4.5 Metallic bonding

Understandings:

- A metallic bond is the electrostatic attraction between a lattice of positive ions and delocalized electrons.
- The strength of a metallic bond depends on the charge of the ions and the radius of the metal ion.
- Alloys usually contain more than one metal and have enhanced properties.

Guidance
Examples of various alloys should be covered.

Applications and skills:

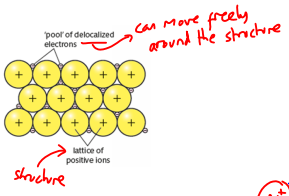
- Explanation of electrical conductivity and malleability in metals.
- Explanation of trends in melting points of metals.

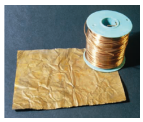
Guidance
Trends should be limited to s- and p-block elements.

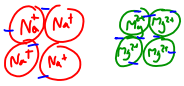
- Explanation of the properties of alloys in terms of non-directional bonding.

Metals:

- Left of periodic table
- Few valence electrons
- Low ionisation energies
- Lose electrons easily to form positive ions







The strength of the metallic bond is determined by:

1. the number of delocalized electrons;
2. the charge on the cation;
3. the radius of the cation.

More = stronger bonding
More = stronger bonding
Lower = stronger bonding

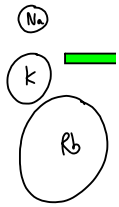
Example 1:

- sodium, Na, Group 1, electron configuration $1s^2 2s^2 2p^6 3s^1$ and
- magnesium, Mg, Group 2, electron configuration $1s^2 2s^2 2p^6 3s^2$

	Na	Mg
Melting point / °C	98	650

Example 2:

	Na	K	Rb
Melting point / °C	98	63	39

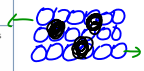


Why do transition metals form very strong metallic bonds?

They have more valence electrons.

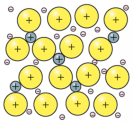
Properties

Metallic property	Explanation	Application
good electrical conductivity	delocalized electrons are highly mobile, and so can move through the metal structure in response to an applied voltage	electrical circuits use copper
good thermal conductivity	delocalized electrons and close packed ions enable efficient transfer of heat energy	cooking utensils
malleable, can be shaped under pressure	movement of delocalized electrons is non-directional and essentially random through the cation lattice, so the metallic bond remains intact while the conformation changes under applied pressure	moulded into many forms including machinery and structural components of buildings and vehicles
ductile, can be drawn out into threads		electric wires and cables
high melting points	a lot of energy is required to break the strong metallic bonds and separate the atoms	high speed tools and turbine engines; tungsten has the highest melting point
shiny, lustrous appearance	delocalized electrons in metal crystal structure reflect light	ornamental structures



Alloys are solutions of metals with enhanced properties

- Made by adding another element (normally a metal or carbon) to a metal in the molten state.
- Have distinct properties - usually stronger



Name of alloy	Component metals	Properties and uses
steel	iron with carbon and other elements	high tensile strength but corrodes, used as structural material
stainless steel	iron with other elements such as nickel and chromium	widely used in domestic and industrial appliances due to strength and corrosion resistance
brass	copper and zinc	variety of plumbing fittings
bronze	copper and tin	coins, medals, tools, heavy gears
pewter	tin and antimony and copper	decorative objects
duralumin	aluminium, copper, and manganese	aircraft, boats, and machinery due to high strength and resistance to corrosion
Nichrome	nickel and copper	heating elements in toasters, electric heaters
solder	lead and tin	low melting point, used in joining two metals together, especially in electric circuitry
sterling silver	silver and copper	jewellery, art objects

Exercises

31 Which is the best definition of metallic bonding?

A the attraction between cations and anions
B the attraction between cations and delocalized electrons ✓
C the attraction between nuclei and electron pairs
D the attraction between nuclei and anions

32 Aluminium is a widely used metal. What properties make it suitable for the following applications?

(a) baking foil — high mp, malleable
(b) aircraft bodywork — light + strong
(c) cooking pans — conducts heat
(d) tent frames — resistant to corrosion, light, strong

33 Suggest two ways in which some of the properties of aluminium can be enhanced.

1. Add copper to change colour
2. Add carbon to strengthen it