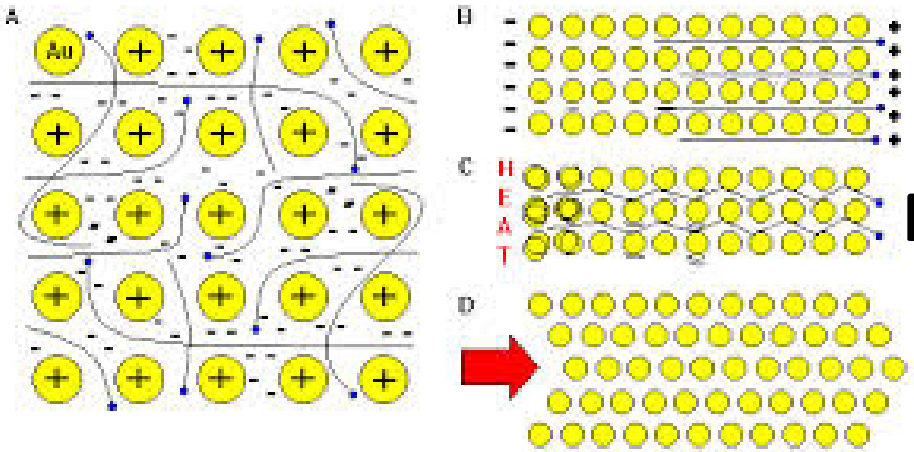
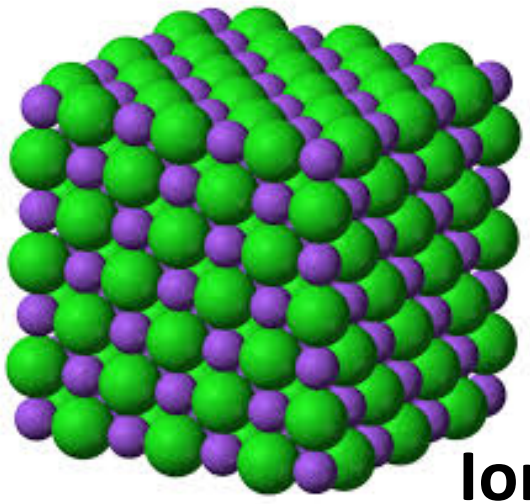
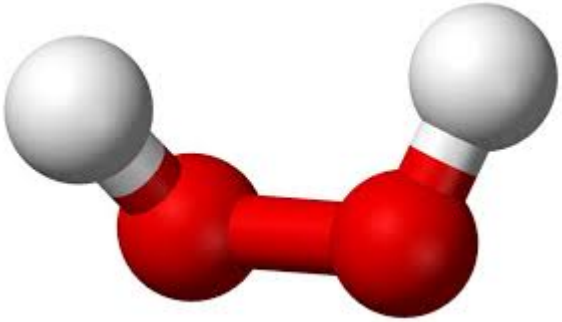


Metallic

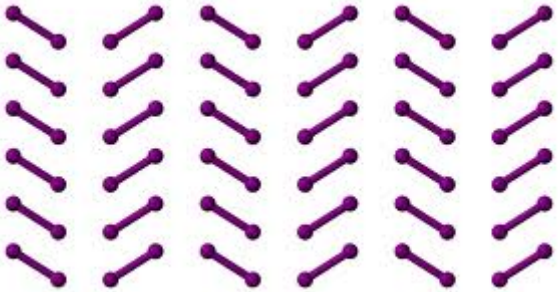


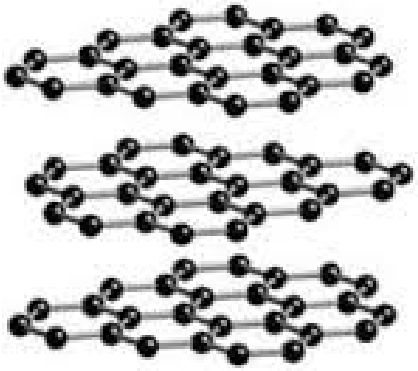
Ionic

Structure and Properties of Solids

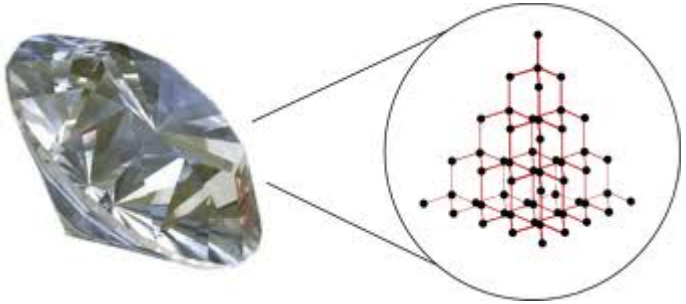


Covalent





Network



Structure and Properties of Solids

We need to use:

- ionic, covalent and metallic bonding

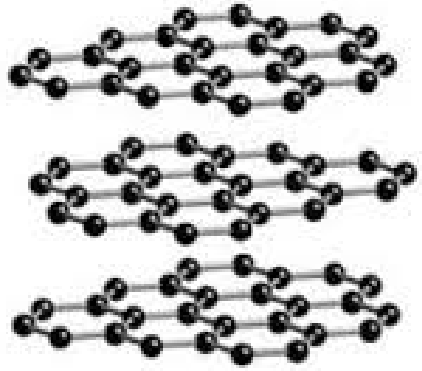
and

- molecular, ionic, metallic and covalent network structure

To explain properties of substances:

- melting and boiling points, solubility, electrical conductivity, malleability, ductility, and hardness.

