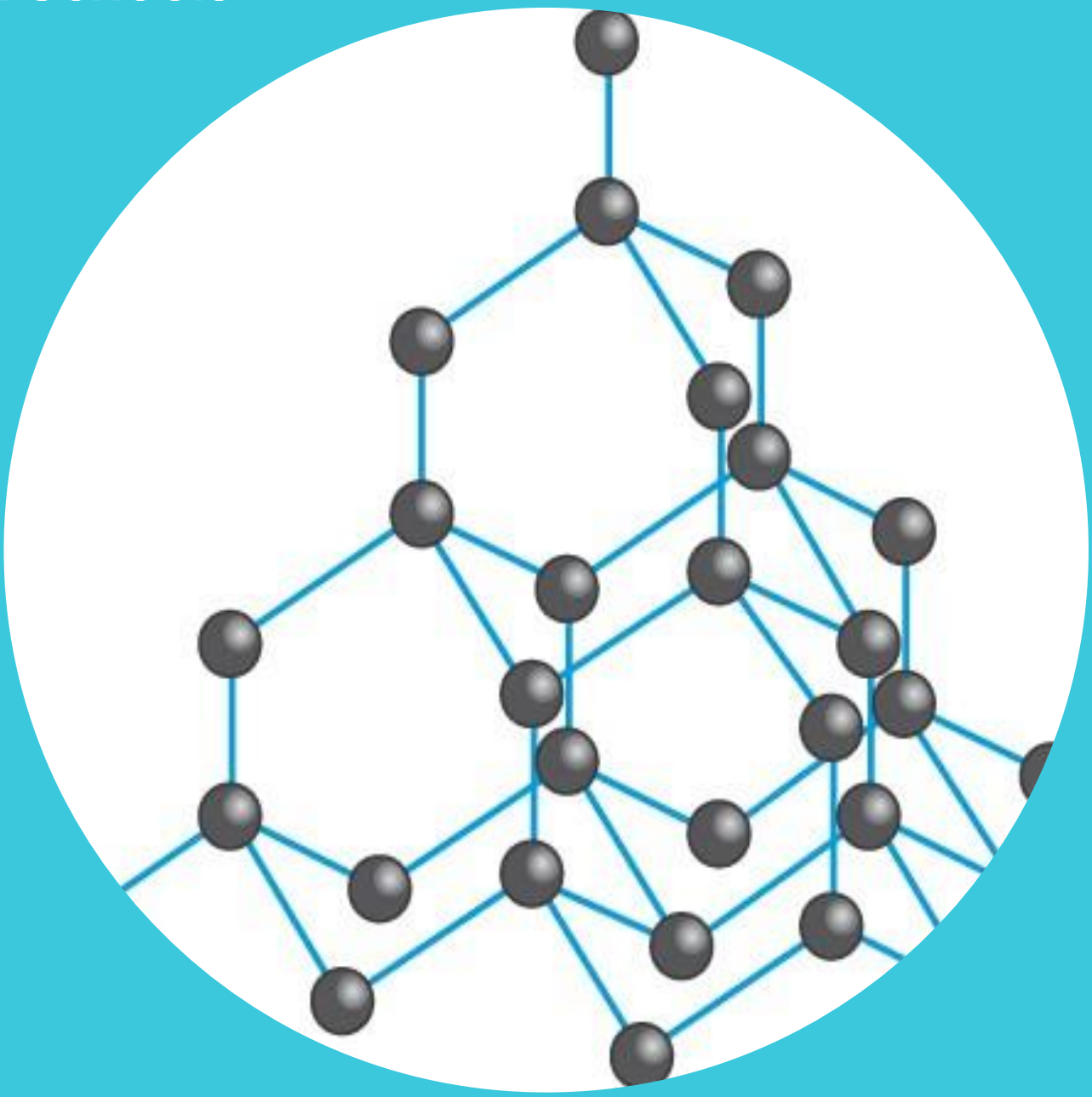
Researchers in Schools



Bonding and Structure

Key Stage 4 Revision Programme

Pupil Name

Handbook Designed by Dr Newnham

Timetable and Assignment Submission

Timetable – Tutorials

Tutorial	Week Beginning Date	Time	Location
1 (Baseline assessment)	Dec 2019	3:15 – 4:15	A11
2	06/01/20	3:15 – 4:15	A11
3	13/01/20	3:15 – 4:15	A11
4	20/01/20	3:15 – 4:15	A11
5	27/01/20	3:15 – 4:15	A11
6 (Final assessment)	10/02/20	3:15 – 4:15	A11
7 (Feedback)	24/02/20	3:15 – 4:15	A11

