Name:

Teacher:

AQA A Level Chemistry Transition Booklet

C3 Bonding and Structure

Topic Reflection:

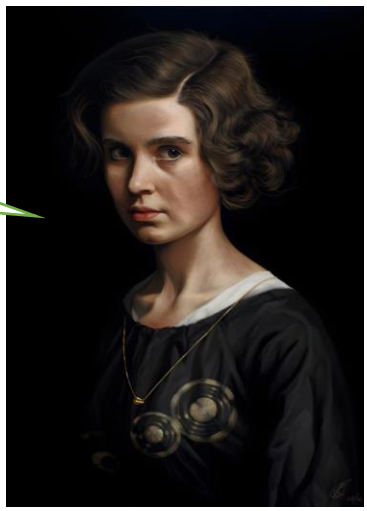
Rate your confidence in this topic out of 10:

Areas of the topic I'm still struggling with:

Questions I need to asks my teacher about this topic:

Science and everyday life cannot and should not be separated

Rosalind Franklin was a pioneering British scientist whose ground-breaking work on X-ray crystallography played a crucial role in unravelling the structure of DNA, laying the foundation for our understanding of the molecule's double helix shape.



Rosalind Franklin
1920-1958

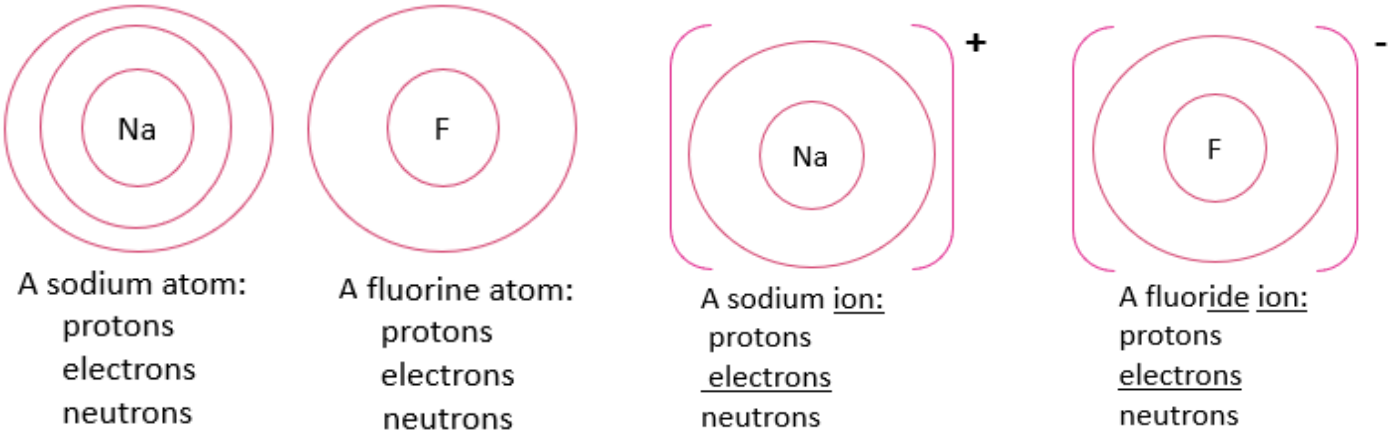
Ionic Bonding

1. Complete the table below:

Subatomic particle	Charge	Mass	Location
Proton			
Electron			
Neutron			

2. Why do atoms always have the same number of protons and electrons?

3. Fill in the number of protons electrons and neutrons in a sodium and fluorine atom and draw the electrons on the shells. Use dots for sodium's electrons and crosses for fluorine's electrons:
4. Are these atoms stable? Why? How could they become stable?



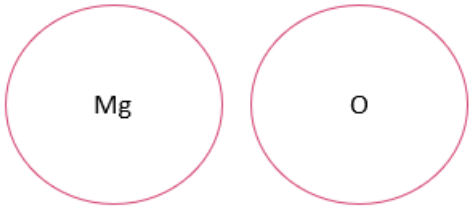
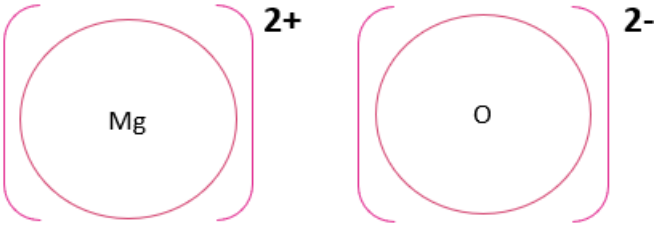
The sodium atom loses 1 _____
The fluorine atom gains 1 electron so they both have a full outer _____.
This forms a sodium ____ with a +1 charge and a _____ ion with a _____ charge.

This type of bonding is called ionic bonding because ions are formed. Opposites attract so the positive sodium ions attract to the negative fluoride ions. An attraction between opposite charges is called an electrostatic attraction. So ionic bonding is the electrostatic attraction between oppositely charged ions.

