Bonding, Structure and the Properties of Matter

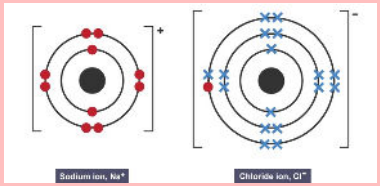
Keyword	Definition
Ionic Bond	A strong, electrostatic force of attraction between oppositely charged ions.
Ion	An atom that has gained or lost electrons to become charged
Electrostatic Force	A strong force of attraction between particles of opposite charge
Giant Ionic Lattice	A 3D structure of strong electrostatic forces acting in all directions between oppositely charged ions
Covalent Bond	A strong type of bond in which atoms share their outer shell electrons
Small Molecule	A covalent molecule that contains only a few atoms
Intermolecular Force	A weak force of attraction between small molecules
Giant Covalent Structure	A lattice structure containing very many atoms, each bonded to other atoms by covalent bonds.
Metallic Bond	A lattice structure of closely packed metal ions surrounded by delocalized electrons
Alloy	A mixture of two or more elements, including at least one metal
Delocalised electrons	Electrons which are not associated to any particular atom or bond
Polymer	A large covalent molecule formed from many smaller molecules
Allotropes	Different forms of the same element
Nanoparticle	Structures that range from 1 to 100 nanometres in size and contain only a few hundred atoms

A

BO01 - Ionic Substances

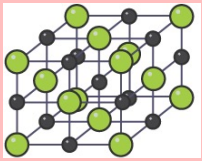
Bonding: metals with non-metals

- Metals lose electrons, become positively charged ions
- Non-metals gain electrons, become negatively charged ions
- Oppositely charged ions held together by electrostatic forces of attraction
- Represented using dot and cross diagrams:



Giant ionic lattice:

BO02



Properties:

High melting and boiling points

- **Reason:** Ionic lattices have many strong bonds, so large amounts of energy are required to break them

Do not conduct electricity unless melted or dissolved

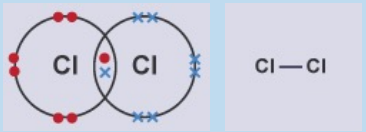
- **Reason:** Ions must be free to move in order for charge to flow

B

BO03 - Covalent Substances

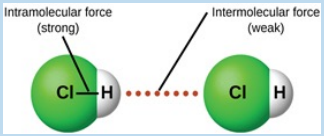
Bonding: non-metals

- A shared pair of outer-shell electrons
- Represented using dot and cross diagrams (left) or structural formulae (right):



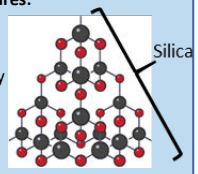
Small Molecules BO04

- Only a few atoms in each molecule
- Strong covalent bonds within molecules
- Weak intermolecular forces between molecules



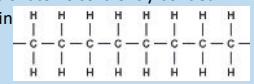
Giant Covalent Structures:

- Many atoms
- All atoms covalently bonded to others



Polymers:

- Thousands of atoms covalently bonded in a long chain



Properties:

Giant covalent structures have very high melting points.

- **Reason:** A high amount of energy is needed to overcome so many strong covalent bonds between atoms

Small molecules have low melting/boiling points, making them gases or liquids at room temperature.

- **Reason:** Weak intermolecular forces are overcome when small molecules melt or boil. This requires a low amount of energy

Polymers are solids at room temperature, as they have moderately high melting points

- **Reason:** polymers are long molecules, and intermolecular forces are much stronger in large molecules

Covalent compounds don't conduct electricity

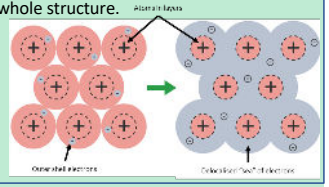
- **Reason:** These compounds do not have a charge, or delocalised electrons, so charge cannot flow through them

C

BO06 - Metallic Substances

Bonding: metals and alloys

- Giant structure of atoms in a regular pattern
- Outer shell electrons of atoms are delocalised – free to move through the whole structure.



Properties

High melting and boiling points (usually much higher than 100°C)

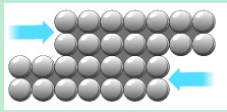
- **Reason:** Metallic bonding is very strong

Very good electrical and thermal conductors

- **Reason:** Delocalised electrons carry charge and transfer thermal energy through the metal structure.

Can be bent and shaped

- **Reason:** atoms are in layers, which can slide over each other

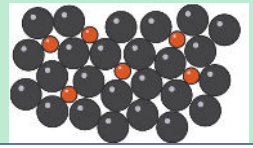


Alloys

- Metals mixed with at least one other element
- Improves properties such as hardness, strength, cost and corrosion-resistance

Alloys are often harder than pure metals

- **Reason:** layers in alloys are disrupted, so cannot slide



E

BO07 - Nanoparticles

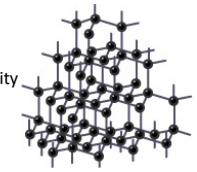
- Particles 1-100nm in size
- Contain only a few hundred atoms
- Used in medicine, electronics, cosmetics and sun creams, as deodorants, and as catalysts
- High surface area to volume ratio means only small quantities needed
- Different properties to the same material in bulk

D

BO05 - Bonding in Carbon

Diamond - properties

- Very hard
- High melting point
- Doesn't conduct electricity

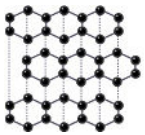


Structure

- Giant covalent structure
- 4 covalent bonds per carbon atom - a large amount of energy is needed to break all the bonds in diamond

Graphite - properties

- Soft
- Conducts electricity

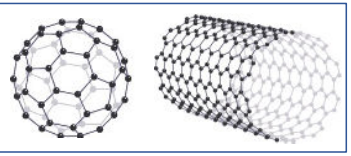


Structure

- 3 covalent bonds per atom
- Layers of hexagonal shapes, weakly held together, can easily slide over each other
- 1 delocalised electron per atom to conduct electricity
- A single sheet of graphite is called graphene

Fullerenes

- Molecules of carbon with hollow shapes
- Shapes made of hexagonal rings
- Buckminsterfullerene (C_{60}) is a spherical fullerene
- Nanotubes are cylindrical fullerenes
- Properties make them useful for nanotechnology and electronics



Required Practical: *none*

Mathematical Skills

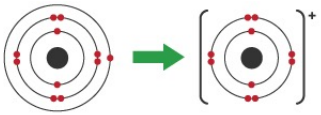
Be prepared to:

- *Work out chemical formulas from molecular diagrams*
- *Draw and understand 2D and 3D images of molecules*
- *Calculate the areas of triangles and rectangles and the surface area and volume of cubes*
- *Recognise and use decimals, standard form, ratios, fractions and percentages*
- *Estimate the results of simple calculations*

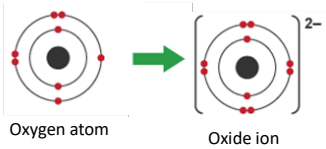
Key Point

Recap: Ions

- Atoms gain or lose electrons to form ions
- Metals lose electrons:



- Non-metals gain electrons:



- Atoms gain or lose electrons in order to achieve a full outer shell.
- Atoms with a full outer shell have the same electron structure as a noble gas:

Linked Modules: AQA

- Atomic Structure
- Chemical Changes
- Organic Chemistry
- Using Resources

Useful YouTube links: