FACTFILE:
GCSE DAS CHEMISTRY: UNIT 1.3

Rewarding Learning

Structures

Learning outcomes:

Students should be able to:

1.3.1 use the accepted structural model for giant ionic lattices to explain the physical properties of ionic substances such as sodium chloride, including melting point, boiling point and electrical conductivity (drawing a diagram of a giant ionic lattice is not expected but students should be able to recognise it);

1.3.2 recall that most ionic compounds are soluble in water;

1.3.3 use the accepted structural model for molecular covalent structures to explain the physical properties of molecular covalent structures such as iodine and carbon dioxide, including melting point, boiling point and electrical conductivity;

1.3.4 demonstrate knowledge and understanding that the intermolecular forces between covalent molecules are weak forces called van der Waals' forces;

1.3.5 recall that many covalent molecular substances are insoluble in water;

1.3.6 demonstrate knowledge and understanding of the giant covalent structure of carbon (diamond) and carbon (graphite), and predict and explain their physical properties, including:

- electrical conductivity;
- hardness;
- melting point and boiling point; and
- their uses in cutting tools (diamond), lubricants and pencils (graphite).

1.3.7 **use the accepted structural model for metals to predict and explain their structure and physical properties including melting point, malleability, ductility and electrical conductivity;**

1.3.8 demonstrate knowledge and understanding that an alloy is a mixture of two or more elements, at least one of which is a metal, and the resulting mixture has metallic properties;

1.3.9 demonstrate knowledge and understanding that carbon can form four covalent bonds;

1.3.10 demonstrate knowledge and understanding of the structure of graphene (a single atom thick layer of graphite), explain its physical properties, including strength and electrical conductivity, and recall its uses such as those in batteries and solar cells;

1.3.11 demonstrate knowledge and understanding of the meaning of the term allotrope as applied to carbon (diamond), carbon (graphite) and graphene;

1.3.12 **use given information, or otherwise, to classify the structure of substances as giant ionic lattice, molecular covalent, giant covalent or metallic**

Types of structure

There are four types of structure:

1. Giant ionic lattice
2. Covalent molecular
3. Giant covalent
4. Metallic.

1. Giant ionic lattice

Ionic compounds form giant lattices with each ion surrounded by ions of opposite charge. The ions are held together by electrostatic attraction. **A giant ionic lattice is a 3d structure of oppositely charged ions held by ionic bonds.**

In sodium chloride each sodium ion is surrounded by six chloride ions and vice versa.

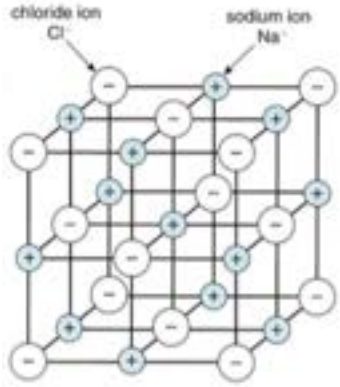


Figure 5 Sodium chloride crystal *Sodium chloride ionic lattice*

DIAGRAM of sodium chloride crystal page 14 figure 5 CCEA chemistry Quigg Laverty

Properties

1. Ionic compounds have **high melting and boiling points** as substantial energy is needed to break the strong ionic bonds and separate the ions.

2. Ionic compounds are **good conductors of electricity when dissolved or molten**. When solid, ionic compounds do not conduct electricity as the ions are held in fixed positions; however, when molten or dissolved in water the lattice breaks down and the ions can act as mobile charge carriers. Therefore, ionic compounds can conduct electricity when molten or dissolved in water.

3. Most ionic compounds **dissolve in water**.

2. Covalent molecular structures

There are only weak intermolecular forces called van der Waals' forces between the molecules.

Properties

1. Covalent molecular structures have low melting and boiling points as little energy is needed to break the weak van der Waals' forces between the molecules. Apart from a few exceptions, (iodine for example) they are therefore gases at room temperature, for example carbon dioxide.