Notice how the number of protons and neutrons in the nucleus and the inner electrons do not change when the electrons are transferred during ionic bonding this means that we can just draw the outer shell electrons.

➔ How can we determine the number of electrons an atom will have on its outer shell from the periodic table?

➔ Complete the diagram below to show the number of protons electrons and neutrons in a magnesium and oxygen atom. Draw the outer shell electrons using dots for magnesium's electrons and crosses for oxygen's electrons

Atoms before ionic bonding	Ions formed after ionic bonding
 A magnesium atom protons electrons neutrons An oxygen atom: protons electrons neutrons	 A magnesium ion: protons electrons neutrons An oxide ion: protons electrons neutrons

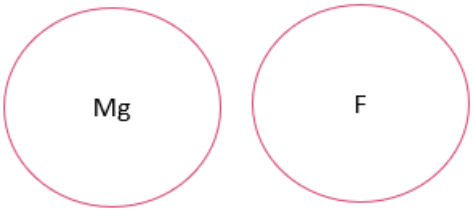
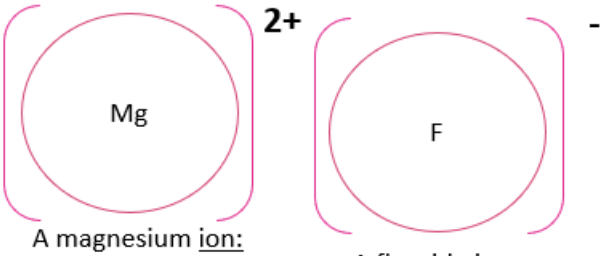
➔ Complete the sentences to describe how the magnesium and oxygen bond together:

The magnesium atom loses _____

The Oxygen atom gains _____ so they both have a full outer _____.

This forms a magnesium ion with a _____ charge and an oxide _____ with a _____ charge.

➔ Complete the diagram below to show the number of protons electrons and neutrons in a magnesium and oxygen atom. Draw the outer shell electrons using dots for magnesium's electrons and crosses for oxygen's electrons

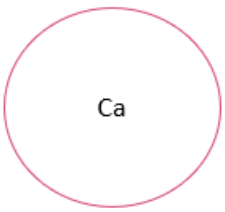
Atoms before ionic bonding	Ions formed after ionic bonding
 A magnesium atom: protons electrons neutrons A fluorine atom: protons electrons neutrons	 A magnesium ion: protons electrons neutrons A fluoride ion: protons electrons neutrons

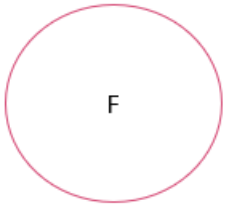
So that both atoms can get a full outer shell there must be 2 fluorine atoms so that magnesium can give 1 electron to each one. This means that 1 magnesium atom must always bond with 2 fluorine atoms. This is why the chemical formula for magnesium chloride is MgF_2

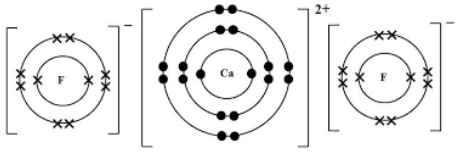
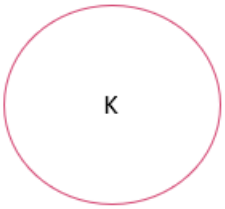
- The Magnesium atom loses 2 electrons
- There are 2 fluorine atoms
- Each fluorine atom gains 1 electron to get a full outer shell
- This forms a magnesium ion with a +2 charge
- And 2 fluoride ions, each one has a -1 charge

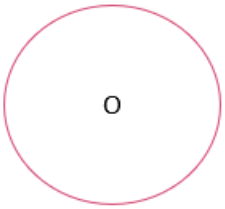
For each compound in the table below draw and describe the bonding. Make sure you include:

1. The number of protons and electrons each atom has before bonding
2. A diagram of the outer shell electrons of each atom before bonding
3. An arrow showing how the electrons are transferred
4. A diagram of the outer shell electrons of each ion formed after bonding
5. The number of protons and electrons each ion has
6. Brackets and charge for each ion
7. A description of how the atoms bong together:

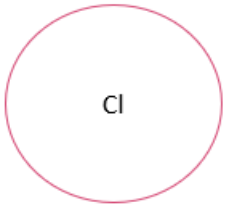
<table>
<tr><td>Compound</td><td>Atoms before ionic bonding</td><td>Ions formed after ionic bonding</td></tr>
<tr><td rowspan="2">Calcium fluoride</td><td> 

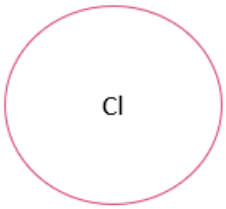


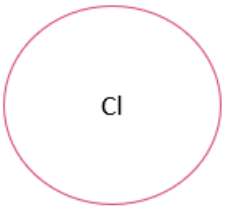
A calcium atom:
protons
electrons
neutrons
A fluorine atom:
protons
electrons
neutrons</td><td> 
</td></tr>
<tr><td colspan="2">• The calcium _____ loses _____
• There are 2 _____ _____
• Each fluorine atom _____ 1 electron.
• To get a full outer shell
• This forms a _____ with a +2 charge
And _____ each one has a -1 charge</td></tr>
<tr><td rowspan="2">Potassium oxide</td><td> 