Properties



What determines the:

melting point of a compound

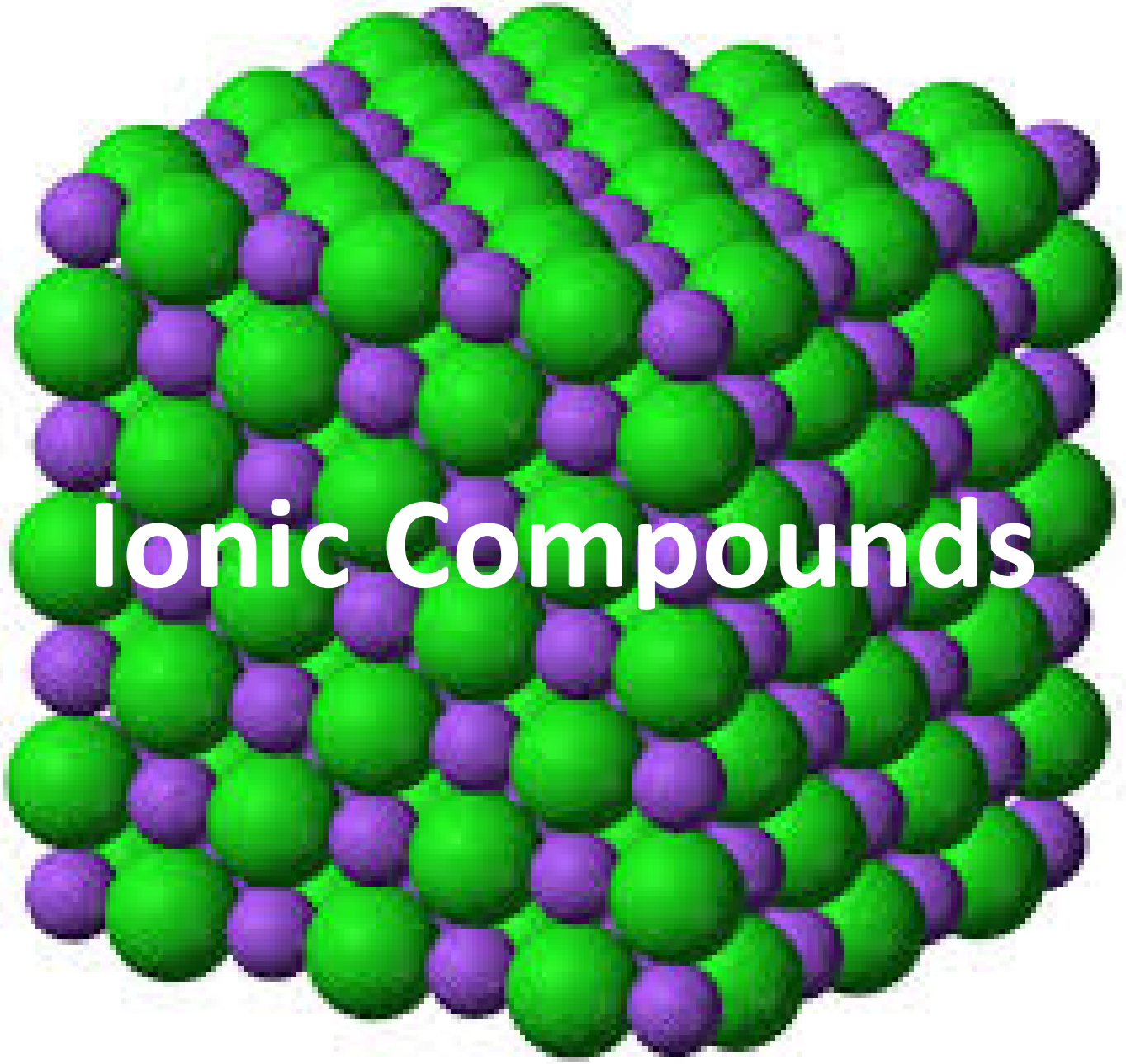
how strong the bonds are that hold the compound together – the stronger the bond the more energy required to break it

conductivity of a compound

if the compound has any ions/electrons that are free to move around and carry the electricity

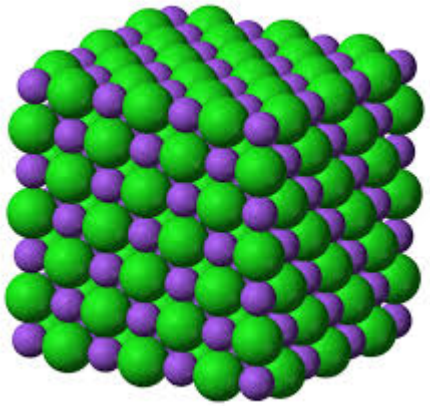
solubility of a compound

if the compound has a similar solubility to the compound dissolving it – like dissolves like <u>and</u> if the energy/stability gained from dissolving is greater than the energy/stability lost from breaking the bonds to dissolve



Ionic Compounds

Structure and bonding in ionic compounds



Bonding

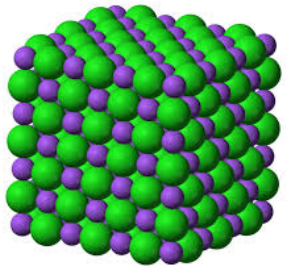
Ionic compounds consist of ions held together by ionic bonds. Ionic bonds are strong bonds.

Structure

These bonds hold ionic compounds together in a regular 3-dimensional lattice. Each ion is surrounded by ions of the opposite charge.

Substance	Type of substance	Type of particle	Attractive forces between particles
	ionic	ions	ionic bonds

Properties of ionic compounds

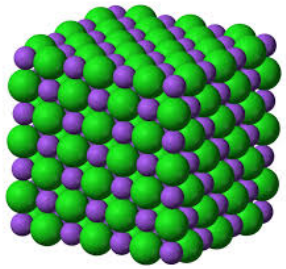


Melting point…
Ionic compounds have high melting points because a lot of energy is required to break the electrostatic attractions between the ions.

Conductivity…
Ionic compounds can only conduct electricity when they are dissolved in water or are molten as there are ions free to move. Ionic compounds can not conduct electricity as a solid, as the ions are not free to move.

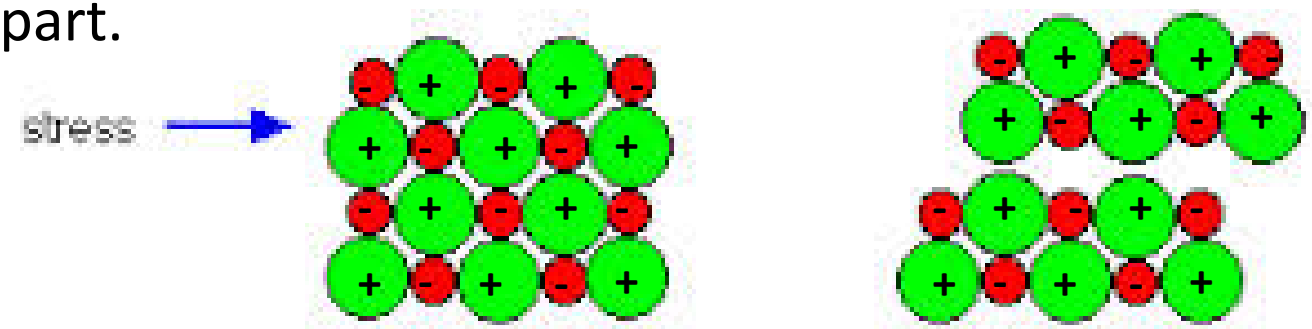
Solubility…
Some ionic compounds are soluble in water (remember back to CHEM2.2) as the water can pull the ions apart from each other.

