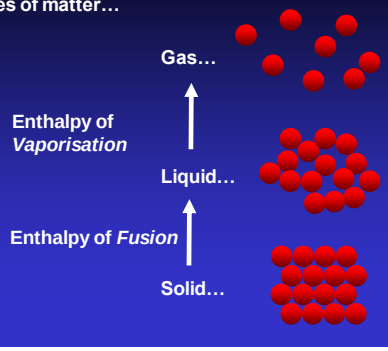
Properties of Solids

Chapter 4.6

SOLID STRUCTURES

States of matter…



SOLID STRUCTURES

Types of solids…

1. Ionic Crystals
2. Metallic Crystals
3. Molecular Crystals
4. Macromolecular Crystals

SOLID STRUCTURES

1. Ionic Crystals – structure…

Oppositely charged ions held together by strong electrostatic forces.

e.g. Sodium Chloride (NaCl) made up of Na^+ and Cl^- ions in a giant 3D lattice of alternate +ve and –ve ions…

SOLID STRUCTURES

1. Ionic Crystals – structure…

e.g. Magnesium Oxide (MgO) made up of Mg^{2+} and O^{2-} ions in a giant 3D lattice of alternate +ve and –ve ions…

SOLID STRUCTURES

1. Ionic Crystals – properties…

a) **High Melting Points** - Due to the strong electrostatic forces that need to be overcome.

b) **Hard** - Due once again due to the high electrostatic forces.

c) **Brittle** - Ions can repel when solid distorted.

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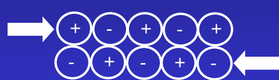

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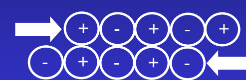

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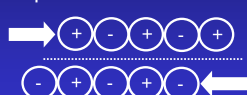

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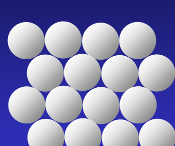
d) **Non-Conductors when solid** - Ions not free to move (carry current).

e) **Conductors when in solution or molten** - Ions free to move.

SOLID STRUCTURES

2. Metallic Crystals – structure…

The metallic ions pack as closely as possible and are held in place because of strong electrostatic forces between the ions and the delocalised electrons.



SOLID STRUCTURES

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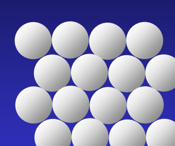
Each metal ion is in contact with 12 others:



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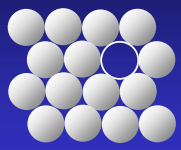

SOLID STRUCTURES

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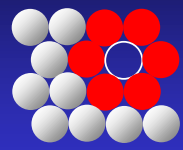
Each metal ion is in contact with 12 others…
Six in the same plain…



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2. Metallic Crystals – structure…

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Each metal ion is in contact with 12 others…
Six in the same plain…
Three above the plain and three below…

SOLID STRUCTURES

2. Metallic Crystals – properties…

a) **High Melting Points** – The metallic bond is a very strong bond.

b) **Malleable (Forced into Shape)** – The metal ions can slide over each other.

c) **Ductile (Drawn into Wires)** – The metal ions can slide over each other.

d) **Conductors of Heat and Electricity** – Delocalised electrons are mobile.

e) **Reflective** – The delocalised electrons absorb and then re-emit light.

SOLID STRUCTURES

3. Molecular Crystal (e.g. Iodine) – structure…

Iodine covalently bonds with each other to make I_2 molecules…

SOLID STRUCTURES

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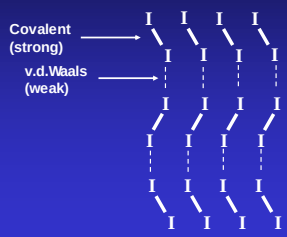
The iodine molecule is large (easily polarisable electrons) and can therefore have a large temporary dipole. This means that in solid Iodine individual I_2 molecules are held together by van der Waals inter-molecular forces…



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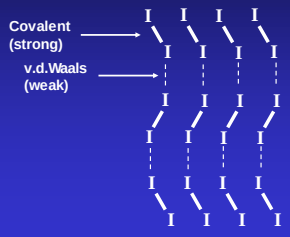


Compare to other halogens:

F_2 - Gas
Cl_2 - Gas
Br_2 – Liquid

All smaller molecules than I_2 so have weaker v. d. Waals forces

SOLID STRUCTURES

3. Molecular Crystal (e.g. Iodine) – properties…

a) **Solid but Very Low Melting point** – Due to the weak v.d. Waals forces.

b) **Often Sublime (solid to Gas)** – Due to weak v.d. Waals forces.

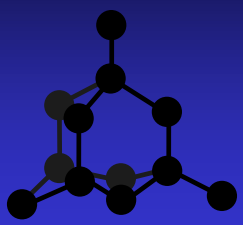
c) **Very Soft** – Due to weak v.d.Waals forces

SOLID STRUCTURES

4. Macromolecular Crystals (Diamond) – structure…

Macromolecular structures have strong covalent bonds making a giant 3D molecule. One such example is diamond an allotrope of carbon…

Each carbon atom is covalently bonded to 4 neighbours in a giant tetrahedral structure



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SOLID STRUCTURES

4. Macromolecular Crystals (Diamond) – properties…

a) **Very High Melting Point** – All carbon atoms bonded covalently (strong bonds) in a giant macromolecular structure.

b) **Very Hard** – Due to macromolecular structure.

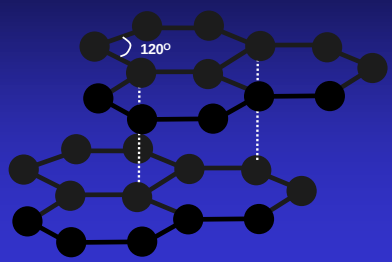
c) **Non-Conductor** – No free electrons.

Used for cutting (because it is the hardest substance known).

SOLID STRUCTURES

4. Macromolecular Crystals (Graphite) – structure…

Macromolecular structures have strong covalent bonds making a giant 3D molecule. One such example is graphite an allotrope of carbon…



Carbon bonds covalently with three neighbours in hexagonal planes

The remaining electron is delocalised between the planes forming a weak bond.

SOLID STRUCTURES

4. Macromolecular Crystals (Graphite) – properties…

a) **High Melting Point** – All atoms in each plane joined by strong (covalent) bonds.

b) **Soft** – The planes are weakly bonded so can slide past each other.

c) **Electrical Conductor** – Due to delocalised electrons between the layers.

Used for lubrication (due to the sliding of the layers), also used as an electrical conductor in motors (brushes).

SOLID STRUCTURES

Summary…

Type of Crystal	Mpt. And Bpt.	Conductor (solid)	Conductor (molten)	Water Solubility
Ionic	High	No	Yes	Often good
Metallic	High	Yes	Yes	Insoluble
Molecular	Low	No	No	Variable
macromolecular	High	No (except graphite)	No	Insoluble