A potassium atom
protons
electrons
neutrons
An oxygen atom:
protons
electrons
neutrons</td><td></td></tr>
<tr><td colspan="2"></td></tr>
<tr><td rowspan="2">Aluminium Chloride</td><td> 



An aluminium atom:
protons
electrons
neutrons
A chlorine atom:
protons
electrons
neutrons
 

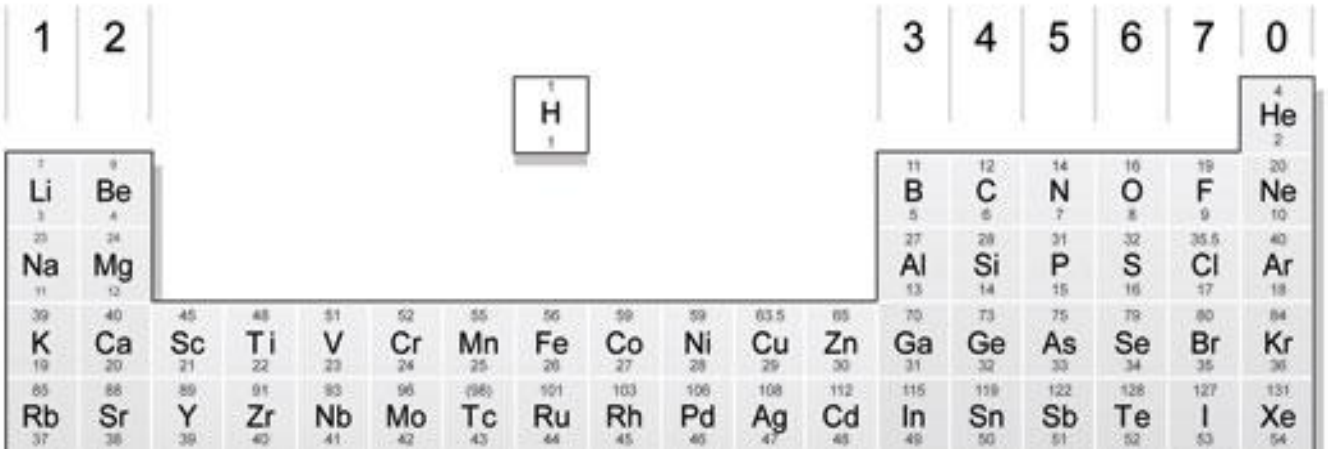

</td><td></td></tr>
<tr><td colspan="2"></td></tr>
</table>

Aluminium oxide	An aluminium atom: protons electrons neutrons Al Al	An oxygen atom: protons electrons neutrons O O O
		protons electrons neutrons Al Al O protons electrons neutrons O O

Ionic Bonding Summary:

- Ionic bonds are formed when _____ atoms bond with non metal atoms.
- The ionic bond is the electrostatic _____ between the two oppositely charged _____.
- The metal atoms lose_____, so they become _____ ions.
- The non metal atom ____ electrons, so they become _____ ions.
-

Groups of the periodic table and charges on ions



Group	Number of electrons in the outer shell	How they form ions	Charge of the ion
1	1	Lose 1 electron	+1
2	2		
3	3		
4	4	Don't form ions – too difficult to lose or gain 4 electrons	
5	5		-3
6	6	Gain 2 electrons	
7	7		
0	Full	Don't form ions – already have a full outer shell	

Working out the formula of an ionic compound

We can work out the formula of an ionic compound by drawing diagrams and looking at how many of each atom is needed for all atoms to get a full outer shell. But this is time consuming, it is quicker to work this out based on the charges of the ions formed which we can deduce from the periodic table.

In a compound the overall charge must be 0 so the positive charge must be cancelled out by the negative charge.

Example: What is the formula for magnesium chloride?

1. Work out the charges on the ions from the periodic table:
    - Magnesium = Mg^{2+}
    - Chloride = Cl^-
2. If the charges of the ions don't add up to make 0, you need to add more of the ions until they do add up to 0
    - Magnesium = Mg^{2+}
    - Chloride = Cl^- x2

    Write the formula using the symbols for the ions, but without the charges. Use a subscript number after the symbol if you have more than 1 of that ion: $MgCl_2$

Complete the table showing the formula and ions in each compound:

Name	formula	Positive ion	Negative ion
	$NaCl$		
	MgO		
		Mg^{2+}	Cl^- x2
		Al^{3+}	Cl^- x3
	Na_2O		
	Al_2O_3		

Challenge:
Work out the ionic formulae of the following compounds:

a) lithium fluoride
b) Calcium oxide
c) Potassium oxide
d) Aluminium chloride

Compound ions

Some ions are made of more than one atom. For these ions you need to remember their formulae and charges as you can't work it out from the periodic table:

hydroxide	nitrate	sulphate	carbonate
OH^-	**NO_3^-**	**SO_4^{2-}**	**CO_3^{2-}**

Example: What is the formula for magnesium hydroxide?

