Bonding Revision materials

Content will be tested on Chemistry Paper 1

Checklist

Keypoints:	☺	☹
Bonding		
State which substance contain ionic bonding		
Explain how ionic bonding works and between what types of atom		
Draw a dot and cross diagram to show the bonding in NaCl		
Describe the bonding in complex ionic compounds (eg. $MgCl_2$)		
Explain structure of an ionic lattice		
State the properties of a giant ionic substance		
Explain the properties of giant ionic substances		
Explain what a simple molecular substance is and name some examples		
State the properties of a simple molecular substance		
Explain the properties of simple molecular substances		
State which substances contain covalent bonding		
Explain what covalent bonding is, when it occurs and the difference between a single		
Draw the bonding for a simple molecule containing 1 single bond (eg. F_2)		
Draw the bonding for a simple molecule containing multiple single bonds (eg. H_20, NH_3) or a double bond (eg. O_2)		
Give examples of giant covalent substances and explain structure		
State the properties of a giant covalent substance		
Explain the properties of giant covalent substances		
Describe the structure of metallic bonding		
Difference in structure of metals and alloys		

There are three types of strong chemical bonds:

- Ionic
- Covalent
- Metallic

Ionic	Covalent	Metallic
Particles are oppositely charged ions	Particles are atoms which share pairs of electrons	Particles are atoms which share delocalised electrons
Between metals and non-metals	Most non-metallic elements Between non-metals and non-metals	In metallic elements and alloys

Ionic bonding

Ionic bonds form between **metals and non-metals**. Ionic bonding involves the transfer of electrons in the **outer** shells.
Metals **lose** electrons to become **positively** charged ions
and non-metals **gain** electrons to become **negatively**
charged ions.

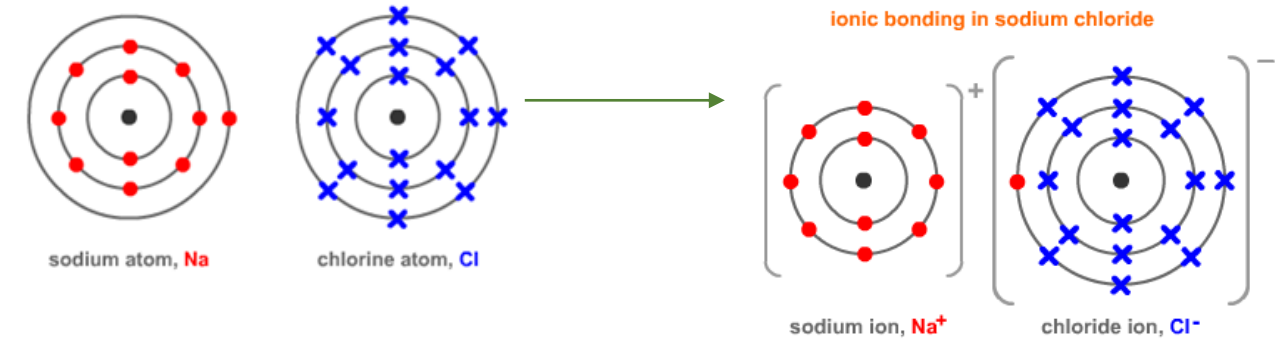
Positive Ions		Negative Ions	
Hydrogen	H^+	Fluoride	F^-
Lithium	Li^+	Chloride	Cl^-
Sodium	Na^+	Bromide	Br^-
Potassium	K^+	Iodide	I^-
Magnesium	Mg^{2+}	Oxide	O^{2-}
Calcium	Ca^{2+}	Hydroxide	OH^-
Aluminium	Al^{3+}	Nitrate	NO_3^-
Silver	Ag^+	Sulphate	SO_4^{2-}
Copper	Cu^{2+}	Phosphate	PO_4^{3-}
Ammonium	NH_4^+	Carbonate	CO_3^{2-}
Iron	Fe^{2+} & Fe^{3+}		
These have all *lost* electrons. They're all metals apart from H^+ and NH_4^+		These have all *gained* electrons. They're all non-metals.	