Properties of ionic compounds



Brittleness…

Ionic compounds are brittle because of their 3-dimensional lattice structure. If they are knocked out of line the anions repel the anions and the cations repel the cations and the compound breaks apart.



Malleability and ductility…

Ionic compounds are not malleable or ductile as the ionic bonds are directional

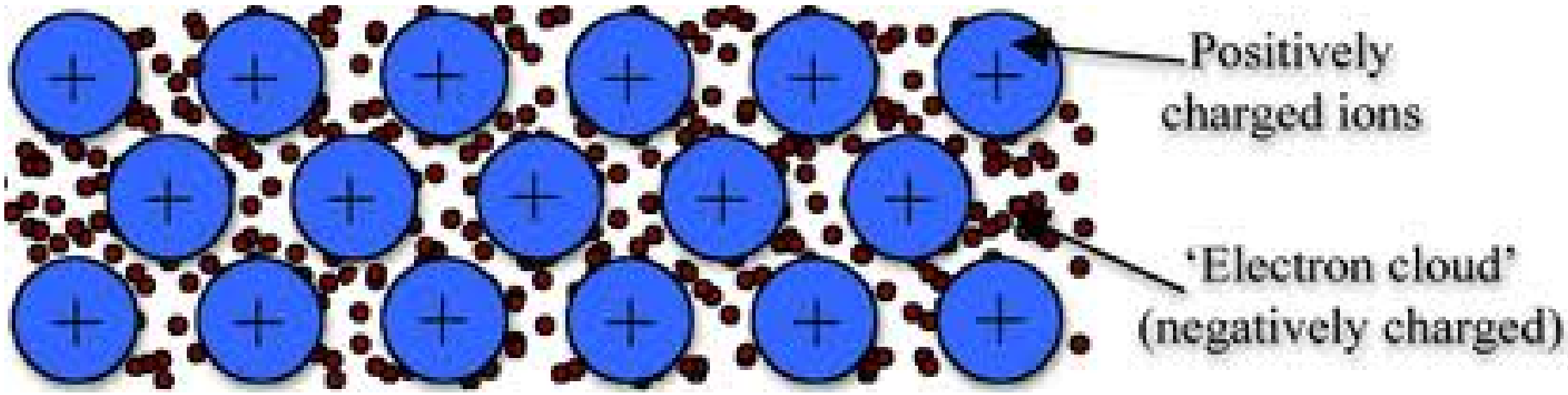
Do now:

Why are some ionic compounds soluble in water?

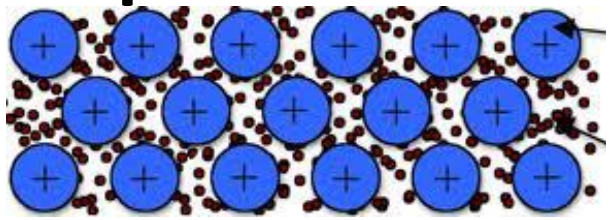
Why do ionic compounds have high melting points?

Why can ionic compounds not conduct electricity when they are solid?

Metallic Compounds



Structure and bonding in metallic compounds



Bonding

Metallic compounds consist of positive nuclei surrounded by electrons. The nuclei and electrons are held together by metallic bonds. Metallic bonds are strong bonds.

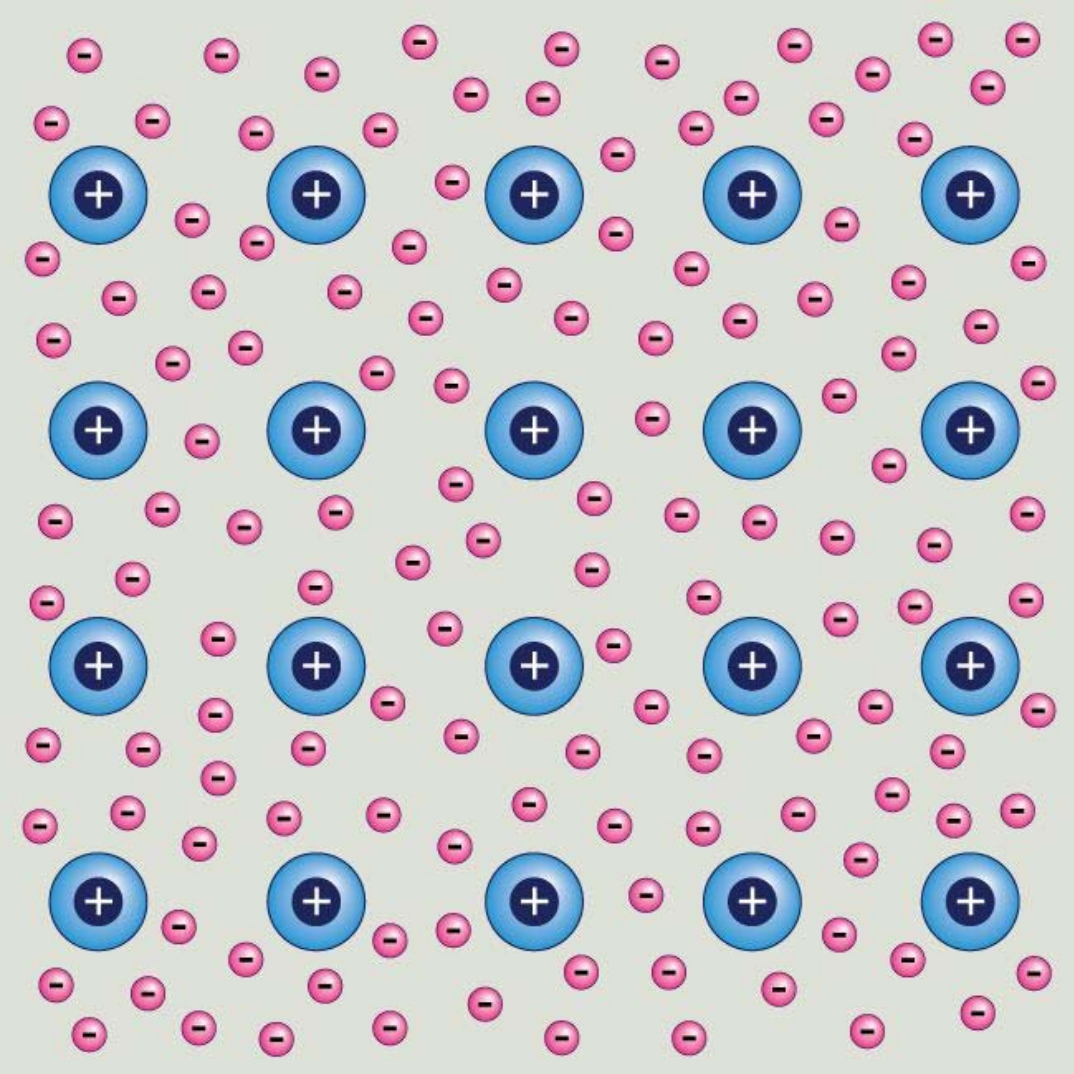
Structure

Metallic bonds are non-directional, and the sea of electrons surround the positive nuclei.