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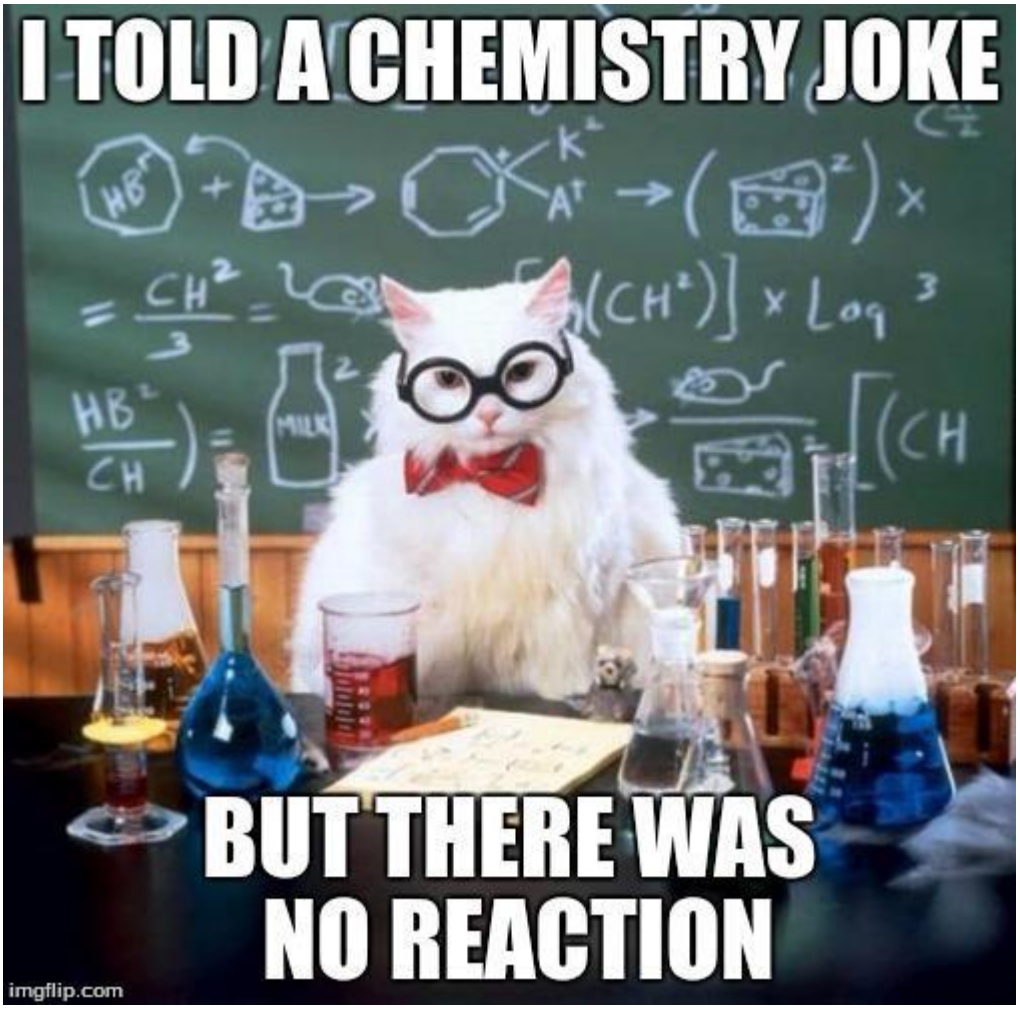
Course Rationale

This series of tutorials will focus on an area of the science curriculum identified as a weakness by the module tests that have been undertaken by students. The data indicate that the area of weakest comprehension from the Year 9 curriculum is structure and bonding of chemicals.

Chemical bonding, and the behaviour of electrons underpins nearly all remaining topics in the Chemistry GCSE and thus is of vital importance to understand. This topic was also the last topic in Year 9, and so a certain level of apathy may have developed.

We will spend the tutorials devoting time to different aspects of the topic. We will not be looking at the structural properties of ionic, covalent, and metallically bonded materials, but rather the processes themselves.



