metal ion with 8 outer electrons.
- Magnesium oxide: Mg (2,8,2) transfers **two** electrons to O (2,6), forming  $\text{Mg}^{2+}$  and  $\text{O}^{2-}$ .



MgO: two electrons (dots, red) have moved from magnesium to oxygen.

## Working out the formula

- A compound has no overall charge, so the total positive charge must equal the total negative charge.
- Two  $\text{K}^+$  balance one  $\text{O}^{2-}$ , so potassium oxide is  $\text{K}_2\text{O}$ . One  $\text{Mg}^{2+}$  balances two  $\text{F}^-$ , so magnesium fluoride is  $\text{MgF}_2$ .

## How to answer each type of question

### Work out the charge on an ion or the formula of a compound

1 to 2 marks

Grade 5

1. Find the group of each element: Groups 1 and 2 form positive ions, Groups 6 and 7 negative ions.
2. Write the charge on each ion.
3. Use enough of each ion to make the total charge zero, and write the numbers as subscripts.

**Example.** Barium is in Group 2. Bromine is in Group 7.

- (a) Give the charge on a barium ion.
- (b) Give the formula of barium bromide.

**Model answer.** (a)  $2+$  (1)

(b)  $\text{BaBr}_2$  (1)

### Draw or complete a dot and cross diagram

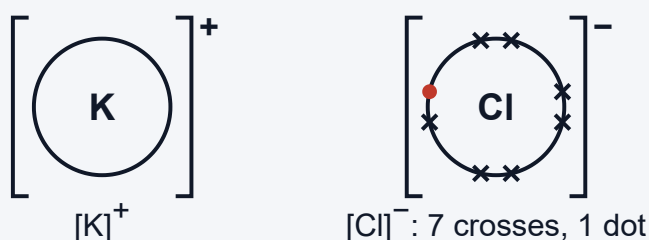
2 to 3 marks

Grade 5

1. Work out the ions formed and how many of each you need.
2. Draw the outer shell of each ion: the non-metal ion has 8 electrons, with the transferred electrons shown as a different symbol.
3. Put square brackets round each ion and write its charge at the top right.

**Example.** Potassium has the electronic structure 2,8,8,1. Chlorine has the electronic structure 2,8,7. Draw a dot and cross diagram for potassium chloride. Show the outer shell electrons only.

**Model answer.**



The diagram should show:

the potassium ion with no electrons in its outer shell (or a full shell of 8) (1)

the chloride ion with 8 outer electrons: 7 of one symbol and 1 of the other (1)

both ions in brackets with the correct charges,  $[\text{K}]^+$  and  $[\text{Cl}]^-$  (1)

## Don't lose marks

- ✗ Saying a metal atom becomes positive by gaining protons. Ions form by losing or gaining electrons; the number of protons does not change.
- ✗ Saying atoms share electrons in ionic bonding. Electrons are transferred.

- ✗ Getting the sign wrong: losing electrons gives a positive ion; gaining electrons gives a negative ion.
- ✗ Leaving out the brackets or charges on a dot and cross diagram, or drawing a shared pair between the ions.
- ✗ Drawing only one ion of each type when two are needed, e.g. one  $\text{Cl}^-$  for calcium chloride.
- ✗ Writing 'chlorine ion' instead of 'chloride ion'. Use the -ide name for the negative ion.

## More tips

### Memory tricks

- Metals lose (positive ions); non-metals gain (negative ions).
- Charge rule: Groups 1 and 2, charge = group number, positive. Groups 6 and 7, charge = 8 – group number, negative.
- Swap and drop for formulae: write the charges, swap the numbers over as subscripts, then cancel.  $\text{Ca}^{2+} \text{Cl}^- \rightarrow \text{CaCl}_2$ ;  $\text{Mg}^{2+} \text{O}^{2-} \rightarrow \text{Mg}_2\text{O}_2 \rightarrow \text{MgO}$ .
- Check:  $\text{Na}^+$ ,  $\text{Mg}^{2+}$ ,  $\text{O}^{2-}$  and  $\text{F}^-$  are all 2,8, the same as neon.

### Exam technique

- In 'answer in terms of electrons' questions, give numbers: 'each magnesium atom loses two electrons' scores; 'magnesium loses electrons' may not.
- Always give the direction of transfer: from the metal atom to the non-metal atom.
- Use the electronic structures given in the question and check that each ion ends with a full outer shell.
- In a dot and cross diagram, the number of transferred electrons shown in the negative ions must equal the number the metal atoms lost.

## What each grade needs

What you need to be able to do, from the first marks up to the top grade.

### Grade 3

#### State that metals lose and non-metals gain electrons

Metal atoms lose outer electrons to form positive ions; non-metal atoms gain electrons to form negative ions.

### Grade 4

#### Work out the charge from the group number

Group 1  $\rightarrow$  1+, Group 2  $\rightarrow$  2+, Group 6  $\rightarrow$  2-, Group 7  $\rightarrow$  1-.

### Grade 5

#### Write the electronic structure of an ion

For example, Na (2,8,1) becomes  $\text{Na}^+$  (2,8) and O (2,6) becomes  $\text{O}^{2-}$  (2,8).

### Grade 5

#### Draw dot and cross diagrams for ionic compounds

Show each ion in square brackets with its charge, using dots and crosses for electrons from different atoms.

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