In the exam you will be asked to fill in a table like this:

Substance	Type of substance	Type of particle	Attractive forces between particles
	metallic	atoms	metallic bonds

Sea of electrons



The electrons are the valence electrons of the metal (the electrons from the outer shell of the atom).

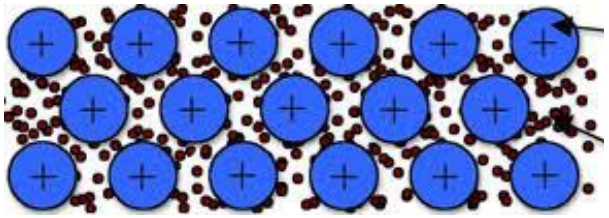
Metallic bonds are strong but non-directional (the nuclei can move around).

Properties of metallic compounds

Use your knowledge of metallic bonding to see if you can predict the following properties of metallic compounds and explain why they might have these properties.

Melting point	High	Low
Conduct electricity	Yes	No
Dissolve in water	Yes	No

Properties of metallic compounds

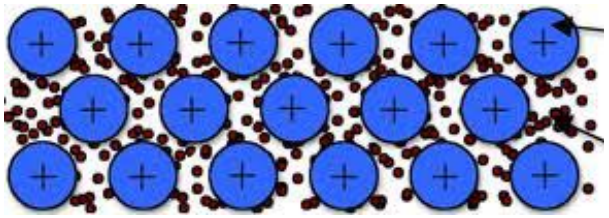


Melting point…
Metallic compounds have high melting points because a lot of energy is required to break the electrostatic attractions between the cations and electrons.

Conductivity…
Metallic compounds can conduct electricity as there are electrons free to move.

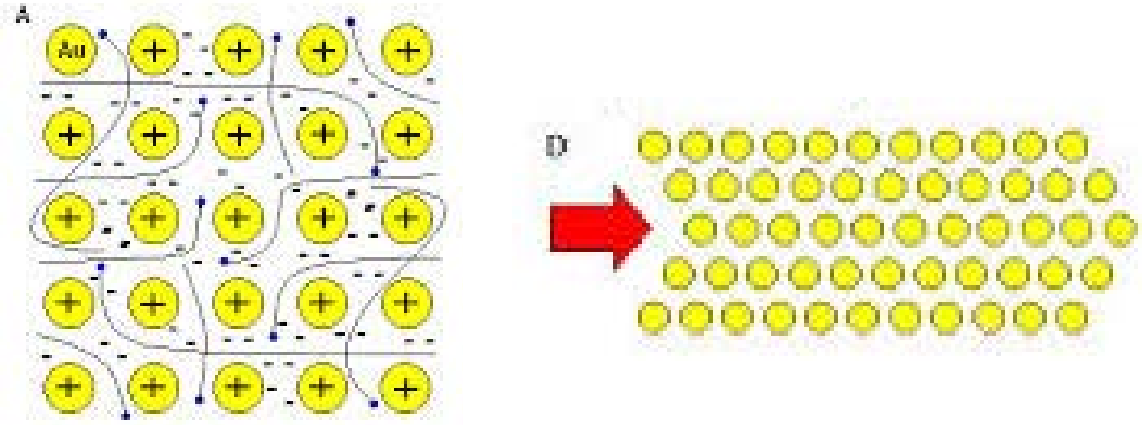
Solubility…
Metallic compounds are not soluble in water, as the water can not pull the cations away from the electrons.

Properties of metallic compounds



Malleability and ductility…
Metallic compounds are ductile (stretchy) and malleable (bendy) because the metallic bonds are non-directional (sea of electrons allow the nuclei to move).

Brittleness…
Metallic compounds are not brittle because the metallic bonds are non-directional (sea of electrons allow the nuclei to move).



Comparisons

Use your knowledge of the structure and bonding in metals and ionic compounds to compare and contrast the following uses of metals and ionic compounds…

Metals like tungsten are used in light bulbs because they can conduct electricity as solids, but ionic compounds can not.

Metals like copper are used in wires because they can be stretched into wires, but ionic compounds shatter when force is applied.

Zinc does not dissolve in water but zinc chloride can dissolve in water.

Do now:

In your own words explain the similarities and differences between metallic and ionic structure.

Types of bonds

IONIC

eg sodium chloride (salt)

