AQA Chemistry Unit 3

Structure and Bonding

Crompton House Chemistry

		Learn it	Revise it
1	I can name the three states of matter, identify them from a simple model and state which changes of state happen at melting and boiling points, including the strength and type of the forces between particles.		
2	(HT) I can discuss the limitations of particle theory		
3	I can fully describe how ionic compounds are formed		
4	I can describe the properties of ionic compounds		
5	I can fully describe how covalent substances are formed		
6	I can fully describe the properties of Giant and simple covalent substances including diamond, graphite and graphene		
7	I can use dot and cross diagrams to show ionic and covalent bonding		
Chemistry only			
8	*I can compare the dimensions of nanoparticles to other particles and explain the effect of their high surface area to volume ratio on their properties*		
9	*I can discuss the applications of nanoparticles and their advantages and disadvantages, including uses in medicine, cosmetics, fabrics and the development of catalysts*		

DODDLE QUIZZES

Kerboodle Extension Quizzes

Positive Points/postcards for completion

C3 Checkpoint quiz: Structure and bonding ____________%

C3 Homework: Structure and bonding 1 ____________%

C3 Homework: Structure and bonding 2 ____________%

C3 Progress quiz: Structure and bonding 1 – test ____________%

C3 Progress quiz: Structure and bonding 2 – test ____________%

Self-Reflection

WWW:

EBI:

Checked by Teacher:

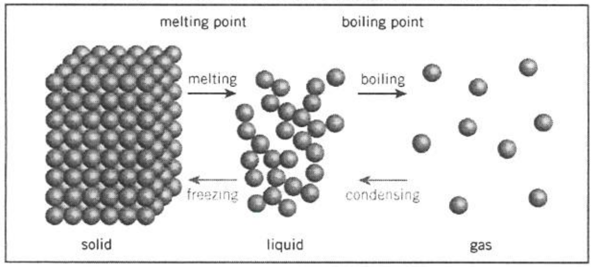
Date:

Chapter 3: Bonding 1

Knowledge organiser

Particle model

The three states of matter can be represented in the particle model.



(HT only) This model assumes that:

- there are no forces between the particles
- that all particles in a substance are spherical
- that the spheres are solid.

The amount of energy needed to change the state of a substance depends on the forces between the particles. The stronger the forces between the particles, the higher the melting or boiling point of the substance.

Covalent bonding

Atoms can share or transfer electrons to form strong chemical bonds.

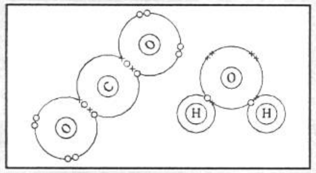
A **covalent bond** is when electrons are *shared* between **non-metal** atoms.

The number of electrons shared depends on how many extra electrons an atom needs to make a full outer shell.

If you include electrons that are shared between atoms, each atom has a full outer shell.

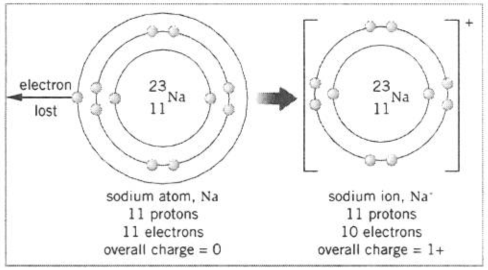
Single bond = each atom shares one pair of electrons.

Double bond = each atom shares two pairs of electrons.



Ions

Atoms can gain or lose electrons to give them a full outer shell. The number of protons is then different from the number of electrons. The resulting particle has a charge and is called an **ion**.



Conductivity

Solid ionic substances do not conduct electricity because the ions are fixed in position and not free to carry charge.

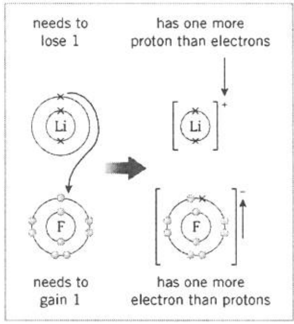
When melted or dissolved in water, ionic substances do conduct electricity because the ions are free to move and carry charge.