1. Work out the charges on the ions from the periodic table:
   - Magnesium = Mg^{2+}
   - Hydroxide = OH^-
2. If the charges of the ions don't add up to make 0, you need to add more of the ions until they do add up to 0
   - Magnesium = Mg^{2+}
   - Hydroxide = OH^- x2
3. Write the formula using the symbols for the ions, but without the charges. Use a subscript number after the symbol if you have more than 1 of that ion. For an ion made of more than 1 atom (eg OH^-) put the ion in brackets before adding the number.

$Mg(OH)_2$

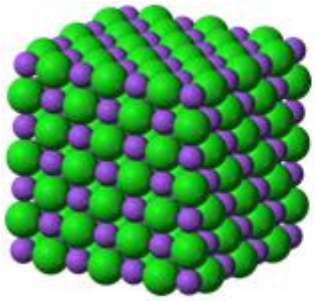
Complete the table showing the formula and ions in each compound:

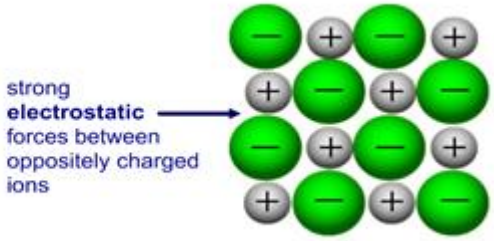
Name	formula	Positive ion	Negative ion
	Li_2CO_3		
	$Ca(OH)_2$		
		Ca^{2+}	NO_3^- x2
		Al^{3+}	OH^- x3
	K_2SO_4		
Sodium nitrate	$NaNO_3$		
		Mg^{2+}	SO_4^{2-}

Challenge: Work out the ionic formulae of the following compounds:

a) lithium hydroxide
b) Potassium nitrate
c) Magnesium sulphate
d) Sodium carbonate
e) Aluminium nitrate
f) Aluminium sulphate

Giant ionic structures





Ionic compounds are formed when meta and non-metal atoms transfer electrons to form oppositely charged ions. Due to the electrostatic attraction between the oppositely charged ions, and the repulsion between ions with same charge the ions are arranged in a giant 3D structure with alternating charged in all directions:

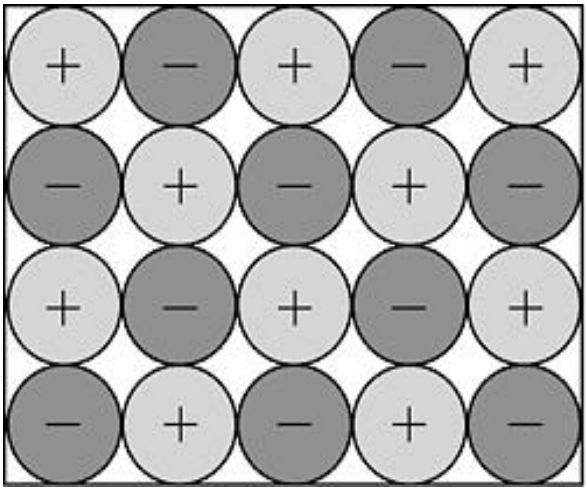
This is called a giant lattice structure

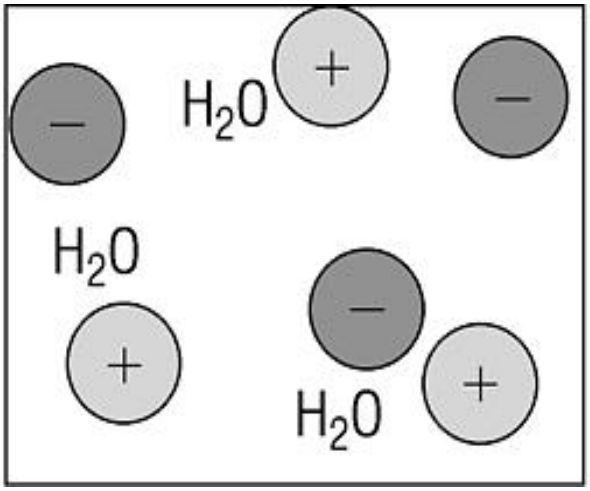
Properties of Ionic Compounds

Ionic compounds are solid at room temperature because they have very high melting points due to the strong electrostatic attraction between the oppositely charged ions which requires a lot of energy to overcome.

Ionic compounds are described as being crystalline because they look like crystals. This is because of the regular lattice arrangement of the oppositely charged ions.

Most ionic compounds dissolve in water because the positive and negative ions can attract to slightly positive and negative parts of the water molecules





For a substance to be able to conduct electricity it must have:

1. Charged particles (+ or -)
2. The charged particles must be free to move to carry electrical charge

Ionic compounds do not conduct electricity when solid because the positive and negative ions are fixed and cannot move around to carry the charge.