COVALENT

SIMPLE MOLECULAR

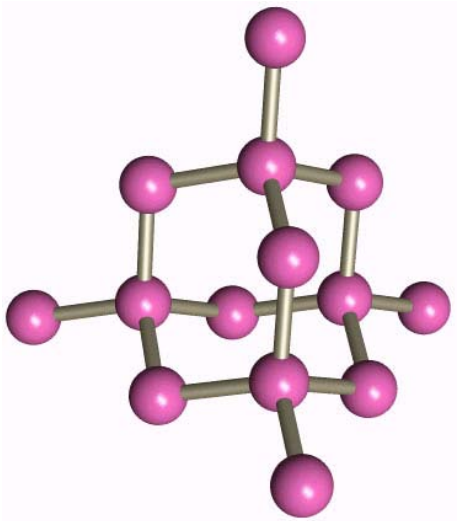
eg carbon dioxide, water

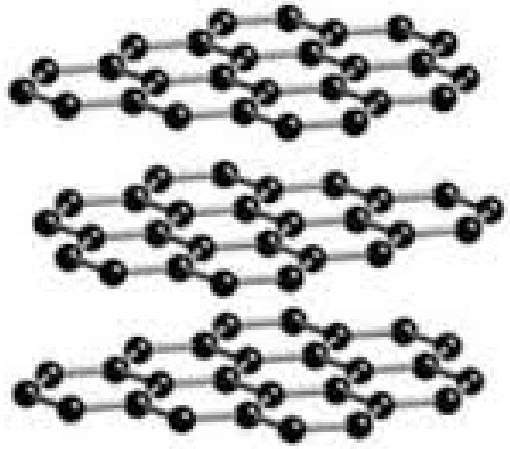
GIANT MOLECULAR

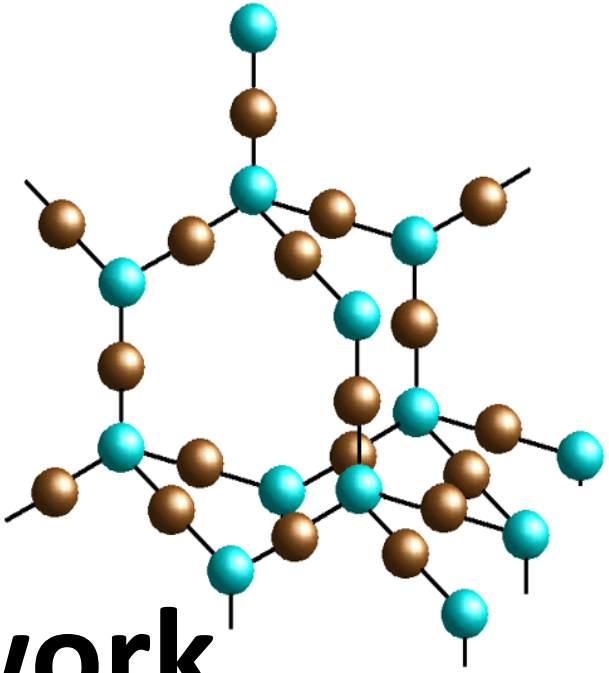
eg diamond, graphite

METALLIC

eg copper

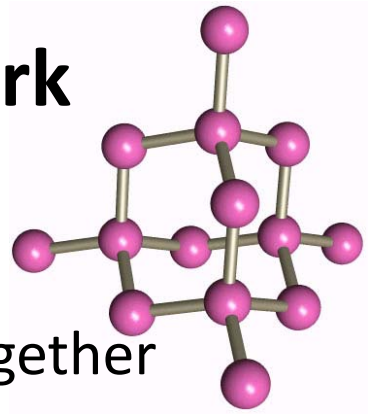






Covalent Network Compounds

Structure and bonding in covalent network compounds



Bonding

The atoms in covalent network compounds are held together by covalent bonds. Covalent bonds are strong.

Structure

Diamond and silica – atoms are covalently bonded in regular 3-dimensional networks, each atom is bonded to 4 other atoms.

Graphite – atoms are covalently bonded in 2-dimensional sheets with free electrons between the sheets, each atom is bonded to 3 other atoms.

Substance	Type of substance	Type of particle	Attractive forces between particles
	covalent network	atoms	covalent bonds

Do now:

What type of substance am I?

(a) I have a melting point of >3500 °C and can not conduct electricity. I am an colourless crystal. Am I an ionic compound or metallic compound or covalent network compound?

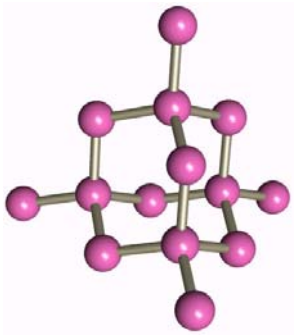
(b) I have a melting point of 801 °C and I shatter easily. I don't conduct charge when I am a solid but I can when I am molten. Am I an ionic compound or metallic compound or covalent network compound?

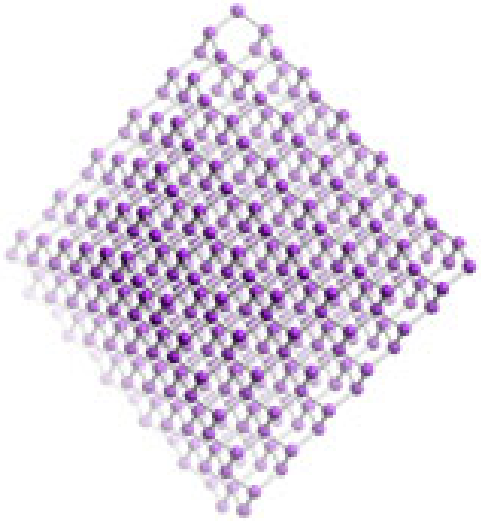
What aspects of structure and bonding give these substances their properties?

Diamond and silica

In diamond each atom is a carbon atom.

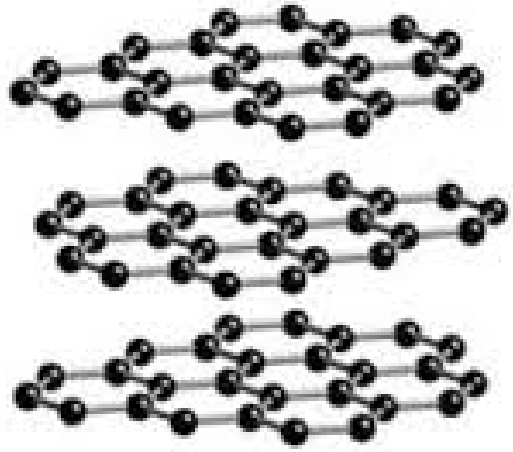
In silica there is a 1:2 ratio of Si:O (SiO_2).





Graphite

Each atom is a carbon atom.

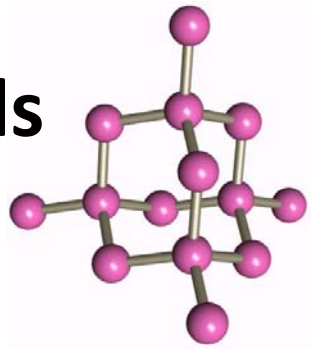


Properties of covalent network compounds

Use your knowledge of bonding in covalent network compounds to see if you can predict the following properties of metallic compounds and explain why they might have these properties.

Melting point	High	Low
Conduct electricity	Yes	No
Dissolve in water	Yes	No

Properties of covalent network compounds

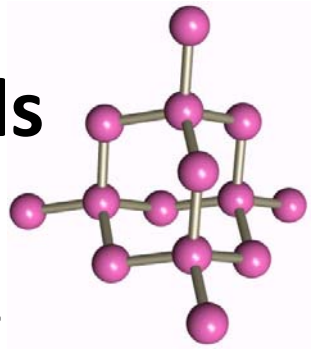


Melting point…
Covalent network compounds have high melting points because a lot of energy is required to break the covalent bonds.