The elements in Group 1 react with the elements in Group 7.

Groups 1 elements can each lose one electron.

This electron can be given to an atom from Group 7, they both achieve the stable electronic structure of a noble gas.

The electrostatic attraction between the oppositely charged Na^+ ions and Cl^- ions is called ionic bonding. The electron transfer during the formation of an ionic compound can be represented by a dot and cross diagram:



The **charge** on the ions produced by metals in group 1 and 2 and by non-metals in group 6 and 7 relates to the **group number** of the element in the periodic table. For example **group 1** form **1+ ions**, **group 3** form **3+ ions**, **group 6** form **2- ions** and **group 7** form **1- ions**.

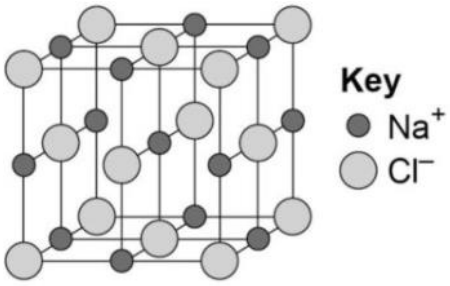
Structure

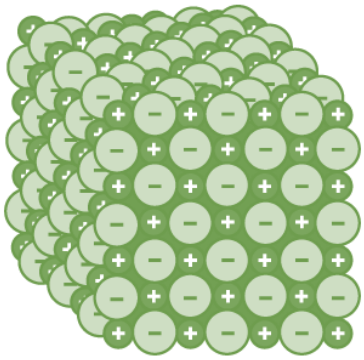
- Ionic compounds have **regular structures** called **giant ionic lattices**.
- There is **strong electrostatic forces** of attraction in all directions between **oppositely changed ions**.

Properties

- **High melting and boiling points** – large amounts of energy is needed to break the many **strong bonds** and overcome the electrostatic attraction.

- **Conduct electricity** when molten or dissolved in water – **ions are free to move** and can carry charge.





Exam Practice 1

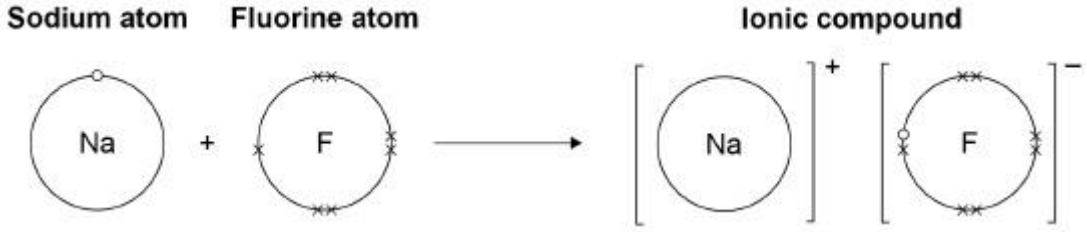
Q1.

A sodium atom and a fluorine atom react together to form an ionic compound.

Figure 1 shows the electron arrangements in the atoms and the ionic compound.

Only the outer shell electrons are shown.

Figure 1



(a) What is the name of the ionic compound shown in **Figure 1**?

Tick **one** box.

Sodium fluorate ☐

Sodium fluoride ☐

Sodium fluorine ☐

(1)

(b) What type of force acts between the ions in an ionic compound?

Tick **one** box.

Electrostatic ☐

Frictional ☐

Gravitational ☐

Magnetic ☐

(1)

(c) What are **two** properties of ionic compounds?

Tick **two** boxes.

Conducts electricity when molten	☐
High melting point	☐
Low boiling point	☐
Small molecules	☐
Weak bonds between particles	☐

(2)

(d) Describe what happens when a sodium atom reacts with a fluorine atom to form an ionic compound.

