FACTFILE:
GCE CHEMISTRY
STRUCTURE

Rewarding Learning

Structure

Students should be able to:

1.5.1 describe the following types of structure:

- the giant ionic lattice of sodium chloride;
- the metallic lattice of metals;
- the giant covalent structures of graphite and diamond;
- molecular covalent structures, for example iodine;

1.5.2 explain the characteristic physical properties of these structures including melting and boiling point, hardness (graphite and diamond only) and electrical conductivity in terms of structure and bonding;

1.5.3 explain the trend in melting point across the Period sodium to argon, in terms of structure and bonding;

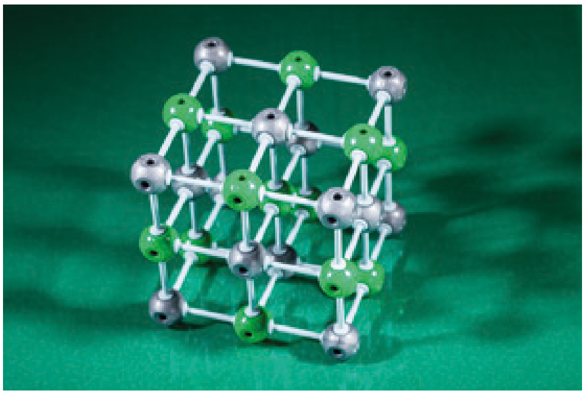
Structure

There are four main type of structure.

1. Ionic lattices

Ionic compounds form giant lattices which are regular arrangements with each ion surrounded by ions of opposite charge. The ions are held together by electrostatic attraction. The structure of sodium chloride is a giant ionic three dimensional lattice of oppositely charged ions held by strong ionic bonds.

It has a 6,6 crystal arrangement, which means that six Na^+ ions surround one Cl^- ion and six Cl^- ions surround one Na^+ ion. It has a cube shape.



Ionic compounds such as sodium chloride have high melting and boiling points as large amounts of energy are needed to break the strong electrostatic forces and separate the ions. When solid, ionic compounds do not conduct electricity as the ions are held in fixed positions and cannot move; however, when molten or dissolved in water the lattice breaks down and the ions can move and carry charge. Therefore, ionic compounds can conduct electricity when molten or dissolved in water. Ionic compounds generally dissolve in water.

2. molecular covalent

These structures have strong covalent bonds in the molecule but weak intermolecular forces between the molecules.

Diatomic elements such as hydrogen, H_2, oxygen, O_2 and the halogens have weak van der Waals' forces between the molecules. In iodine the forces are strong enough for it to exist as a solid at room temperature.

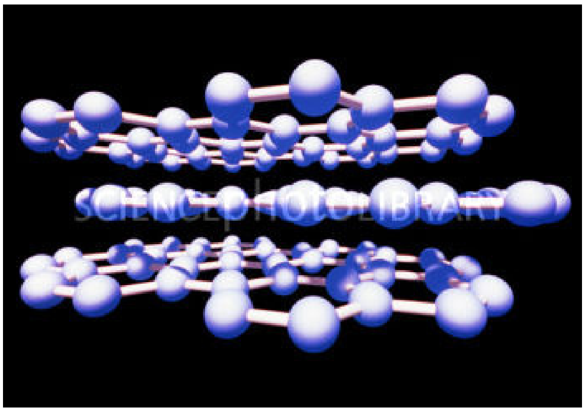
Molecular covalent structures have low melting and boiling points as low temperatures provide enough energy to break the weak van der Waals' forces between the molecules. They do not conduct electricity as there are no free charged particles to move and carry charge.

3. Giant covalent.

Giant covalent structures have thousands of atoms bonded together in a lattice by strong covalent bonds. Carbon allotropes of graphite and diamond have giant covlalent structures.

In diamond each carbon atom is covalently bonded to four others in a tetrahedral arrangement. The structure is a rigid three-dimensional lattice. Diamond is very hard due to the strong covalent bonds and rigid tetrahedral 3d arrangement. It does not conduct electricity, as there are no electrons free to move and carry charge. It has a high melting point and boiling point as much energy is needed to break the many strong covalent bonds.