2. They do not conduct electricity as there are no free charged particles.

3. They are generally insoluble in water.

3. Giant covalent structures

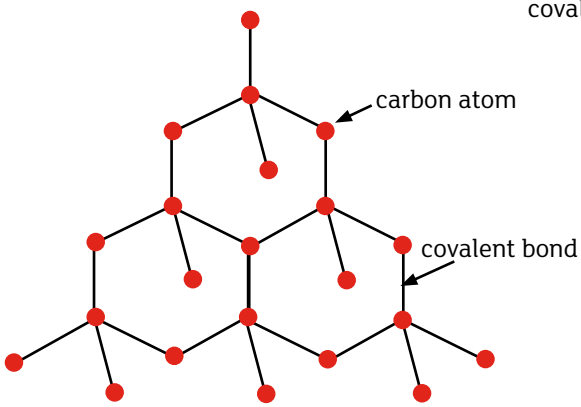
Giant covalent structures have thousands of atoms bonded together in a lattice by strong covalent bonds. **A giant covalent structure is a three dimensional structure of atoms that are joined by covalent bonds.**

Allotropes are different forms or structures of the same element in the same physical state.

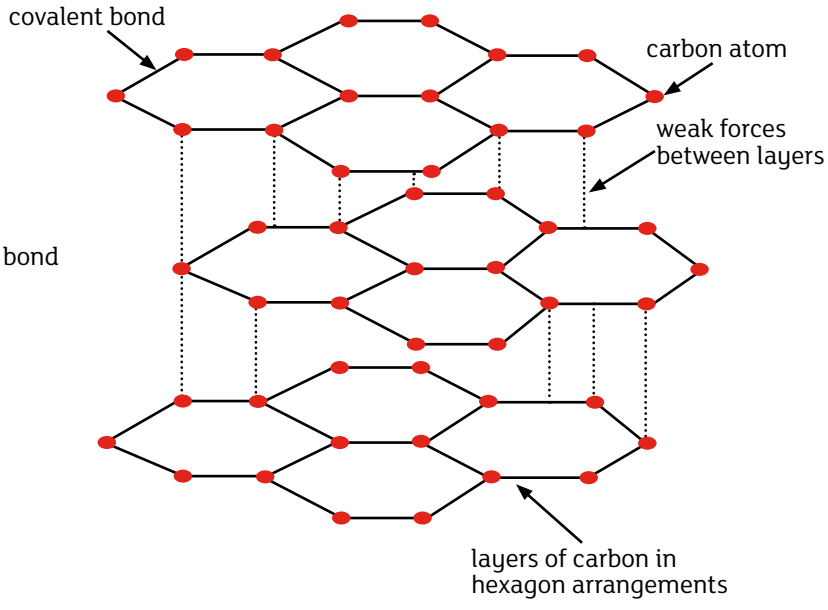
Carbon has three allotropes graphite, diamond and graphene – they are giant covalent structures.

In **diamond** each carbon atom is covalently bonded to four others in a tetrahedral three dimensional structure. It has a **high melting point** and boiling point as substantial energy is needed to break the strong covalent bonds. It **does not conduct electricity** and is very **hard** due to the many strong covalent bonds arranged in the tetrahedral structure. It is used in cutting tools.

In graphite there are layers of hexagons with each carbon atom bonded to three others and weak forces between the layers. In graphite there is one electron per carbon which is not involved in bonding, which is delocalised throughout the layers of carbon atoms and can move and carry charge allowing it to **conduct electricity**. Graphite has a **high melting point** and boiling point as substantial energy is needed to break the strong covalent bonds. It is **soft** because there are weak forces between the layers, which allow the layers to slide off and is used in lubricants.

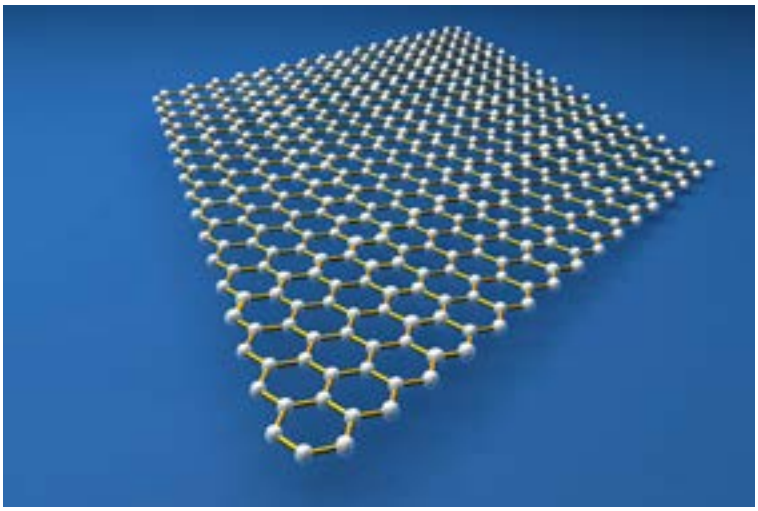


Diamond



Graphite

Graphene is a single atom thick layer of graphite with strong covalent bonds between each carbon atom, arranged in hexagons. It can conduct electricity and is very strong due to the strong covalent bonds and light as it is only one atom thick. Since it is strong, light and relatively inexpensive and an electrical conductor and will have many future uses for example in **solar cells and batteries.**



4. Metallic structures.

Metals have giant metallic lattice structures held together by strong electrostatic attractions between positive ions and delocalised electrons.