Conductivity…
Diamond and silica can not conduct electricity, because there are no free electrons.
Graphite can conduct electricity, because there are free electrons between the layers of graphite.

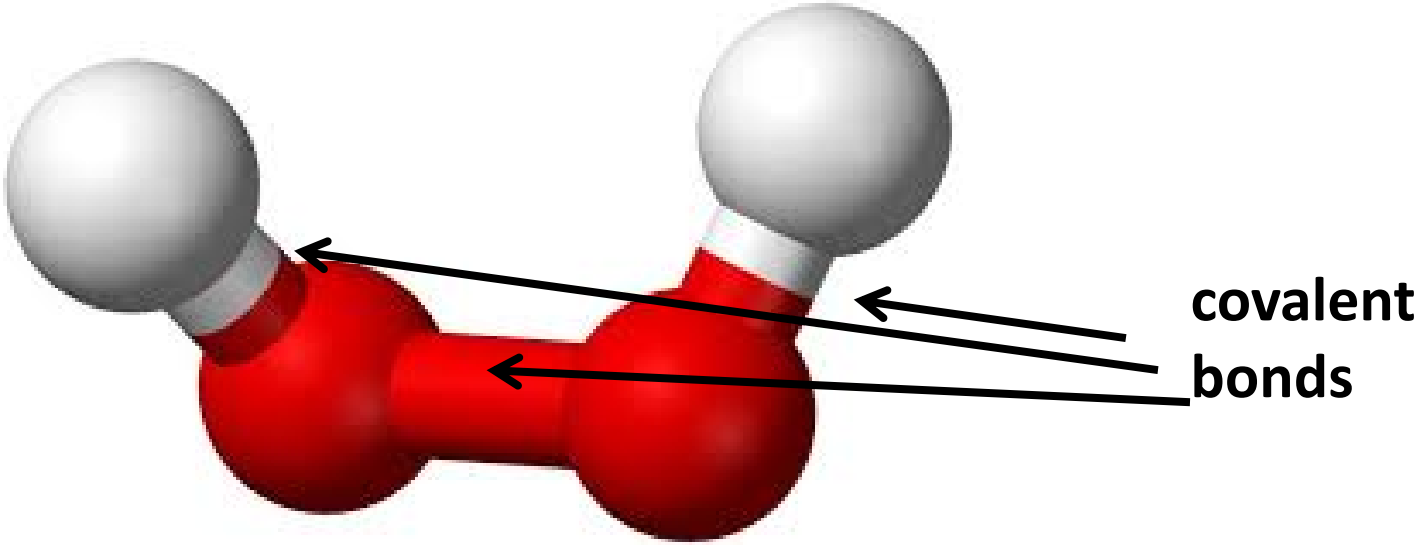
Solubility…
Covalent network compounds are not soluble in water, as the water can not pull the atoms away from each other.

Properties of covalent network compounds

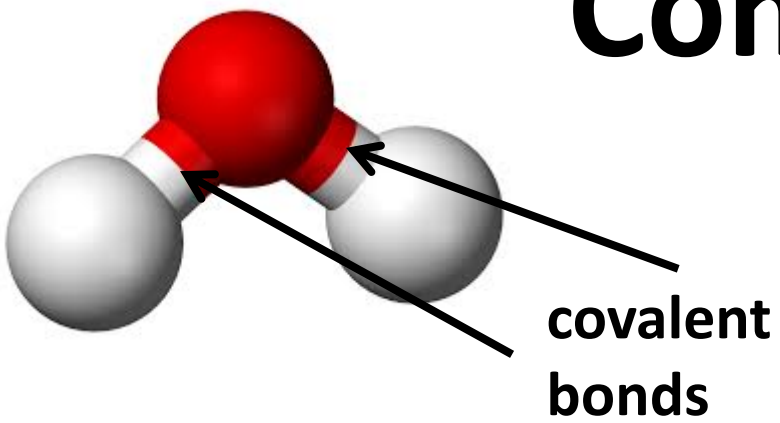


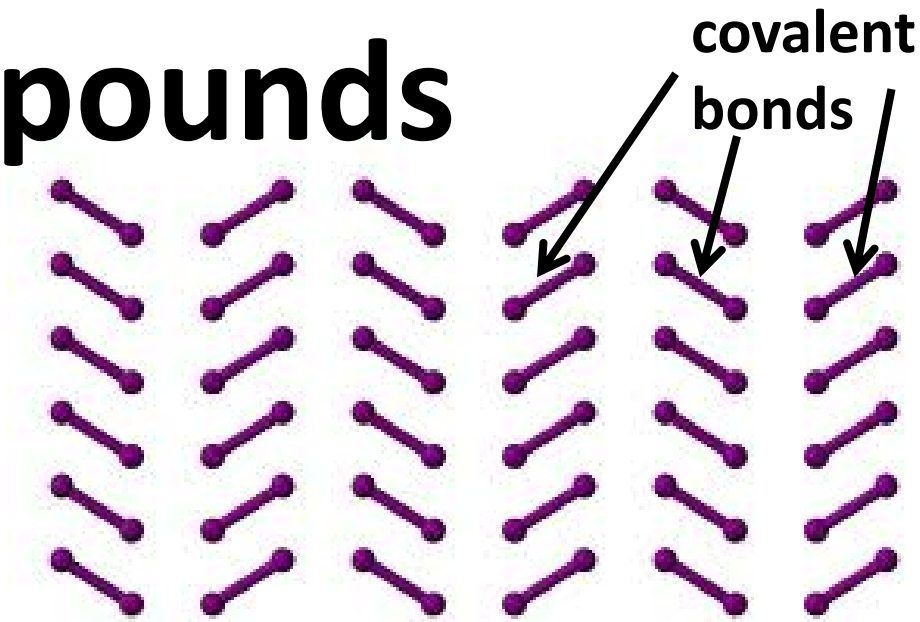
Brittleness…
Covalent network compounds not brittle because of their strong covalent bonds

Malleability and ductility…
Covalent network compounds are not malleable or ductile as the covalent bonds do not allow the atoms to move.