Ionic compounds can conduct electricity when molten or dissolved because the ions become free to move to carry the electrical charge.

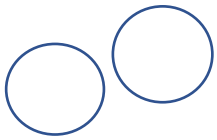
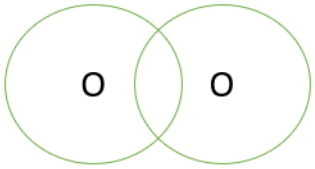
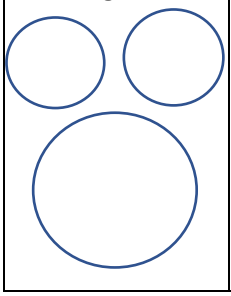
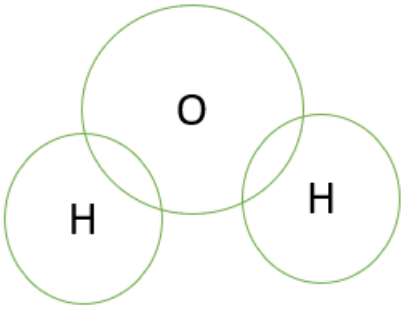
Questions

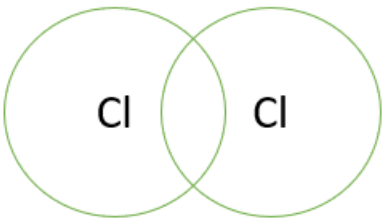
1	What type of atoms form ionic bonds?	
2	Do ionic compounds conduct electricity when solid? Explain your answer	
3	Do ionic compounds conduct electricity when molten or dissolved in water? Explain your answer	
4	Do ionic compounds have high or low melting points? Explain your answer	

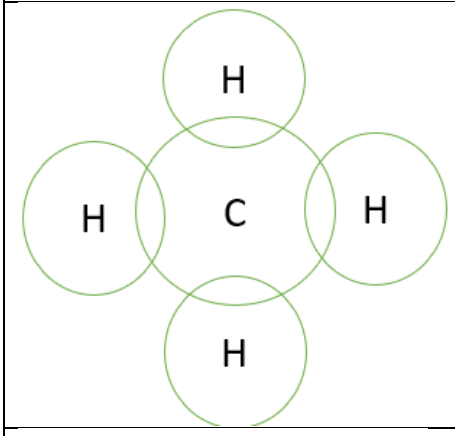
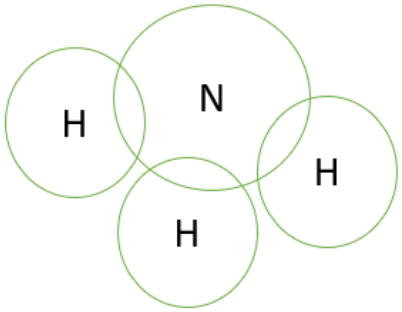
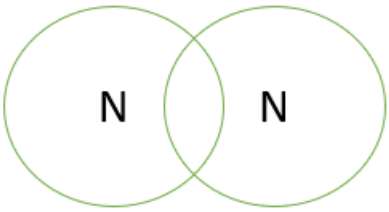
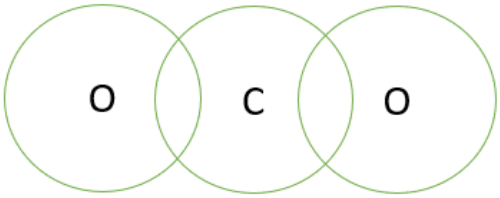
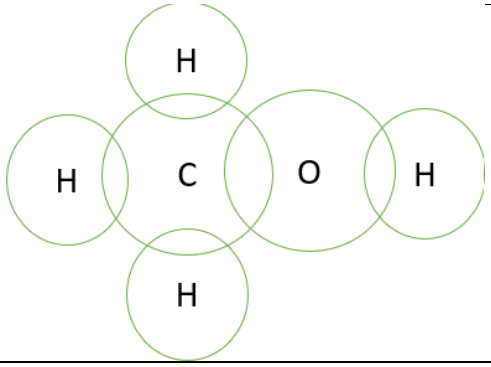
Covalent Bonding

- When 2 or more non metal atoms bond together they can't get a full outer shell by giving and taking electrons like with ionic bonding. Instead they share electrons so both atoms feel like they have a full outer shell.
- This is covalent bonding.
- A small group of atoms bonded together by covalent bonding is called a molecule

Complete the dot and cross

2 oxygen atoms before bonding: 	Dot and cross diagram for an oxygen molecule: 	Displayed formula for a hydrogen molecule: O=O The 2 lines shows the double covalent bond between the atoms.	Molecular formula for an oxygen molecule: O_2
Atoms before bonding: 		Displayed formula for a water molecule:	Molecular formula for a water molecule:

Dot and cross diagram	Displayed formula	Molecular formula	Name
			Chlorine

Dot and cross diagram	Displayed formula	Molecular formula	Name
			Methane
			Ammonia
			Nitrogen
			Carbon dioxide
			Methanol