Properties

1. Most metals have high melting and boiling points as substantial energy is needed to break the strong metallic bonds.

2. They are good conductors of electricity as the delocalised electrons can move and carry charge.

3. They are malleable (easily hammered into shape) and ductile (can be drawn into a wire) . This is because the layers of ions can slide over each other, yet the delocalised electrons still attract the ions and hold the structure together- the metallic bonding is not disrupted.

Alloys

An alloy is a mixture of two or more elements, at least one of which is a metal and the resulting mixture has metallic properties.

Revision Questions

1.

Substances may be classified in terms of their physical properties. Use the table below to answer the following questions.

Substance	Melting point °C	Boiling point °C	Electrical conductivity	
			As solid	As liquid
A	3550	4827	poor	poor
B	1540	2750	good	good
C	776	1500	poor	good
D	−95	69	poor	poor
E	327	1760	good	good

(a) Which substance, A, B, C, D or E, is an ionic compound? Explain your answer.

Substance _____

Explanation _____

_____ [2]

(b) Which substance, A, B, C, D or E, has a molecular covalent structure?

_____ [1]

(c) Which substance, A, B, C, D or E, is a metal with a low melting point?

Substance _____ [1]

(d) Which substance, A, B, C, D or E, is an allotrope of carbon? Name the allotrope.

Substance _____

Name _____ [2]

2.

Aluminium is a metal which is used in overhead cables because it is a good conductor of electricity and it is ductile.

(a) Describe the structure of a metal such as aluminium.

[3]

(b) Explain why aluminium is a good conductor of electricity.

[2]

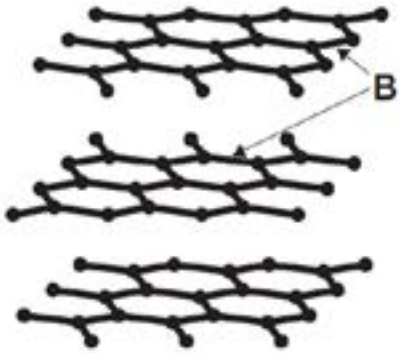
(c) The term ductile means that the metal can be stretched or drawn into thin wires.
Explain, in terms of its structure, why aluminium is ductile.

[1]

3.

The diagrams below show the structure of two **allotropes** of carbon, diamond and graphite. Diamond is a hard substance which is used in cutting tools. Graphite is a soft shiny grey substance which is used as pencil lead.

diamond



graphite

(a) What are allotropes?

_____

_____ [2]

(b) What is represented on the diagrams by:

(i) the black dots labelled **A**?

_____ [1]

(ii) the solid lines labelled **B**?

_____

_____ [1]

(c) Using the structure of diamond and graphite explain why:

(i) diamond is used in cutting tools

_____

_____

_____

_____ [2]

(ii) graphite is used in pencil lead.

_____

_____

_____

_____ [2]

4.

Aluminium is combined with small amounts of some other elements to produce a new material called **X**. This new material has improved properties making it tougher and stronger than pure aluminium. It has excellent corrosion resistance and very good resistance to seawater.

The table below gives some information about material **X**.

elements used to make X	% by weight	relative atomic mass
aluminium		27
magnesium	0.8	24
silicon	0.6	28
iron	0.7	56
zinc	0.2	65
copper	0.4	64

(a) Why can **X** be described as an alloy?

_____

_____ [2]

(b) **(i)** Calculate the **total** percentage by weight of all the other elements added to aluminium in this alloy.

_____ [1]

(ii) Calculate the percentage by weight of aluminium in this alloy.
Show your working.

_____% [2]

(c) (i) From the information given in the passage opposite and your own knowledge, explain why **X** would be very suitable in the manufacture of aircraft.

_____

_____

_____

_____ [2]

(ii) Suggest another use for **X** based on the information in the passage and the table.

_____ [1]

5.

Explain why oxygen has a low boiling point.

_____

_____

_____

_____ [3]