Subject Vocabulary

Word	Definition	In a sentence

AQA

The Periodic Table of Elements

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

1	2											3	4	5	6	7	0
							1 **H** hydrogen 1										4 **He** helium 2
7 **Li** lithium 3	9 **Be** beryllium 4											11 **B** boron 5	12 **C** carbon 6	14 **N** nitrogen 7	16 **O** oxygen 8	19 **F** fluorine 9	20 **Ne** neon 10
23 **Na** sodium 11	24 **Mg** magnesium 12											27 **Al** aluminium 13	28 **Si** silicon 14	31 **P** phosphorus 15	32 **S** sulfur 16	35.5 **Cl** chlorine 17	40 **Ar** argon 18
39 **K** potassium 19	40 **Ca** calcium 20	45 **Sc** scandium 21	48 **Ti** titanium 22	51 **V** vanadium 23	52 **Cr** chromium 24	55 **Mn** manganese 25	56 **Fe** iron 26	59 **Co** cobalt 27	59 **Ni** nickel 28	63.5 **Cu** copper 29	65 **Zn** zinc 30	70 **Ga** gallium 31	73 **Ge** germanium 32	75 **As** arsenic 33	79 **Se** selenium 34	80 **Br** bromine 35	84 **Kr** krypton 36
85 **Rb** rubidium 37	88 **Sr** strontium 38	89 **Y** yttrium 39	91 **Zr** zirconium 40	93 **Nb** niobium 41	96 **Mo** molybdenum 42	[98] **Tc** technetium 43	101 **Ru** ruthenium 44	103 **Rh** rhodium 45	106 **Pd** palladium 46	108 **Ag** silver 47	112 **Cd** cadmium 48	115 **In** indium 49	119 **Sn** tin 50	122 **Sb** antimony 51	128 **Te** tellurium 52	127 **I** iodine 53	131 **Xe** xenon 54
133 **Cs** caesium 55	137 **Ba** barium 56	139 **La*** lanthanum 57	178 **Hf** hafnium 72	181 **Ta** tantalum 73	184 **W** tungsten 74	186 **Re** rhenium 75	190 **Os** osmium 76	192 **Ir** iridium 77	195 **Pt** platinum 78	197 **Au** gold 79	201 **Hg** mercury 80	204 **Tl** thallium 81	207 **Pb** lead 82	209 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111	[285] **Cn** copernicium 112	[286] **Nh** nihonium 113	[289] **Fl** flerovium 114	[289] **Mc** moscovium 115	[293] **Lv** livermorium 116	[294] **Ts** tennessine 117	[294] **Og** oganesson 118

* The Lanthanides (atomic numbers 58 – 71) and the Actinides (atomic numbers 90 – 103) have been omitted.

Relative atomic masses for **Cu** and **Cl** have not been rounded to the nearest whole number.

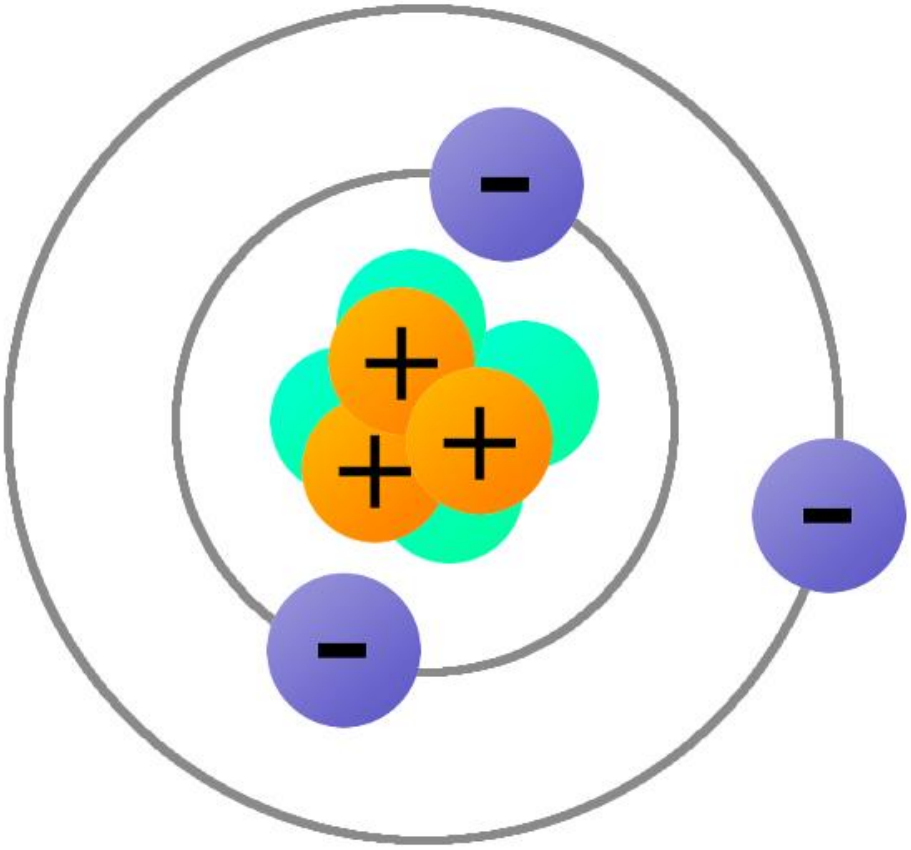
Tutorial 1 – Baseline Assessment

What is the Purpose of Tutorial 1?