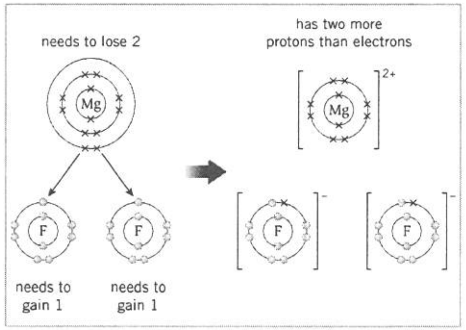
Melting points

Ionic substances have high melting points because the electrostatic force of attraction between oppositely charged ions is strong and so requires lots of energy to break.

Ionic bonding

When metal atoms react with non-metal atoms they **transfer** electrons to the non-metal atom.

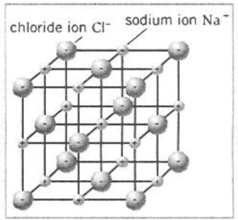




Metal atoms lose electrons to become positive ions. Non-metal atoms gain electrons to become negative ions.

Giant ionic lattice

When metal atoms transfer electrons to non-metal atoms you end up with positive and negative ions. These are attracted to each other by the strong **electrostatic force of attraction**. This is called ionic bonding.

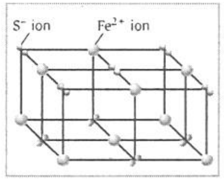


The electrostatic force of attraction works in all directions, so many billions of ions can be bonded together in a 3D structure.

Formulae

The formula of an ionic substance can be worked out

1. from its bonding diagram: for every one magnesium ion there are two fluoride ions – so the formula for magnesium fluoride is MgF_2
2. from a lattice diagram: there are nine Fe^{2+} ions and 18 S^- ions – simplifying this ratio gives a formula of FeS_2



Covalent structures

There are three main types of covalent structure:

Structure and bonding

Giant covalent

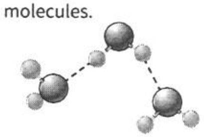
Many billions of atoms, each one with a strong covalent bond to a number of others.

An example of a giant covalent structure is diamond.

Small molecules

Each molecule contains only a few atoms with strong covalent bonds between these atoms. Different molecules are held together by weak **intermolecular forces**.

For example, water is made of small molecules.



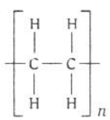
Large molecules

Many repeating units joined by covalent bonds to form a chain.

The small section is bonded to many identical sections to the left and right. The 'n' represents a large number.

Separate chains are held together by intermolecular forces that are stronger than in small molecules.

Polymers are examples of long molecules.



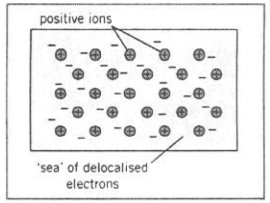
Metals: structure and properties

The atoms that make up metals form layers. The electrons in the outer shells of the atoms are **delocalised** – this means they are free to move through the whole structure.

The positive metal ions are then attracted to these delocalised electrons by the electrostatic force of attraction.

Some important properties of metals are:

- pure metals are **malleable** because the layers can slide over each other
- they are good **conductors** of electricity and of thermal energy because delocalised electrons are free to move through the whole structure
- they have high melting and boiling points because the electrostatic force of attraction between metal ions and delocalised electrons is strong so lots of energy is needed to break it.



Chapter 3: Bonding 2

Knowledge organiser

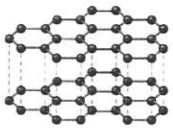
Properties			
Properties	High melting and boiling points because the strong covalent bonds between the atoms must be broken to melt or boil the substances. This requires a lot of energy. Solid at room temperature.	Low melting and boiling points because only the intermolecular forces need to be overcome to melt or boil the substances, not the bonds between the atoms. This does not require a lot of energy as the intermolecular forces are weak. Normally gaseous or liquid at room temperature.	Melting and boiling points are low compared to giant covalent substances but higher than for small molecules. Large molecules have stronger intermolecular forces than small molecules, which require more energy to overcome. Normally solid at room temperature.