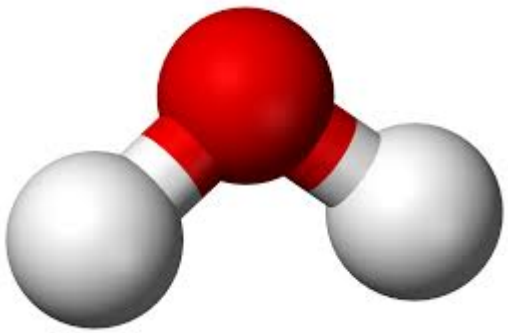
Covalent Molecular Compounds

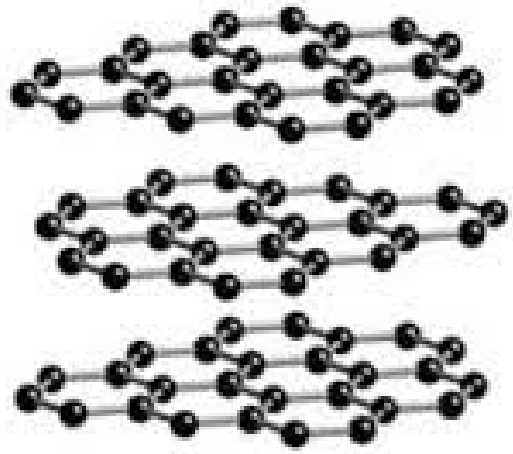


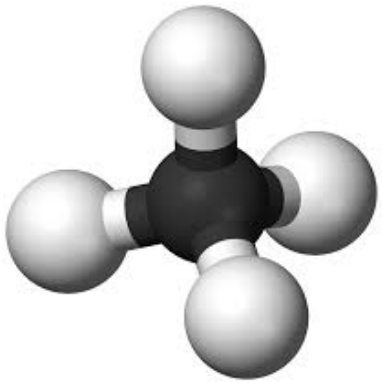


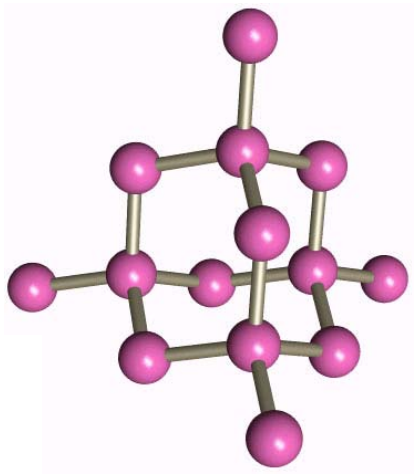
Do now:

Below are some pictures of covalent network compounds and covalent molecular compounds. What differences and similarities do you notice between these two different types of compounds?

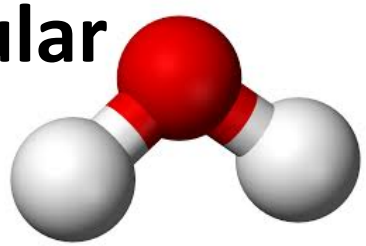








Structure and bonding in covalent molecular compounds

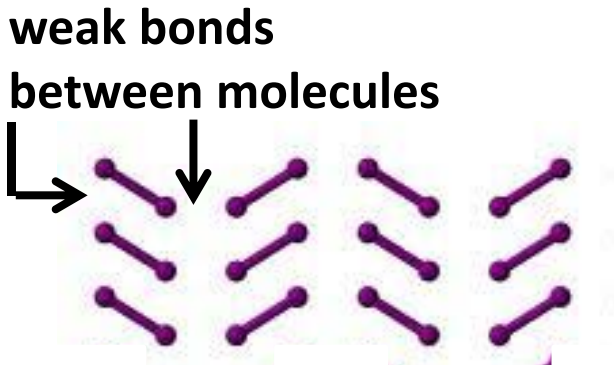


Bonding

The atoms in covalent molecular compounds are held together by covalent bonds. Covalent bonds are strong.

Structure

The individual molecules are held together by weak intermolecular forces

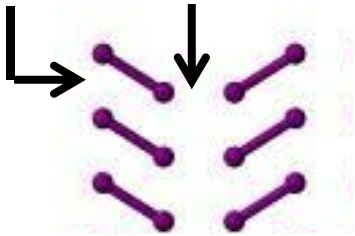


Substance	Type of substance	Type of particle	Attractive forces between particles
	covalent molecular	atoms	intermolecular forces

covalent bond between atoms

Bonds between atoms are called **intra**-molecular bonds

weak bonds between molecules



Bonds between molecules are called **inter**-molecular bonds

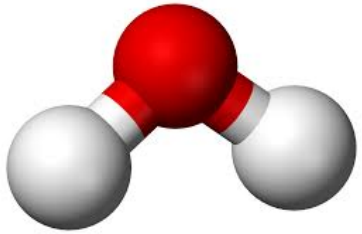
Think of it as like the difference between **intra**net and **inter**net.
Intranet – within a company
Internet – between the world

Properties of covalent molecular compounds

Use your knowledge of bonding in covalent molecular compounds to see if you can predict the following properties of metallic compounds and explain why they might have these properties.

Melting point	High	Low
Conduct electricity	Yes	No
Dissolve in water	Yes	No

Properties of covalent network compoun



Melting point…
Covalent molecular compounds have low melting points because a small amount of energy is required to break the intermolecular forces

The mass of a compound affects the melting point – the heavier the compound the more energy required to break the bonds between the molecules

Conductivity…
Covalent molecular compounds can not conduct electricity, because there are no free electrons.

Solubility…
The solubility of covalent molecular compounds depends on their intermolecular forces.

Arrange the cards in your envelope under these four headings

Metallic	Ionic	Covalent Network	Molecular Covalent

You should have under each heading:

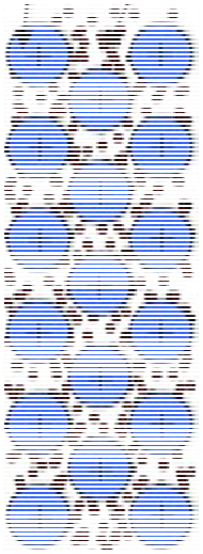
- examples of each compound
- properties of each compound
- the type of particles each compound has.

Putting it all together

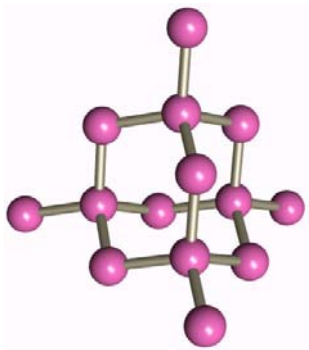
Type of solid	Particles	Melting point	Conductivity	Solubility
Ionic	Ions	High	Only when liquid	In water
Metallic	Atoms	High	Yes	No
Covalent	Atoms	High	No	No
Molecular	Molecules	Low	No	Depending of polarity of compound and solvent

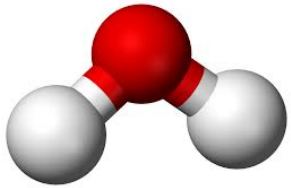
What type of solid am I?