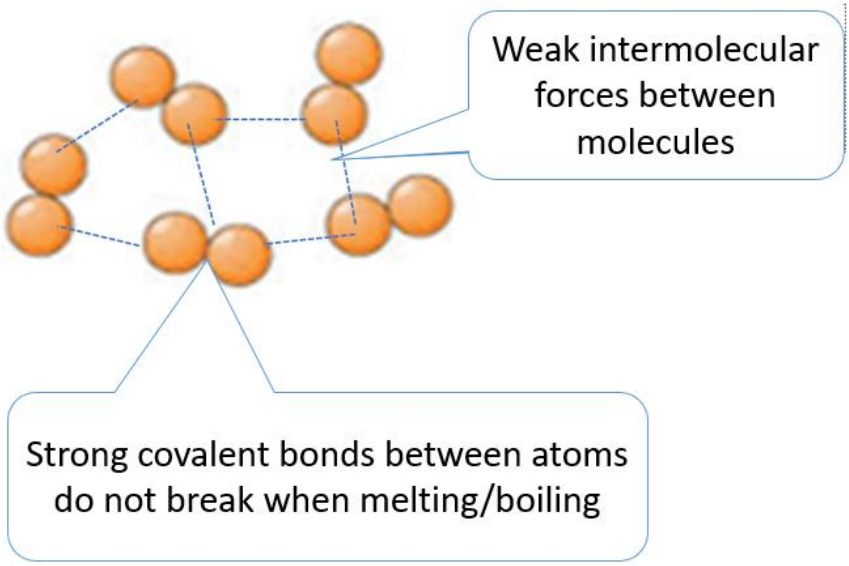
Covalent Bonding Summary:

- When _____ atoms bond together they form covalent bonds by _____ electrons.
- A small group of atoms bonded together is called a _____.

Molecules sharing non metal

Properties of Simple Molecular Structures

- Most substances with covalent bonding have simple molecular structures made of a number of atoms bonded together to make molecules.
- Whilst the covalent bonds between the atoms in the molecules are very strong, there are only weak intermolecular forces between the molecules.
- When simple molecular structures change state, the covalent bonds between the atoms do not break, only the weak intermolecular forces between the molecules are broken.



Most substances with _____bonding are simple molecular structures because they are small _____ made of only a few atoms bonded together.

They have _____ melting and boiling points so they are usually liquids or _____ at room temperature. This is because there are only _____ intermolecular forces between the molecules which need very little _____ to break.
They don't conduct _____ because there are no free moving _____.

Molecules	Electricity	Low	Covalent
Weak	Gases	Electrons	Energy

Questions

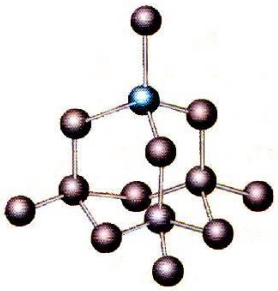
1	What type of atoms form covalent bonds?	
2	Draw a diagram to show 5 chlorine molecules. Label the intermolecular forces	
3	Why do simple molecular structures have low boiling and melting points?	
4	Do the covalent bonds in simple molecular structures break when they change state?	
5	Are the covalent bonds between atoms in simple molecular structures strong or weak	
6	Do simple molecular structures conduct electricity?	

Giant Covalent Structures

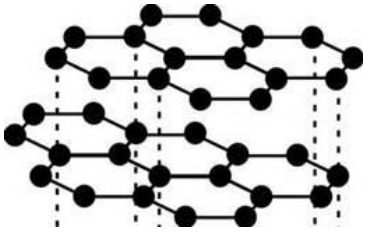
- While most substances with covalent bonding have simple molecular structures made of small molecules with weak intermolecular forces between them, some substances with covalent bonding exist as giant structures or macromolecules with many strong bonds between the non-metal atoms.
-

Diamond

- Giant covalent structure made from carbon.
- Each carbon atom forms 4 strong covalent bonds forming a giant lattice structure
- Very high melting point
- Very hard
- Crystalline appearance

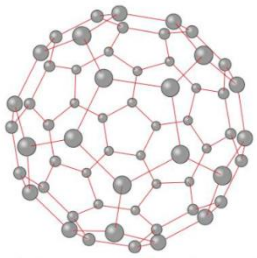


Graphite



- Another giant covalent structure made from carbon.
- Each C atom forms 3 covalent bonds forming hexagonal layers
- Good conductor of electricity -Delocalised electrons move through the structure to carry current
- Soft – No covalent bonds between the layers
- Found in pencil "lead" and used as a lubricant

Fullerenes are hollow cages of carbon atoms joined together by covalent bonds



Fullerenes could be used for:

- Delivering drugs to specific cells
- Lubricants
- Catalysts (speeding up chemical reactions