Most covalent structures do not conduct electricity because they do not have **delocalised electrons** or ions that are free to move to carry charge.

Graphite

Graphite is a giant covalent structure, but is different to other giant covalent substances.

Structure



Made only of carbon – each carbon atom bonds to three others, and forms hexagonal rings in layers. Each carbon atom has one spare electron, which is delocalised and therefore free to move around the structure.

Hardness

The layers can slide over each other because they are not covalently bonded. Graphite is therefore softer than diamond, even though both are made only of carbon, as each atom in diamond has four strong covalent bonds.

Conductivity

The delocalised electrons are free to move through graphite, so can carry charges and allow an electrical current to flow. Graphite is therefore a conductor of electricity.

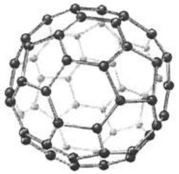
Graphene

Graphene consists of only a single layer of graphite. Its strong covalent bonds make it a strong material that can also conduct electricity. It could be used in composites and high-tech electronics.

Fullerenes

- hollow cages of carbon atoms bonded together in one molecule
- can be arranged as a sphere or a tube (called a **nanotube**)
- molecules held together by weak intermolecular forces, so can slide over each other
- conduct electricity

Spheres

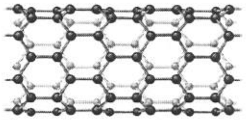


Buckminsterfullerene was the first fullerene to be discovered, and has 60 carbon atoms.

Other fullerenes exist with different numbers of carbon atoms arranged in rings that form hollow shapes.

Fullerenes like this can be used as lubricants and in drug delivery.

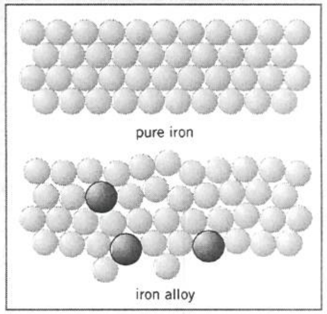
Nanotubes



The carbon atoms in nanotubes are arranged in cylindrical tubes.
Their high **tensile strength** (they are difficult to break when pulled) makes them useful in electronics.

Alloys

Pure metals are often too soft to use as they are. Adding atoms of a different element can make the resulting mixture harder because the new atoms will be a different size to the pure metal's atoms. This will disturb the regular arrangement of the layers, preventing them from sliding over each other.
The harder mixture is called an **alloy**.



Measuring particles

We use different units and scales to measure the size of particles.

Particle	Particulate matter	Size	Standard form	Full form
grain of sand	N/A	0.1 mm	1×10^{-4} m	0.0001 m
coarse particles (e.g., dust)	PM_{10}	10 μm	1×10^{-5} m	0.00001 m
fine particles	$PM_{2.5}$	100 nm	1×10^{-7} m	0.0000001 m
nanoparticles	$< PM_{2.5}$	1 to 100 nm	1×10^{-9} to 1×10^{-7} m	0.000000001 m to 0.0000001 m

PM stands for **particulate matter** and is another way of measuring very small particles.

Uses of nanoparticles

Nanoparticles often have very different properties to bulk materials of the same substance, caused by their high surface area-to-volume-ratio.

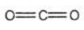
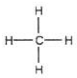
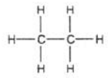
Nanoparticles have many uses and are an important area of research. They are used in healthcare, electronics, cosmetics, and as catalysts.

However, nanoparticles have the potential to be hazardous to health and to ecosystems, so it is important that they are researched further.

