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EB Education Revision Guide

How to work with Ionic Bonding: Part 2

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Properties of Ionic Compounds

High Melting and Boiling Points

When a metal element reacts with a non-metal element an ionic compound is formed.

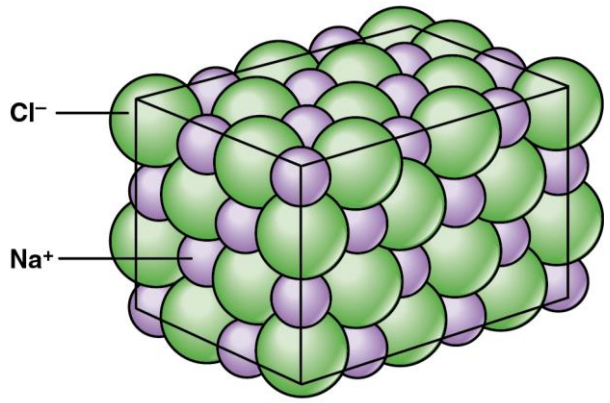
The ions in a solid ionic compound are not arranged randomly. They have a regular, repeating arrangement called an **ionic lattice**.

The lattice forms because the negative and positive ions attract each other and form a regular pattern with oppositely charged ions next to each other

This giant lattice structure has many strong ionic bonds. Ionic bonds are strong electrostatic forces between oppositely charged ions.

To melt or boil a substance, energy has to be transferred to it in order to break the bonds between the particles. Some bonds are overcome during melting and all remaining bonds are overcome during boiling

A lot of energy is needed to overcome the many strong bonds in ionic compounds, so they have high melting points and boiling points.



Crystal of NaCl

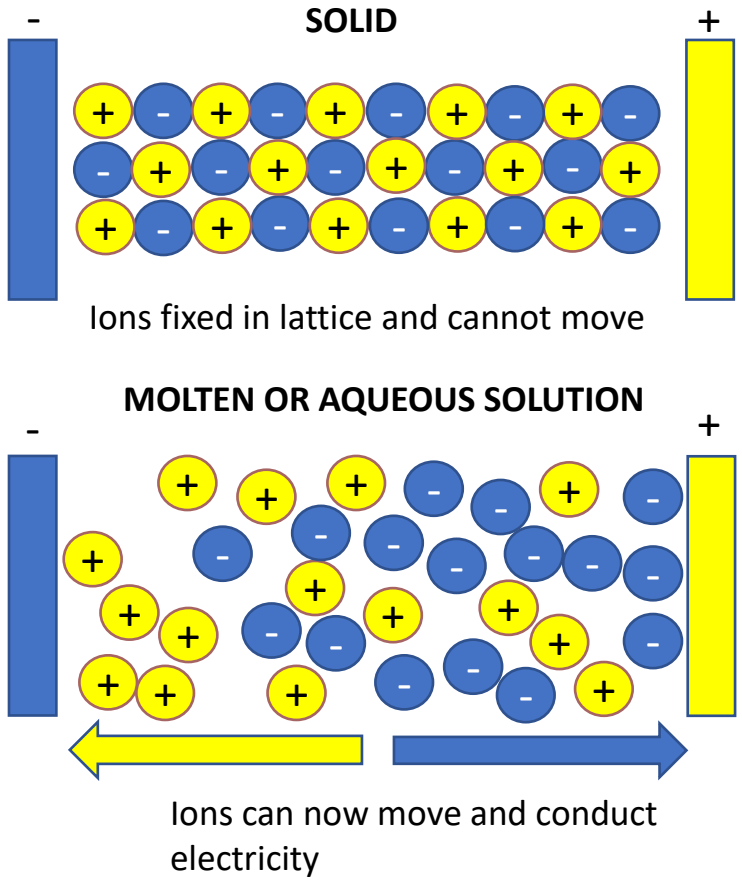
Properties of Ionic Compounds

Conducting Electricity

For a substance to conduct electricity it needs to have charged particles which are free to move.

Solid ionic compounds cannot conduct electricity as the ions are held in fixed positions.

When ionic compounds are **molten, or dissolved in water, they can conduct electricity**. This is because the ions become free to move.



Formulae of ionic compounds

Working out a formula

You may need to work out what the formula of an ionic compound is.

The formula for an ionic compound must contain the same number of positive and negative charges so that the charges are balanced and then it is neutral overall.

Example:

Potassium chloride contains K^+ and Cl^- ions: Potassium is in Group 1 so loses 1 electron. Chlorine is in Group 7 and gains 1 electron

- this is one positive charge and one negative charge
- the charges are balanced
- so the formula is **KCl**

Example:

Copper oxide contains Cu^{2+} and O^{2-} ions: Copper, Cu(II) is a 2+ ion so loses 2 electrons. Oxygen is in Group 6 and gains 2 electrons.

- this is two positive charges and two negative charges
- the charges are balanced
- so the formula is **CuO**

Example:

Aluminium oxide contains Al^{3+} and O^{2-} ions: Aluminium is in Group 3 so loses 3 electrons. Oxygen is in Group 6 so gains 2 electrons.

- this is three positive charges and two negative charges
- to balance, we need two Al^{3+} ions and three O^{2-} ions
- so the formula is **Al_2O_3**

Formulae of ionic compounds

Polyatomic ions

Ions can also be formed from groups of atoms. These are polyatomic ions.

You need to remember the formulae and charge of some of these ions.

The formulae of compounds containing polyatomic ions is worked out in the same way as for single atom ions.