Use **Figure 1**.

_____

_____

_____

_____

_____

_____

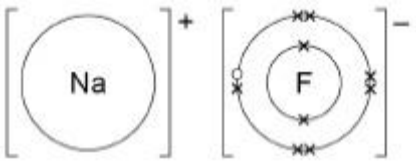
_____

_____

(4)

(e) **Figure 2** shows the structure of the ionic compound formed in the reaction.

Figure 2



Suggest **one** limitation of using **Figure 2** to show the structure of this compound.

_____

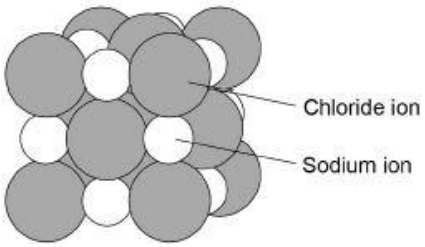
_____

(1)

Q2.

Figure 2 shows part of the structure and bonding in sodium chloride (NaCl).

Figure 2



Explain the conditions needed for sodium chloride to conduct electricity.

_____

_____

_____

_____

_____

_____

_____

(3)

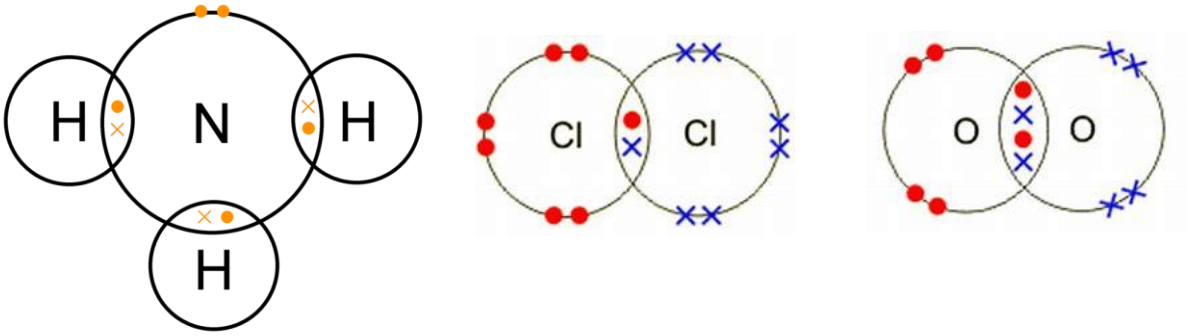
Covalent Bonding

When atoms **share pairs of electrons**, they form **covalent bonds**.

These are **STRONG** bonds.

Covalently bonded substances may be: **Small molecules**, **very large molecules** or **giant covalent structures.**

Covalently bonded substances may consist of small molecules. The covalent bond in molecules can be represented in the following models.



Properties of small molecules

<u>Structure</u>

- They have **weak forces between the molecules**. These weak forces are overcome when they change state **<u>not</u>** the strong covalent bonds.

<u>Properties</u>

- **Low melting and boiling points** – small amounts of energy is needed to break the **intermolecular forces**. Most are gases or liquids.
- **Do not conduct electricity** – Particles do not have an overall electric charge.

Intermolecular forces increase with the size of the molecules. So larger molecules have higher melting and boiling points

Exam practice 2

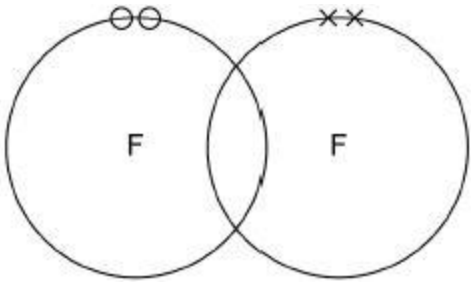
Q1.

(a) A fluorine atom has 7 electrons in the outer shell.

