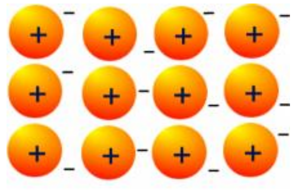
Metallic bonding

Metals consist of giant lattices of metal ions in a sea of delocalised electrons

Definition: **Metallic bonding** is the **electrostatic force** of attraction between the **positive metal ions** and the **delocalised electrons**



sodium

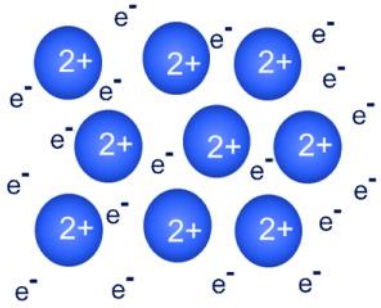
The positive ions are formed when the outer electrons become detached from the atom , leaving a positive ion behind. The electrons that leave the atom, join in the sea of delocalised electrons. The metal ions are arranged in a giant lattice.

Metals have high melting points because the strong electrostatic forces between positive ions and sea of delocalised electrons require a lot of energy to break

The three main factors that affect the strength of **metallic bonding** are:
1. Number of protons/ Strength of nuclear attraction.
   The more protons the stronger the bond
2. Number of delocalised electrons per atom (the outer shell electrons are delocalised)
   The more delocalised electrons the stronger the bond
3. Size of ion.
   The smaller the ion, the stronger the bond.

Example

Magnesium has stronger metallic bonding than sodium and hence a higher melting point. The metallic bonding gets stronger because in magnesium there are more electrons in the outer shell that are released to the sea of electrons. The magnesium ion is also smaller and has one more proton than sodium. There is therefore a stronger electrostatic attraction between the positive metal ions and the delocalised electrons and higher energy is needed to break bonds.



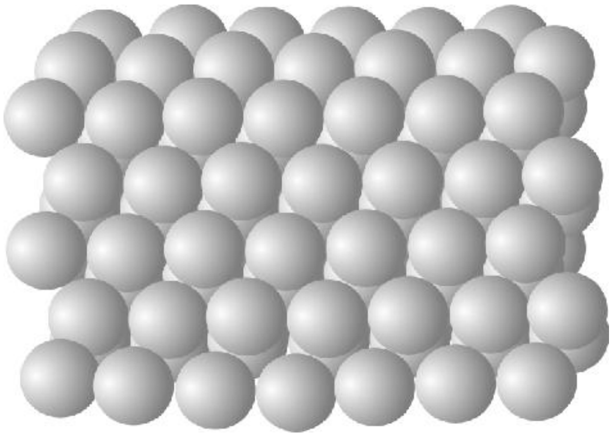
magnesium

Conductivity of electricity
Metals can conduct electricity well because the delocalised valence electrons can move throughout the structure in all directions.

Conductivity of heat
Metals can conduct heat well. There is a strong connection between a metal's ability to conduct heat and electricity. This suggests the delocalised valence electrons are mainly responsible for conducting heat through a metal. Energy is conducted through a metal by more energetic electrons colliding and passing on their energy to less energetic electrons

Malleability and Ductility
A malleable material is one that may be beaten or pressed into new shapes. A ductile material is one that can be drawn into wires and made thinner through stretching .
Metals are malleable and ductile because the positive ions in the lattice are all identical. So the planes of ions can slide easily over one another. The attractive forces in the lattice are the same whichever ions are adjacent

Metallic Crystals



The metal cations are held in place by a sea of delocalised electrons. The cations are packed as closely as possible.

Typical properties of metals

- High melting points (metallic bonding is a strong type of bonding)
- Malleable
- Conductors of electricity (the delocalised electrons will flow when a potential difference is applied across it)
- Shiny (due to delocalised electrons causing light to be reflected)

Metallic bonding Questions

1) Describe the bonding in a metal
Describe the crystal structure of a metal (use a diagram to show the structure)

2 Draw diagrams that show how the particles are arranged in a crystal of sodium and aluminium. You should identify the particles and show a minimum of six particles in a two-dimensional diagrams.

3) Explain why metallic substances:

i) usually have high melting and boiling points

ii) can conduct electricity

iii) are malleable and ductile

4) What 3 factors affect the strength of metallic bonding?

5) a) Explain why the melting point of potassium is lower than that of sodium.

b) Explain why the melting point of magnesium is higher than that of sodium.

c) Explain why the melting point of aluminium is higher than the melting point of sodium.

6) Suggest a reason why aluminium is a better conductor of electricity than magnesium.

7) Silver and sodium chloride melt at similar temperatures. Describe the physical properties of silver which are different from those of sodium chloride and, in each case, explain why the property of silver is different from that of sodium chloride.