Questions

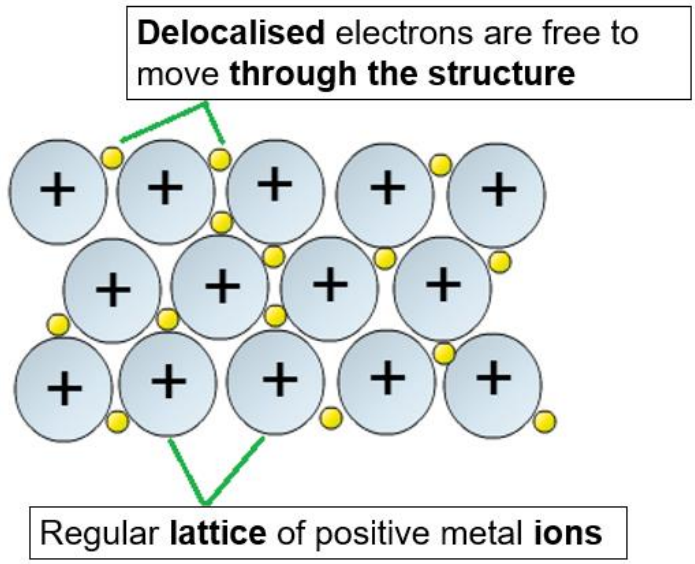
7	Give 3 examples of giant covalent structures	
8	Does diamond conduct electricity? Explain your answer	
9	Does graphite conduct electricity? Explain your answer	
10	Describe the structure of diamond	
11	Describe the structure of graphite	
12	Explain why graphite is soft	
13	Why do giant covalent structures have high melting points?	

Metals and Metallic Bonding

Comparing the properties of metals and non-metals:

	Metals	Non metals
Appearance		
Melting and boiling point		
Density		
Conduction of electricity		
Conduction of heat		
Other	Malleable= can be hammered or pressed into shape by force without breaking or cracking Ductile = Can be drawn into a thin wire Sonorous = makes a ringing sound when hit	Brittle = will break if a force is applied Makes a dull sound when hit

The majority of the elements are metals. Metals are found to the left of the periodic table, non-metals are in the top right-hand corner.
All metallic elements exist as giant metallic structures with metallic bonding:



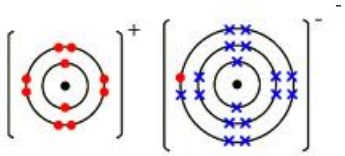
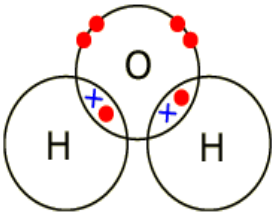
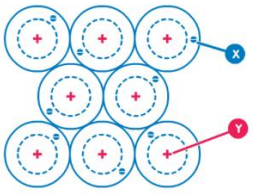
The outer electrons of the metal atoms become free to move around or "delocalised" around a regular lattice of positively charged metal ions.

The metallic bond is the electrostatic attraction between the positive meta ions and the delocalised electrons.

We can use our knowledge of metallic bonding to explain the properties of metals:

Property	Explanation
High melting and boiling point	There is a strong attraction between the positive ions and the negative electrons which requires lot of energy to break.
Good conductors of electricity	The delocalised electrons are free to move through the structure and carry the current.
Malleable, ductile	The delocalised electrons allow the layers of metal ions to slide over each other.
Good conductors of heat	The delocalised electrons can move through the structure to transfer thermal energy quickly.

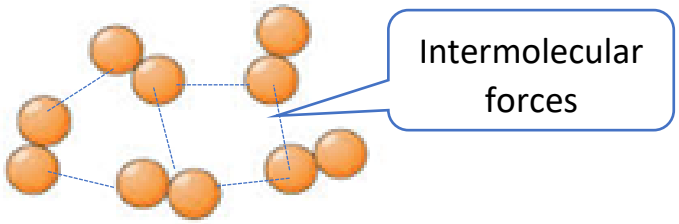
Types of Bonding summary

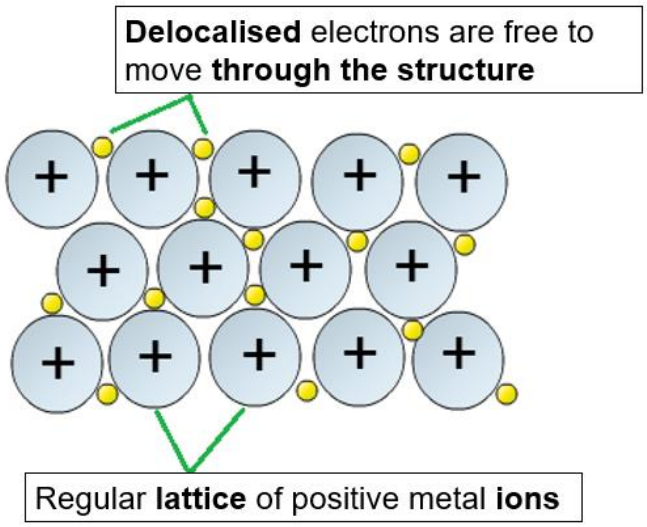
Metal and non metal atoms	Non metal atoms	Metal atoms
Electrons are transferred	Electrons are shared	Electrons are delocalised
Ions are formed	Molecules are formed	Gian metallic structure is formed
		