The diagram below shows part of a dot and cross diagram to represent a molecule of fluorine (F_2).

Complete the dot and cross diagram.

You should show only the electrons in the outer shells.



(i) Explain why fluorine is a gas at room temperature.

Use the following words in your answer:

energy **forces** **molecules** **weak**

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

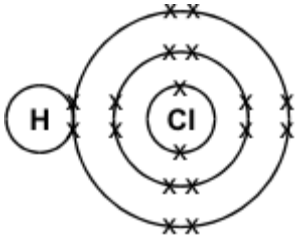
_____

(3)

Q2.

The hydrogen halides (hydrogen fluoride, hydrogen chloride, hydrogen bromide and hydrogen iodide) are important chemicals.

The diagram below represents a molecule of hydrogen chloride.



(i) What type of particles are represented by the crosses (X)?

_____

(1)

(ii) What type of chemical bond holds the atoms in this molecule together?

_____

(1)

Q3.

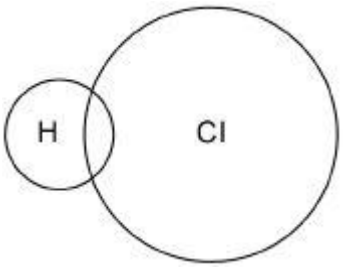
This question is about hydrogen chloride.

(a) A hydrogen atom contains 1 electron and a chlorine atom contains 17 electrons.

Complete **Figure 1** to show a dot and cross diagram for a hydrogen chloride molecule.

Show the outer electrons only.

Figure 1



(2)

Q4.

Use the relevant electron arrangements to describe the bonding in water.

_____

_____

_____

_____

_____

_____

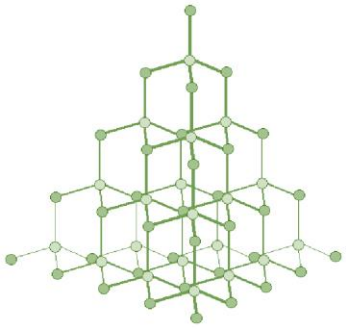
(2)

Giant Covalent Structure

Diamond

In diamond, each carbon atom forms **four covalent bonds** with other carbon atoms in a **giant covalent structure**.

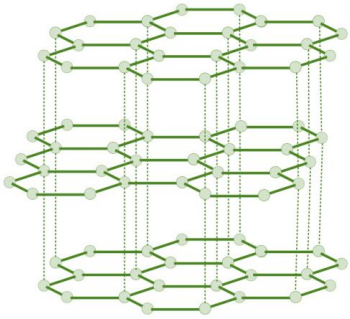
- Diamond is very **hard** – it is the hardest natural substance, so it is often used to make jewellery and cutting tools.
- Diamond has a **very high melting** and **boiling point** – a lot of energy is needed to break the covalent bonds.
- Diamond **cannot conduct electricity** – there are no free electrons or ions to carry a charge.



Graphite

In graphite, carbon atom forms **three** covalent bonds with three other carbon atoms, forming layers of **hexagonal rings** which have no covalent bonds between the layers.

- **Graphite is soft and slippery** – **layers** can easily slide over each other because the weak forces of attraction between the layers are easily broken. This is why graphite is used as a lubricant.
- **Graphite conducts electricity** – the only non-metal to do so. One **electron** from each carbon atom is **delocalised**.

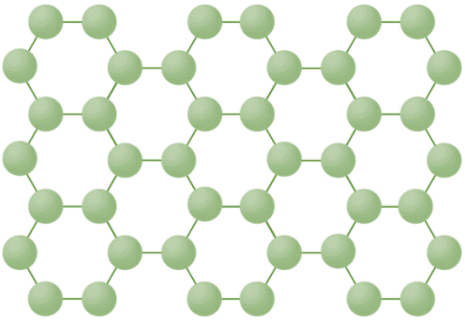


Graphene

This is a **single layer** of graphite – a layer of inter-locking hexagonal rings of carbon atoms **one atom thick**.