Key terms **Make sure you can write a definition for these key terms.**

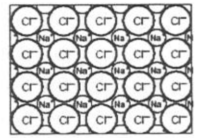
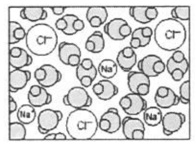
conductivity *conductor* *delocalised electron* *electrostatic force of attraction* *ion* *lattice* *layer* *malleable* *nanoparticle* *particulate matter* *surface area to volume ratio* *transfer*

THE TRUTH ABOUT STRUCTURE & BONDING

SIMPLE MOLECULAR substances			If false, what is wrong?
 molecule of carbon dioxide, CO_2	 molecule of methane, CH_4	 molecule of ethane, C_2H_6	
1	T F	Methane is a gas at room temperature because the bonds between the atoms are weak.	
2	T F	Ethane has a higher boiling point than methane because there are more bonds to break.	
3	T F	Carbon dioxide has a higher boiling point than methane because its atoms are held together by double bonds rather than single bonds.	

GIANT COVALENT substances			If false, what is wrong?
4	T F	Diamond has a high melting point because there are strong covalent bonds between its molecules	
5	T F	Diamond has a high melting point because the atoms are all joined by covalent bonds in a lattice	

METALLIC structures			If false, what is wrong?
6	T F	Copper has a high melting point because there are strong forces of attraction between the nucleus of the copper atoms and the delocalised outer shell electrons	
7	T F	Copper has a high melting point because there are strong forces of attraction between the nucleus of each copper atom and its electrons	
8	T F	The metal conducts electricity because there is a delocalised electron	
9	T F	Copper has a high melting point because there are lots of strong covalent bonds to break	
10	T F	Copper can be bent because the layers of copper atoms can slide relative to each other	

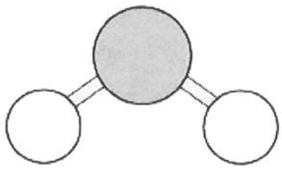
IONIC structures			If false, what is wrong?
Ionic structures as a SOLID		 Sodium chloride as a solid, NaCl(s)	
11	T F	Each molecule of sodium chloride contains one sodium ion and one chloride ion.	
12	T F	Each sodium ion is attracted to one chloride ion.	
13	T F	The ions exist in pairs containing one sodium ion and one chloride ion.	
14	T F	Each sodium ion is bonded ionically to one chloride ion, and then to others by attractive forces.	
15	T F	There is a bond between the ions in each molecule, but no bonds between molecules.	
16	T F	There are no molecules shown in the diagram.	
17	T F	An ionic bond is when one atom donates an electron to another atom.	
18	T F	A sodium ion can only form one ionic bond because it only has one electron in its outer shell.	
19	T F	The sodium ions and chloride ions are not joined to each other, but are attracted to each other by electrostatic attraction.	
20	T F	Each sodium ion is attracted to all the chloride ions surrounding it.	
Ionic structures as a solution		 Sodium chloride as a solution, NaCl(aq)	
21	T F	The ions are separated	
22	T F	The sodium chloride molecules break apart when they dissolve	
23	T F	The sodium and chloride ions move around in Na^+ Cl^- pairs.	
24	T F	The solution conducts electricity because electrons can pass through the solution	

© www.CHEMSHEETS.co.uk 15-July-2021 Chemsheets GCSE 1072

Exam Questions

Q1. This question is about substances with covalent bonding.

(a) The diagram below shows a ball and stick model of a water molecule (H_2O).



Suggest **one** limitation of using a ball and stick model for a water molecule.

____

____

____

(1)

(b) Ice has a low melting point.

Water molecules in ice are held together by intermolecular forces.