In graphite there are hexagonal layers of carbon atoms, each connected by covalent bonds. Between the layers there are weak forces. Carbon atoms have four unpaired electrons and can form four covalent bonds. Each carbon is covalently bonded to three others, so there is one electron delocalised per carbon atom which is free to move between the layers and carry charge. Hence graphite conducts electricity. Like diamond it has a high melting point. Graphite is a lubricant as the layers can easily slide due to the weak forces between the layers.

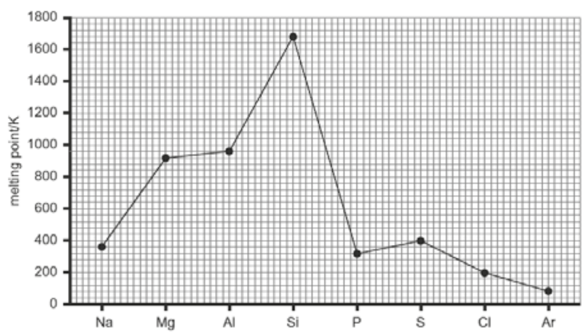


4. Metallic lattice

Metals have giant metallic lattice structures held together by strong electrostatic attractions between positive ions and negative electrons. Most metals have high melting and boiling points as high temperatures and substantial energy is needed to break the strong electrostatic attractions between positive ions and negative electrons. The delocalised electrons can move and carry charge so metals conduct electricity.

Trends in melting point across Period 3

The effect of bonding and structure on the physical properties of substances can be illustrated by comparing the melting points of the Period three elements.



The relatively high melting points of sodium, magnesium and aluminium, can be explained by the strong electrostatic attraction between the delocalised electrons and lattice of positive ions in each metallic structure. The increase between sodium and aluminium is explained by the increasing number of electrons donated, per atom, to the delocalised sea of electrons; sodium donates one electron per atom, aluminium donates three electrons per atom. Hence the metallic bond increases in strength and needs more energy to be broken, and so a higher melting point.

Silicon has a very high melting point due to its giant covalent structure; a lot of energy is needed to break the strong covalent bonds throughout the structure.

Phosphorus, sulfur and chlorine exist as molecular covalent structures with weak van der Waals' forces between the molecules which require little energy to break, resulting in low melting points. Sufur can exist as S_8 molecules, which have a larger number of electrons than a P_4 molecule so it has stronger van der Waals' forces between the molecules. Argon exists as individual atoms with weak van der Waals' forces between them, which again results in a low melting temperature.

Revision Questions

1 The melting point of the elements going across the Periodic Table from sodium to argon...

A increases steadily.
B decreases steadily.
C increases to silicon and then decreases.
D decreases to silicon and then increases.

2 a) Diamond and graphite have giant covalent structures.

(i) Explain what is meant by the term **covalent**.

.... [1]

(ii) Describe the structures of diamond and graphite.

Diamond: ....

....

.... [2]

Graphite: ....

....

.... [2]

(iii) Explain why graphite conducts electricity.

....

....

.... [2]

(iv) Explain why diamond is exceptionally hard.

....

.... [1]

3 Sodium is a reactive, soft, silvery metal. Chlorine is a poisonous gas. The two react together to form sodium chloride that is essential to our diet.

a) (i) Using a labelled diagram explain the bonding in sodium metal.

....

.... [3]

(ii) Metals are good conductors of electricity. Explain why the electrical conductivity of aluminium is greater than that of sodium.

....

....

.... [2]

b) What type of structure is present in the element chlorine?

.... [1]

c) (i) Draw dot and cross diagrams to show how sodium bonds with chlorine gas. Only outer shell electrons should be shown.

[3]

(ii) Name the type of bonding in sodium chloride.

.... [1]

(iii) The structure of sodium chloride is described as a lattice. Explain what is meant by the term **lattice.**

....

.... [2]

(iv) Apart from its appearance give **three** physical properties of sodium chloride.

....

....

.... [3]

4 A crystalline solid melts sharply at 95°C. It does not conduct electricity in the solid and liquid states. It dissolves in hexane. What type of structure does the solid have?

A giant molecular
B ionic
C metallic
D molecular covalent

5 Which one of the following solids consists of molecular covalent crystals?

A diamond
B graphite
C ice
D quartz