It is an excellent **conductor** of **thermal** energy and **electricity** (even better than graphite), has a very **low density** and is incredibly **strong**.

It has many uses in the **electronics industry**.

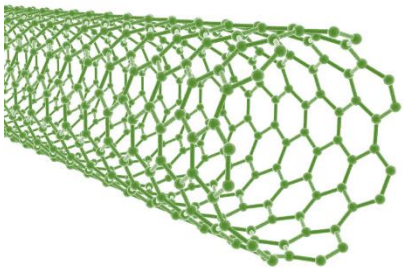


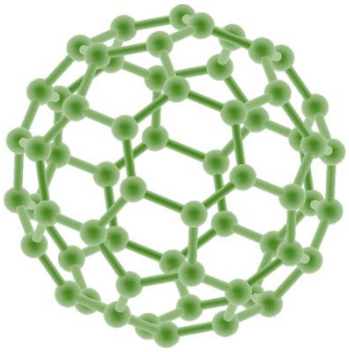
Fullerenes

Fullerenes are molecules of carbon with **hollow shapes**.

The structure is based on hexagonal rings of carbon atoms, but may have 5 or 7 carbon rings. The first to be discovered was **Buckminsterfullerene** (C_{60})

which is spherical (like a football).

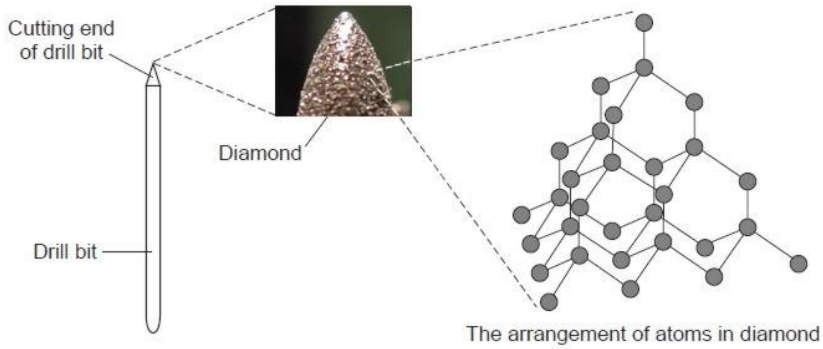




Exam practice 3

Q1.

A drill bit is used to cut holes through materials. The cutting end of this drill bit is covered with very small diamonds.



Draw a ring around the correct word in each box.

(a) Diamond is made from [carbon / nitrogen / oxygen] atoms.

(1)

(b) Diamond has a giant structure in which [none / some / all] of the atoms are joined together.

(1)

(c) The atoms in diamond are joined together by [covalent / ionic / metallic] bonds.

(1)

(d) In diamond each atom is joined to

two
three
four

other atoms.

(1)

(e) Diamond is suitable for the cutting end of a drill bit because it is

hard.
shiny.
soft

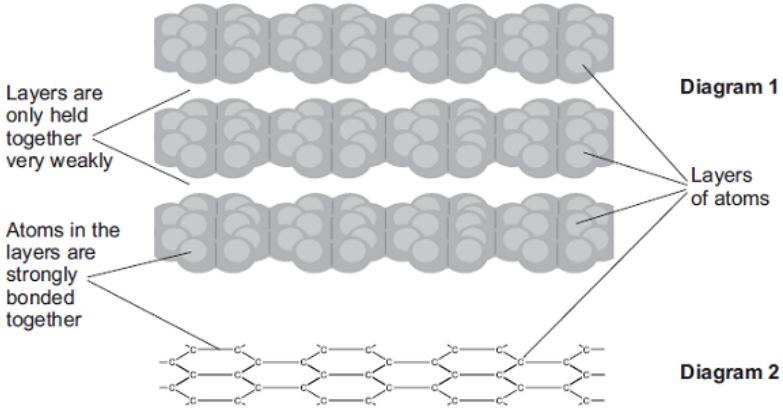
(1)

Q2.