Quick check questions:

1	What type of bond is formed between non metal atoms?	
2	What type of bond is formed between metal and non metal atoms?	
3	What type of bond is formed between metal atoms?	
4	Draw a labelled diagram to show the bonding in metals	
5	Why do metals have high melting points?	
6	Do metals conduct electricity? Explain your answer	
7	Explain why metals are good conductors of heat	
8	Explain why metals are malleable	

C3 – Structure and Bonding – Knowledge Organiser

1	What type of atoms form ionic bonds?	Metal and non metal
2	Describe the structure of a ionic compound	All ionic compounds exist as a giant ionic lattice made up of many oppositely charged ions with strong electrostatic forces of attraction between them
3	Do ionic compounds conduct electricity when solid? Explain your answer	No, because the ions are in fixed positions and are not free to move
4	Do ionic compounds conduct electricity when molten or dissolved in water? Explain your answer	Yes, the ions are free to move to carry the charge
5	Do ionic compounds have high or low melting points? Explain your answer	High, due to the strong electrostatic attraction between oppositely charged ions which require a lot of energy to over come
6	What type of atoms form covalent bonds?	Non metals
7	Draw a diagram to show 5 chlorine molecules. Label the intermolecular forces	
8	Why do simple molecular structures have low boiling and melting points?	Because the strong covalent bonds do not break during changes of state, only the weak intermolecular forces break, which requires very little energy
9	Do the covalent bonds in simple molecular structures break when they change state?	No, for simple molecular structures only the weak intermolecular forced break during changes of state
10	Are the covalent bonds between atoms in simple molecular structures strong or weak	Strong
11	Do simple molecular structures conduct electricity?	No, because all electrons are used in bonding and therefore there are no delocalised electrons
12	Give 3 examples of giant covalent structures	Diamond, Graphite, Fullerenes
13	Does diamond conduct electricity? Explain your answer	No because it doesn't have delocalised electrons
14	Does graphite conduct electricity? Explain your answer	Yes, because it has delocalised electrons between the layers which are free to move through the structure to carry the current.
15	Describe the structure of diamond	Each carbon atom forms 4 strong covalent bonds to other carbon atoms, forming a tetrahedral shape in a giant lattice structure.
16	Describe the structure of graphite	Each carbon atom forms 3 strong covalent bonds to other carbon atoms forming hexagonal layers. There are weak intermolecular forces between the layers
17	Explain why graphite is soft	Due to the delocalised electrons the layers slide over each other
18	Why do giant covalent structures have high melting points?	Due to the many strong covalent bonds between the atoms which require lots of energy to overcome.
19	What are fullerenes?	Fullerenes are large hollow cages made of 50+ carbon atoms covalently bonded together
20	What could fullerenes be used for?	Delivering chemotherapy drugs specifically to cancer cells, lubricants, catalysts due to their large surface area
21	What type of bond is formed between non metal atoms?	Covalent bonding

22	What type of bond is formed between metal and non metal atoms?	Ionic bonding
23	What type of bond is formed between metal atoms?	Metallic bonding
24	Draw a labelled diagram to show the bonding in metals	
25	Why do metals have high melting points?	There are strong electrostatic forces of attraction between the lattice of positive metal ions and the sea of delocalised electrons
26	Do metals conduct electricity? Explain your answer	Yes, because there are delocalised electrons which are free to move through the structure to carry the current.
27	Explain why metals are good conductors of heat	When heated the delocalised electrons gain kinetic energy and move quickly through the structure allowing the energy to pass through the structure quickly.
28	Explain why metals are malleable	When a force is applied, the layers slide over each other, due to the delocalised electrons allowing the shape to be altered.
29	What is the formula for the sulphate ion?	SO_4^{2-}
30	What is the formula for the nitrate ion?	NO_3^-
31	What is the formula for the hydroxide ion?	OH^-
32	What is the formula for the carbonate ion?	• CO_3^{2-}

Bonding and Structure Summary

Structure	Giant Ionic	Simple molecular	Giant covalent	Giant Metallic
Bonding type	Ionic	Covalent	Covalent	Metallic
Type of atoms involved	Metals with non metal	Non metal	Non metal	Metal
What happens to the outer shell electrons?	Transferred (give and take)	Shared	Shared	Delocalised
Example:	Salt (NaCl)	Water (H_2O)	Graphite/ diamond	Any metal eg copper
Melting point & boiling point	High because there is a strong attraction between the oppositely charged ions.	Low – weak intermolecular forces don't need much energy to break.	High – because there are many strong bonds, which require lots of energy to break.	High because there is a strong attraction between the positively charged ions and negative electrons.
State at room temp	Solid	Liquid/ gas	solid	solid
Conductivity of heat and electricity	Only when molten or dissolved, when the ions are free to move.	None – no delocalised electrons.	None – no delocalised electrons. Except graphite – has delocalized electrons are free to move through the structure and carry the current	Good – delocalized electrons are free to move through the structure and carry the current