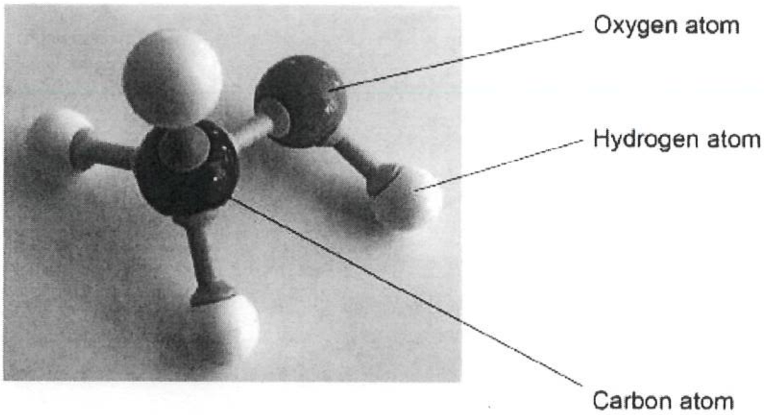
Complete the sentence.

Ice has a low melting point because the intermolecular forces are

_____________________.

(1)

(c) The image below shows the structure of a molecule.



What is the molecular formula of the molecule in the above image?

____

____

(1)

Diamond has a giant covalent structure.

(d) What is the number of bonds formed by each carbon atom in diamond?

Tick (✓) **one** box.

2 ☐ 3 ☐ 4 ☐ 8 ☐

(1)

(e) Give **two** physical properties of diamond.

1. ____________________

2. ____________________

(2)

(f) Name **two** other substances with giant covalent structures.

1. ____________________

2. ____________________

(2)

(Total 8 marks)

Q2. Three substances are all solid at room temperature.

The table describes tests and the result of each test on the three substances.

Substance	**Effect of large force applied**	**Effect of heating gently at first, then strongly**	**Effect of passing electricity through solid**	**Effect of passing electricity through liquid**
A	Breaks into many pieces	Easily melts and then boils	Does not conduct	Does not conduct
B	Breaks into many pieces	No change	Does not conduct	Conducts
C	Becomes thinner	No change	Conducts	Conducts

(a) The covalent bonds in the molecules are not overcome when substance **A** is heated.

What forces are overcome when substance **A** melts?

____

(1)

(b) What could substance **A** be?

Tick **one** box.

Graphite	☐	Sodium chloride	☐
Iron	☐	Sulfur	☐

(1)

(c) Suggest why substance **B** conducts electricity as a liquid but does **not** conduct electricity as a solid.

____

____

____

____

____

____

(3)

(d) Suggest why substance **C** becomes thinner when a large force is applied.

____

____

____

____

(2)

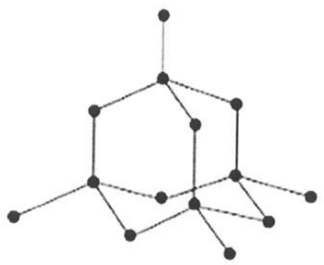
(e) What could substance **C** be?

Tick **one** box.

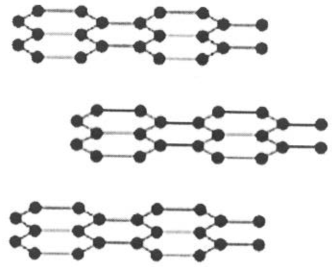
Copper	☐	Iodine	☐
Diamond	☐	Magnesium oxide	☐

(1)
(Total 8 marks)

Q3. The diagrams show the structures of diamond and graphite.



Diamond



Graphite

(a) Diamond and graphite both contain the same element.

What is the name of this element?

____

(1)

(b) Use the diagrams above and your knowledge of structure and bonding to explain why:

(i) graphite is very soft

____

____

____

____

(2)

(ii) diamond is very hard

____

____

____

____

(2)

(iii) graphite conducts electricity.

____

____

____

____

(2)

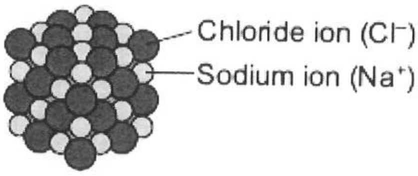
(Total 7 marks)

Q4. In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.

Explain why chlorine (Cl_2) is a gas at room temperature, but sodium chloride (NaCl) is a solid at room temperature.

Chlorine

Sodium chloride



Include a description of the bonding and structure of chlorine and sodium chloride in your answer.

(Total 6 marks)