The picture shows a student filling in a multiple choice answer sheet using a pencil.

The pencil contains graphite. Graphite rubs off the pencil onto the paper.

Diagrams **1** and **2** show how the atoms are arranged in graphite.



(a) Use the diagrams to help you explain why graphite can rub off the pencil onto the paper.

_____

_____

_____

_____

(2)

(b) Draw a ring around the type of bond which holds the atoms together in each layer.

covalent **ionic** **metallic**

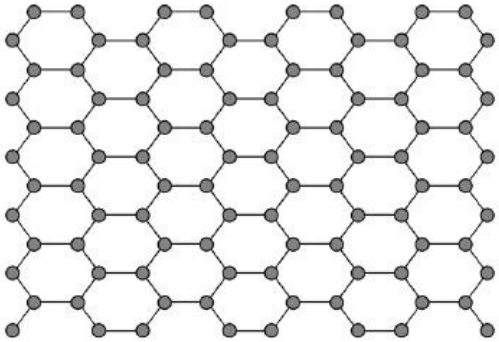
(1)

Q3.

This question is about structure and bonding.

(a) **Figure 1** shows part of one layer of graphene.

Figure 1



Which element is graphene made from?

Tick **one** box.

Carbon ☐

Copper ☐

Hydrogen ☐

Sodium ☐

(1)

(b) Each atom in graphene has one delocalised electron.

Complete the sentence.

Choose the answer from the box.

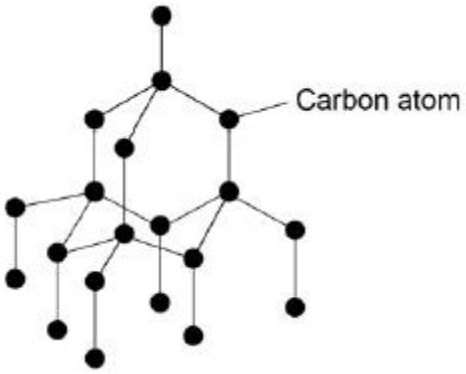
act as a lubricant	**be used as a fuel**
conduct electricity	**dissolve in water**

Delocalised electrons allow graphene to _____ .

(1)

(c) Which structure is a fullerene?

Tick **one** box.



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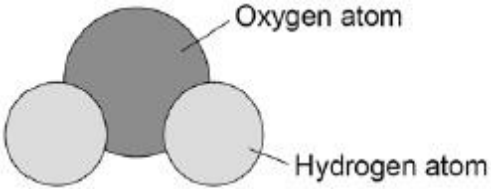

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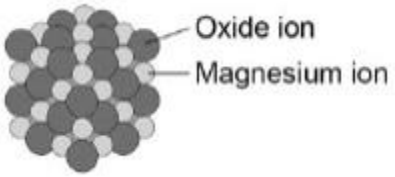

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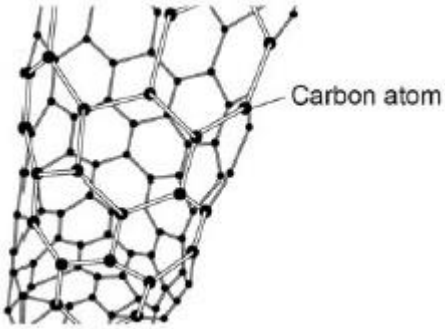


☐

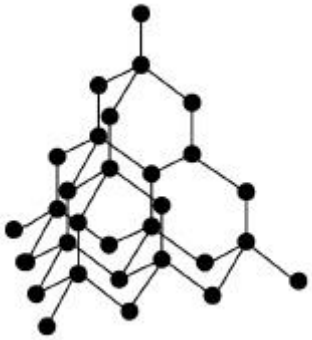
(1)

Q4.

