Chemical bonds

4.2.1.1 · Bonding, structure and the properties of matter · revision notes

There are three types of strong chemical bond: ionic, covalent and metallic. This subtopic is about telling them apart from the elements involved and the particles they hold together. It comes up as quick 1 to 3 mark questions, often a table to complete, and it underpins every explanation later in this topic.

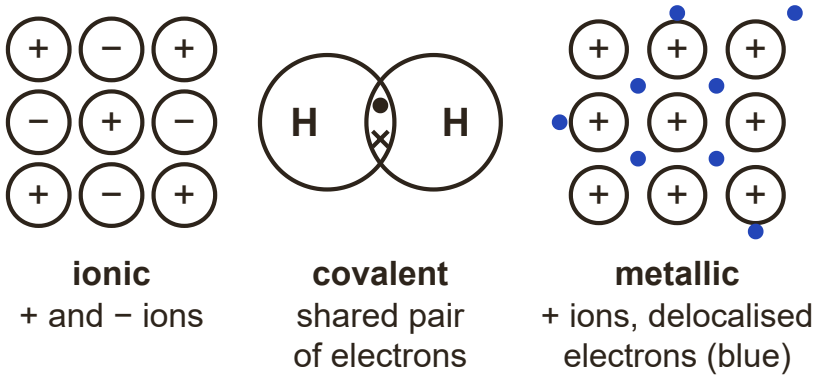
Key facts

- Three types of strong bond: ionic, covalent, metallic
- Covalent: non-metals; atoms share pairs of electrons
- Ionic = electrons transferred; covalent = electrons shared; metallic = electrons delocalised
- Ionic: metal + non-metal; oppositely charged ions
- Metallic: metals and alloys; positive ions and delocalised electrons
- Hydrogen is a non-metal, so HCl and CH_4 are covalent

Notes

The three types of strong bond

- A **chemical bond** holds particles together in an element or compound. There are three types, and all of them are **strong**.
- **Ionic bonding**: the particles are **oppositely charged ions**. It happens in compounds formed from a **metal combined with a non-metal**.
- **Covalent bonding**: the particles are **atoms that share pairs of electrons**. It happens in most **non-metal elements** and in **compounds of non-metals**.
- **Metallic bonding**: the particles are **atoms that share delocalised electrons** (outer electrons that are free to move through the whole structure). It happens in **metals and alloys**.



The three types of strong chemical bond.

What happens to the electrons

- Ionic: electrons are **transferred** from the metal atoms to the non-metal atoms, making positive and negative ions.
- Covalent: electrons are **shared in pairs**. Each shared pair of electrons is one covalent bond.
- Metallic: the outer shell electrons leave the metal atoms and become **delocalised**, leaving positive metal ions.
- Each bond is a strong **electrostatic attraction** between opposite charges: positive and negative ions (ionic), a shared pair and the nuclei of both atoms (covalent), positive metal ions and delocalised electrons (metallic).

How to decide the type of bonding

- Find each element in the periodic table. Metals are on the left and in the centre; non-metals are on the right. Hydrogen is a non-metal.
- Metal + non-metal (e.g. NaCl, MgO, CaF_2) → **ionic**.
- Non-metals only, whether an element or a compound (e.g. Cl_2, H_2O, CO_2, NH_3) → **covalent**.
- A metal element or an alloy (e.g. Cu, Fe, brass) → **metallic**.
- Chemical bonds are not the same as **intermolecular forces**. Intermolecular forces are much weaker forces between separate molecules.

How to answer each type of question

Give the type of bonding in a substance

1 mark each | **Grade 4**

1. Decide whether each element in the substance is a metal or a non-metal.
2. Apply the rule: metal + non-metal = ionic; non-metals only = covalent; metal or alloy = metallic.
3. Write the name of the bond exactly: ionic, covalent or metallic.

Example. Give the type of bonding in each substance.
(a) potassium iodide, KI
(b) sulfur dioxide, SO_2
(c) zinc, Zn
(d) bronze, an alloy of copper and tin

Model answer.

(a) ionic (1)
(b) covalent (1)
(c) metallic (1)
(d) metallic (1)

Match each type of bonding to its particles

2 to 3 marks | Grade 4

1. Ionic goes with ions of opposite charge.
2. Covalent goes with atoms sharing pairs of electrons.
3. Metallic goes with positive ions and delocalised electrons. Cross out any option that does not fit any bond.

Example. Draw one line from each type of bonding to the particles it involves. One of the descriptions of particles is not needed.

Type of bonding	Particles
ionic	A atoms that share pairs of electrons
covalent	B positive ions and delocalised electrons
metallic	C oppositely charged ions
	D molecules that share protons

Model answer.

ionic → C (1)

covalent → A (1)

metallic → B (1)

Explain how you know the type of bonding

2 marks | Grade 5

1. Say what type of element each one is (metal or non-metal).
2. Link this to the bond and say what the electrons do: transferred, shared in pairs or delocalised.

Example. Hydrogen chloride, HCl, has covalent bonding.
Explain why.

Model answer. Hydrogen and chlorine are both non-metals (1). So their atoms share a pair of electrons (1).

Don't lose marks

- Treating hydrogen as a metal because it sits above Group 1. It is a non-metal, so HCl, H_2O and CH_4 are covalent.
- Mixing up the words: ionic bonding is a transfer of electrons, not sharing; covalent bonding is sharing pairs of electrons.
- Saying covalent bonds are weak. Covalent bonds are strong; it is the forces between molecules that are weak.
- Forgetting that alloys have metallic bonding.

Calling the particles in an ionic compound 'molecules'. Ionic compounds are made of ions.

More tips

Memory tricks

- Metal meets non-metal = ionic; non-metals together = covalent; metals together = metallic.
- Transfer, share, delocalise: ionic transfers electrons, covalent shares them, metallic delocalises them.
- Sense check with everyday examples: table salt is ionic, water is covalent, copper wire is metallic.

Exam technique

- Use the exact phrases: 'oppositely charged ions', 'share pairs of electrons', 'delocalised electrons'. These are what mark schemes look for.
- If a question says 'in terms of electrons', say what the electrons do: transferred, shared or delocalised.
- When asked to explain, give the evidence (metal or non-metal) as well as the type of bond. The name of the bond on its own usually earns only one mark.

What each grade needs

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

Grade 3

Name the three types of strong bond

Ionic, covalent and metallic.

Grade 4

Choose the bond type from the elements

Metal + non-metal gives ionic bonding; non-metals only give covalent bonding; metals (elements or alloys) have metallic bonding.

Grade 4

Name the particles in each type of bond

Ionic: oppositely charged ions; covalent: atoms sharing pairs of electrons; metallic: positive ions and delocalised electrons.

Grade 5

Decide the bond type from a formula

Use the periodic table to decide whether each element in, for example, KBr, SO_2 or Zn is a metal or a non-metal.

Grade 6

Describe what the electrons do in each bond

Electrons are transferred (ionic), shared in pairs (covalent) or delocalised (metallic).

Grade 7

Tell chemical bonds from intermolecular forces

Chemical bonds hold atoms or ions together and are strong; intermolecular forces are weak forces between separate molecules.

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