8) Find out about the different structures that exist in different metals and describe the different structures

Metallic Lattices

Some of the simplest crystal structures are those of metals where all particles are identical.
There are three major types of metallic lattice. Two of these involve the close packing of particles; the third involves cubic packing of particles :

Almost all metals crystallise in one or more of these systems. The close packed structures account for about 50 metals; cubic packing accounts for about 20 metals.

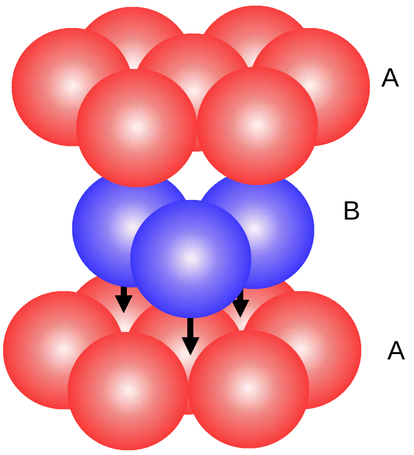
CLOSE PACKING → HEXAGONAL CLOSE PACKING (HCP)
CLOSE PACKING → CUBIC CLOSE PACKING (CCP)

CUBIC PACKING → BODY CENTRED CUBIC (BCC)

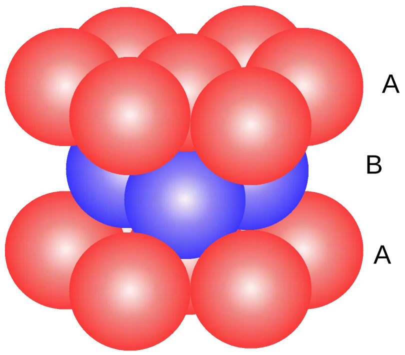
There is no obvious relationship between structural type and position in the periodic table.

In the both close packed arrangements a given sphere has 12 other spheres in contact with it. It is said to have 12 co-ordination or a co-ordination number of 12.

Hexagonal Close Packing (HCP)



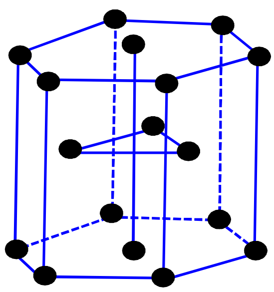
In hexagonal close packing
 the metal ions are arranged in layers. The second layer (B) sits in the holes above the first layer(A).
The pattern continues ABABAB



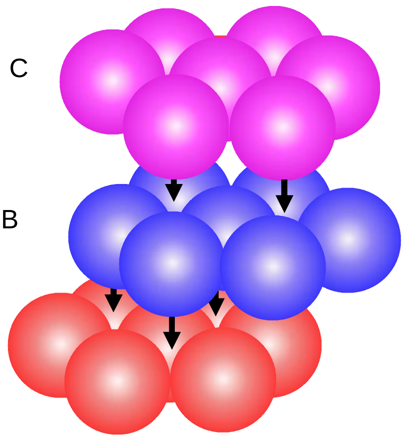
Mg, Zn, Cd all have HCP structures

The **unit-cell representation** is defined as the simplest repeating unit of the lattice which displays the full symmetry of the crystal

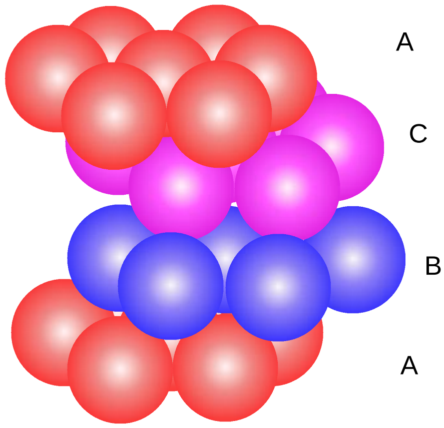
This is unit-cell representation for hexagonal close packing



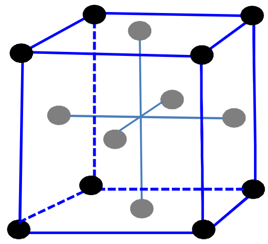
Cubic Close Packing CCP



In Cubic Close Packing the layer are arranged differently from hexagonal close packing. The second layer (B) sits in the holes above the first layer(A)in the same way but the third layer does not sit above the first. The third layer is displaced over and is called layer (C).
The pattern continues ABCABCABC



This is unit-cell representation for cubic close packing. This packing is also called face centred cubic packing. You can see there are particles at the centre of each face of the unit cell.



Cu, Ag, Au, Al, Pb all have CCP packing

In body centred packing each sphere is in contact with 8 others and is said to have 8 co-ordination or a co-ordination number of 8.

Examples: Group1 metals
many transition metals