This question is about diamond and graphite.

Figure 1 shows part of the structure of diamond.

Figure 1



(a) Complete the sentence.

Choose the answer from the box.

calcium	**carbon**	**chromium**	**cobalt**

Diamond is a form of

_____ .

(1)

(b) Which **two** statements about diamond are correct?

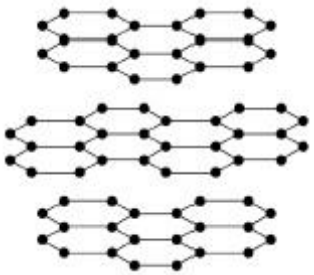
Tick **two** boxes.

Diamond has a giant structure.	☐
Diamond has ionic bonds.	☐
Diamond is made of layers.	☐
Diamond has weak bonds.	☐
Each atom is joined to four other atoms.	☐

(2)

Figure 2 shows part of the structure of graphite.

Figure 2



(c) Explain why graphite is soft and slippery.

Use **Figure 2** and your own knowledge.

(3)

(d) Graphite has covalent bonds between the atoms.

How many covalent bonds does each atom form?

Tick **one** box.

1 ☐ 2 ☐ 3 ☐ 4 ☐

(1)

(e) Explain why graphite can conduct electricity.

You should include a reference to electrons in your answer.

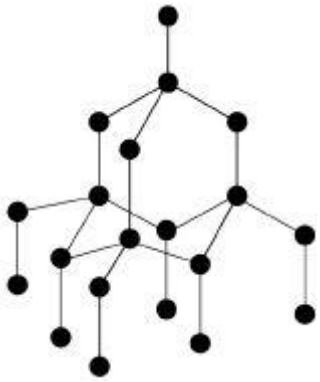
(2)

Q5.

This question is about structure and bonding.

(a) **Figure 1** shows part of the structure and bonding in diamond.

Figure 1



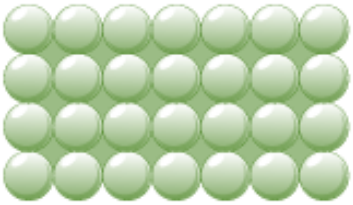
Explain why diamond has a high melting point.

(3)

Metallic bonding and Alloys

Metallic bonding

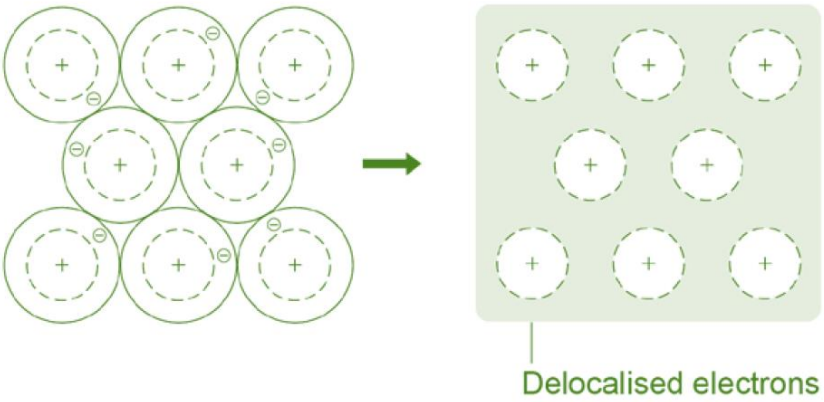
The atoms in metals are built up **layer upon layer** in a **regular** pattern. They are another example of a **giant structure**.



The electrons in the **outer shell** of metal atoms are **delocalised** and are **free to move** throughout the structure. **Delocalised** electrons in metals enable **electricity** and **heat** to pass through the metal easily

The sharing of delocalised electrons leads to **strong metallic bonds**.