If there is more than one polyatomic ion, its formula needs to be written inside brackets

Nitrate	NO_3^-
Sulphate	SO_4^{2-}
Hydroxide	OH^-
Hydrogen carbonate	HCO_3^-
Phosphate	PO_4^{3-}
Ammonium	NH_4^+
Carbonate	CO_3^{2-}

Example:

Sodium carbonate contains Na^+ and CO_3^{2-} ions.

- this is one positive charge and 2 negative charges
- to balance we need 2 Na^+ ions and 1 CO_3^{2-} ions
- so the formula is $Na_2CO_3^{2-}$

Example:

Calcium hydroxide contains Ca^{2+} and OH^- ions

- this is 2 positive charges and 1 negative charge
- to balance we need 1 Ca^{2+} ions and 2 OH^- ions
- so the formula is $Ca(OH)_2$

Naming ionic compounds

Rules for naming compounds

There are a couple of simple rules to remember when naming ionic compounds:

The name of the compound will end in

a) - 'ide' if it contains only 2 elements

b) - 'ate' if it contains 3 or more elements, and one of these is oxygen

The element furthest to the left in the Periodic Table will be at the beginning of the name.

Examples

Chlorine + Sodium = Sodium chloride

Magnesium and Iodine = Magnesium Iodide

Iron, oxygen and sulphur = Iron sulphate

Oxygen, nitrogen and potassium = Potassium nitrate

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Your turn:

1 a) The names and formulae of three ions are shown in the table below.

Name of ion	Formula of ion
Nitrate	NO_3^-
Phosphate	PO_4^{3-}
Calcium	Ca^{2+}

What is the formula of calcium nitrate?

A: $CaNO_3$
B: Ca_2NO_3
C: Ca_3NO_2
D: $Ca(NO_3)_2$

b) How many oxygen atoms are there in $Ca_3(PO_4)_2$

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c) The table below provides information about the elements, sodium and sulphur.

	Sodium	Sulphur
Atomic symbol	Na	S
Number of electrons in one atom	11	16
Metal or non-metal	Metal	Non-metal

Sodium sulphide is an ionic compound.
Describe how sodium atoms react with sulphur atoms to form sodium sulphide in terms of electron transfer. You should include the charges on the ions formed.

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Your turn:

d) Explain the difference in the ability of molten sodium chloride and solid sodium chloride to conduct electricity in terms of their structures.

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2a) Copper nitrate contains copper ions, Cu^{2+}, and nitrate ions, NO_3^-. Describe how a copper atom becomes a copper ion.

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b) Write the formula for copper nitrate.

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3. Both sodium (Na) and sodium chloride (NaCl) have lattice structures.

The table below shows their melting points.

	Melting point in °C	Type of lattice structure
sodium	98	giant metallic
sodium chloride	801	

a) Complete the table.

b) Explain why sodium and sodium chloride have different melting points. You should refer to the types of particle and the types of forces between the particles in each substance.

You will need to revise metallic bonding to answer this question.

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Answers:

1 a) The names and formulae of three ions are shown in the table below.

Name of ion	Formula of ion
Nitrate	NO_3^-
Phosphate	PO_4^{3-}
Calcium	Ca^{2+}

What is the formula of calcium nitrate?

A: $CaNO_3$
B: Ca_2NO_3
C: Ca_3NO_2
D: $Ca(NO_3)_2$ X

b) How many oxygen atoms are there in $Ca_3(PO_4)_2$

8

c) The table below provides information about the elements, sodium and sulphur.

	Sodium	Sulphur
Atomic symbol	Na	S
Number of electrons in one atom	11	16
Metal or non-metal	Metal	Non-metal

Sodium sulphide is an ionic compound.
Describe how sodium atoms react with sulphur atoms to form sodium sulphide in terms of electron transfer. You should include the charges on the ions formed.

Sodium has the electronic structure 2,8,1 so has 1 electron in the outer shell. Each sodium atom will lose 1 electron, to form Na^+ ion.
Sulphur has the electronic structure 2,8,6 so has 6 electrons in the outer shell. Each sulphur atom will gain 2 electrons , to form S^{2-} ions.
This means two sodium ions bond with each sulphur ion to form Na^2S.

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Answers:

d) Explain the difference in the ability of molten sodium chloride and solid sodium chloride to conduct electricity in terms of their structures.

In a solid, the Na^+ and Cl^- ions are held together by strong ionic bonds (electrostatic forces) between the oppositely charged ions. They are closely packed together, and the ions cannot move, so it does not conduct.
In molten sodium chloride, heat energy breaks the bonds between the ions, which means the ions can move, and it can conduct electricity,

2a) Copper nitrate contains copper ions, Cu^{2+}, and nitrate ions, NO_3^-.
Describe how a copper atom becomes a copper ion.

A copper atom will lose 2 electrons

b) Write the formula for copper nitrate.

$Cu(NO_3)_2$

3. Both sodium (Na) and sodium chloride (NaCl) have lattice structures.

The table below shows their melting points.

	Melting point in °C	Type of lattice structure
sodium	98	giant metallic
sodium chloride	801	giant ionic

a) Complete the table.

b) Explain why sodium and sodium chloride have different melting points. You should refer to the types of particle and the types of forces between the particles in each substance.

In sodium there are positive Na ions and delocalised electrons and electrostatic forces of attraction between them.
In sodium chloride there are many strong electrostatic forces between the positive Na ions and negative Cl ions.
The forces in Na are weaker than the forces in NaCl, so it has a lower melting point

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