Choose from ionic, metallic, covalent network or molecular

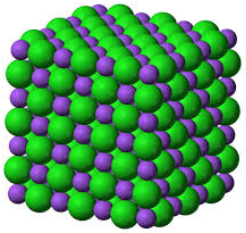


- I am a white crystalline solid with a melting point of 80 °C, I can not conduct electricity
- I am a white crystalline solid with a melting point of 801 °C, I am soluble in water and conduct electricity when dissolved in water
- I am an off-white crystalline solid with a melting point of 1600 °C, I can not conduct electricity





Discuss in groups how the properties of each substance allowed you to determine the type of solid. Discuss what the properties tell you about the structure and bonding in the solid.



2013 Exam Q2 a)

QUESTION TWO

(a) Complete the table below by stating the type of substance, the type of particle, and the bonding (attractive forces) between the particles for each of the substances.

Substance	Type of substance	Type of particle	Attractive forces between particles
$C(s)$ (graphite)			
$Cl_2(s)$ (chlorine)			
$CuCl_2(s)$ (copper chloride)			
$Cu(s)$ (copper)			

2013 Exam Q2 b) (i)

(b) (i) Explain why chlorine is a gas at room temperature, but copper chloride is a solid at room temperature.

In your answer, you should refer to the particles and the forces between the particles in **both** substances.

What key words are used in the question? Write down **five**

What key words will we use in our answer? Write down **three**

What key statements will we make in our answer? Write down **three**

Achieved level answer

Chlorine is a molecular substance the attractive forces between particles is very weak and so breaks at low temperatures to form gas. Copper Chloride is an ionic substance with very strong ~~for~~ ionic forces between particles. It takes a lot more energy to break ionic bonds so the copper chloride is solid at room temperature

mention melting point? **links to structure and property need to be clearer**

Excellence level answer

* Cl_2 is a covalent molecule made up of discrete neutral molecules with weak intermolecular forces between them. There are two types of forces involved, the strong covalent bonds between the atoms and weak intermolecular forces between the molecules. Cl_2 is a gas at room temperature, because the molecular bonds are weak, they require a little amount of kinetic energy to seperate the molecules. Cl_2 has a low melting/boiling point.

Excellence level answer

* Melting/boiling requires the breaking of the bonds/forces. This is done by supplying enough kinetic energy to over- come these bonds/forces.

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seperate the ions.

$CuCl_2$ is an ionic substance, made up of ions held together in a 3D by strong ionic bonding. This is strong electrostatic attraction between the positively charged Cu^{2+} cations and the negatively charged Cl^- anions. $CuCl_2$ is a solid at room temperature because the ionic bonds are strong, they require a large amount of kinetic energy to

ASSE USE

2013 Exam Q2 b) (ii)

(ii) Using your knowledge of structure and bonding, explain why, although both graphite and copper are good conductors of electricity, copper is suitable for electrical wires, but graphite is not.

What key words are used in the question? Write down **five**

What **two** properties of copper and graphite is the question asking you to compare?

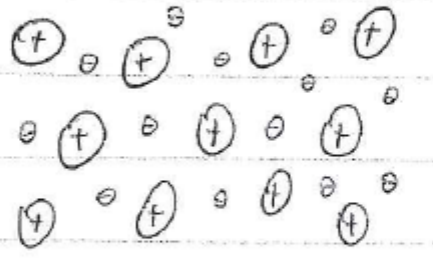
What key words will we use in our answer? Write down **three**

What key statements will we make in our answer? Write down **three**

2013 Exam Q2 b) (ii)

• Copper is a metallic substance. the force that attract these atoms is metallic bond, so metallic bonds holds these atoms. The structure of a copper metal is like this:

Virtual Ions/Protons in the sea with "delocalized electrons"



These metallic bonds only require high melting/boiling point to break.

In this diagram, electrons are running around the virtual ions therefore, the copper metal is a good conductor of electricity and is suitable for electrical wires.

Is this answer A, M or E? What is good about it?
What could be improved?

Do now:

Answer the following question. It is Q 2 b from the 2012 exam.

Silicon dioxide has a melting point of 1770°C.
Explain why silicon dioxide has a high melting point by referring to the particles and the forces between the particles in the solid.

Make sure you state the type of compound, the type of bonding and the structure of the compound, and use the type of bonding and the structure to explain the property.

Merit level answer

The forces between the particles in Silicon dioxide are known as covalent bond. These bond are incredibly strong and require large amounts of energy to break them Hence Silicon dioxide having such a high melting point of 1770°C //

What is missing from this answer?

The type of compound

The type of particles

Excellence level answer

Silicon dioxide is a giant covalent network. The strong covalent bonds which hold the atoms ~~SiO_2~~ together require a large amount of energy to overcome. Therefore, SiO_2 has a ~~very~~ high melting point of 1770°C to overcome the strength of the covalent bonds.

Assessment schedule

ACHIEVEMENT	MERIT	EXCELLENCE
• Silicon dioxide has **strong** covalent bonds. • High melting point because a lot of energy is required to break the covalent bonds.	• Explains why silicon dioxide has a high melting point	• In (b) the high melting point of silicon dioxide is explained and justified by the type of bonding.

Give your answer a grade
1 point of achieved for A
Explains answer for M (basically both A points)
Explains and **justifies** answer for E (because AND therefore/this means that)

This is the answer, what is the question?

Both graphite and copper chloride are able to conduct electricity. Compounds can conduct electricity when there is free electrons or ions that are able to move to conduct the charge.
Graphite is a covalent network solid. It has strong covalent bonds between atoms and is arranged in layer of 2-dimensional sheets covalently bonded t each other. Between these sheets are electrons that are free to move. This allows graphite to conduct electricity as a solid.
Copper chloride is an ionic solid so it can only conduct electricity when it is molten or dissolved in water. As a solid the ions are held together in a 3-dimensional lattice that does not allow the ions to move, but when copper chloride is dissolved in water or melted the ions are free to move around and this allows copper chloride to conduct electricity.

This is the answer, what is the question?

Two of the following substances can conduct electricity.

Copper chloride **Diamond** **Graphite** **Iodine** **Silicon dioxide**

Write the names of the two substances and discuss, with reference to their structure and bonding, why the substances you chose are able to conduct electricity. Include any conditions that are required.