Metallic bonding can be represented in the following form:



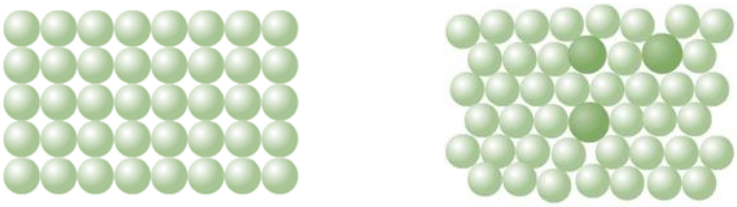
The giant structure of atoms with strong metallic bonding gives most metals a **high melting** and **boiling point**.

Metals are **malleable** (can be hammered into shape) and **ductile** (can be drawn out into a wire) because the **layers** of atoms (or ions) in a giant metallic structure can **slide** over each other

Alloys

A **metal mixed** with other **elements** is called an **alloy.** Alloys are **harder** than pure metals. Alloys are made from **two or more** different metals.

Pure metal **Alloy**



The **different sized** atoms of the metals **distort** the **layers** in the structure, making it more **difficult** for them to **slide** over each other, and so make the **alloys harder** than pure metals.

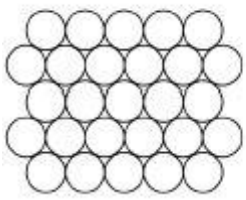
For example, **gold** is naturally **soft** but adding **copper** to make jewellery **stronger** and last longer.

Q1.

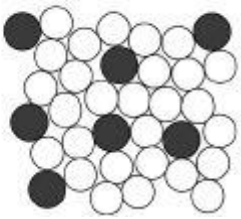
Copper is a metal.

(a) Which structure represents the arrangement of atoms in pure copper?

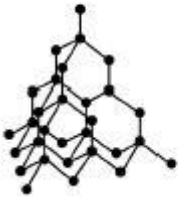
A



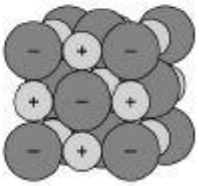
B



C



D



Tick **one** box.

A ☐

B ☐

C ☐

D ☐

(1)

(b) Copper is used in electrical wiring.

Give **one** reason why.

_____

_____

(1)

Q2.

(a) What is an alloy?

_____

_____

(1)

(b) Give **one** reason why alloys are used instead of pure metals.

_____

_____

(1)

Q3.

(a) Complete the sentence.

Choose the answer from the box.

attract	**bond**	**slide**	**vibrate**

Metals can be stretched into wires

because the layers of atoms can _____ .

(1)

(Total 7 marks)

Q4.

(a) Glass can be coloured using tiny particles of gold. Gold is a metal.

Describe the structure of a metal.

_____

_____

_____

_____

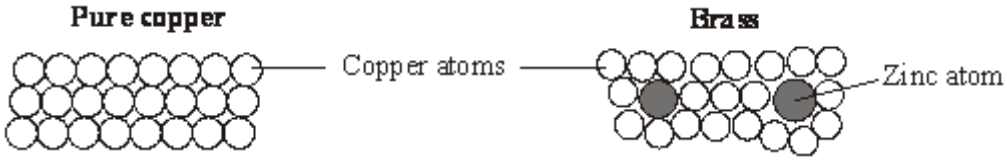
_____

_____

(3)

Q5.

(a) Pure copper is made up of layers of copper atoms. Brass is an *alloy* of copper and zinc.



Why are the physical properties of brass different from the physical properties of pure copper?

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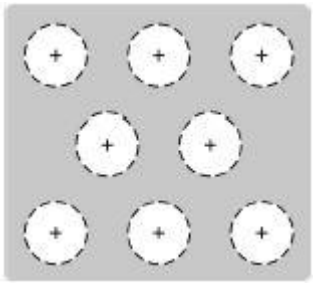
(2)

(b)

Figure 3 shows the structure of sodium.

Figure 3



Describe how sodium conducts thermal energy.

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(3)