- Pre-SEF
- Baseline assessment- 30 mark exam question selection

Tutorial 2 – Use and abuse of the Periodic Table

Starter: On the diagram below label the following components of an atom:
Proton, neutron, electron, shell (orbit), nucleus



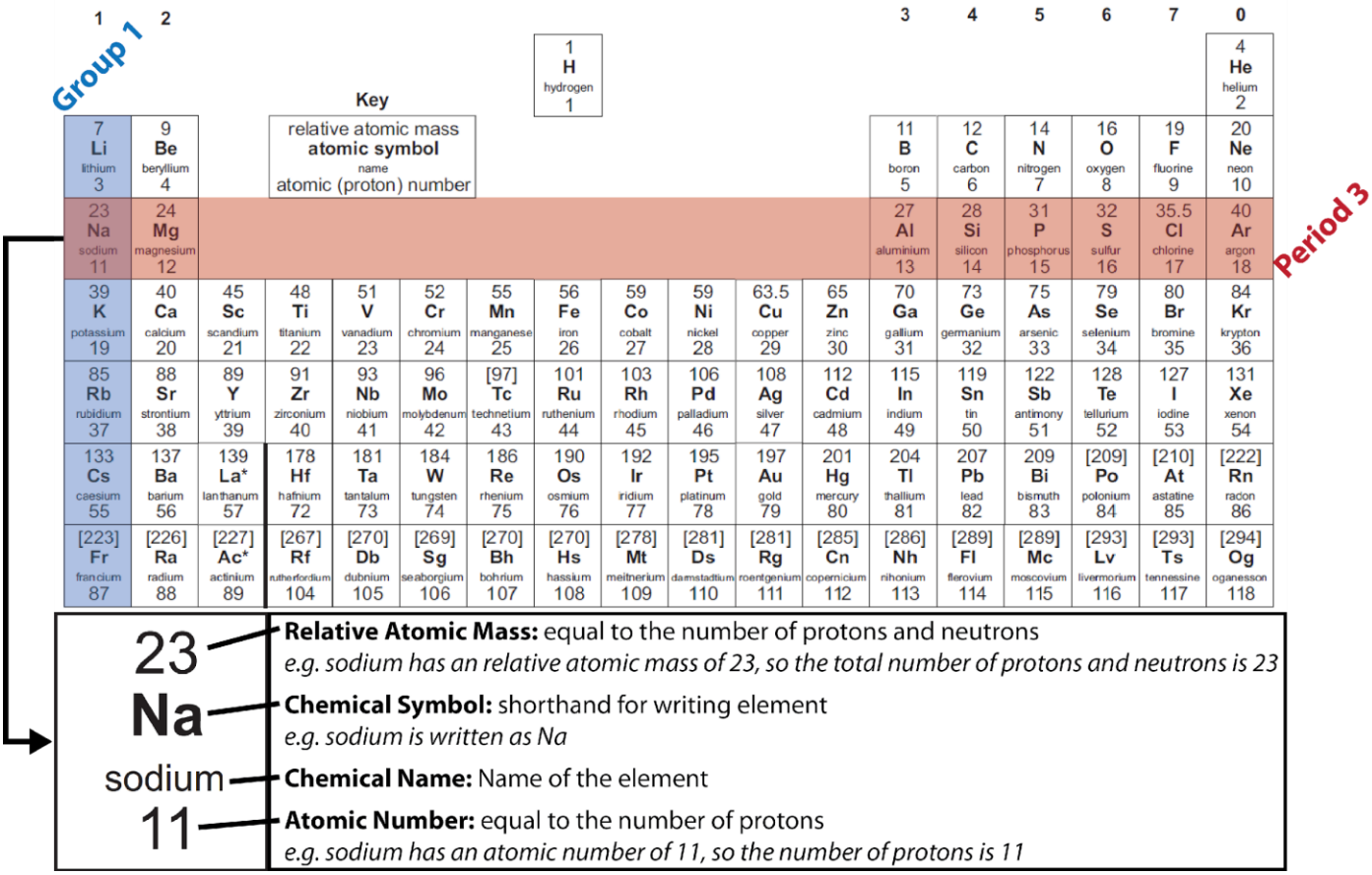
Fill in the table for the mass and charge of the subatomic particles

Particle	Mass	Charge
Proton		
Electron		
Neutron		

What is the Purpose of Tutorial 2?

- Extracting and using information from the Periodic Table
- Applying and drawing electronic structure diagrams for atoms
- Understanding the rules of ion formation and their electronic structure

Objective 1- How to interpret the Periodic Table



Practice- Using the Periodic Table, fill in this table

Name	Symbol	Group	Period	Metal/ non-metal	Atomic (proton) Number	Mass number	Protons	Electrons	Neutron (show calculation)
Sodium	Na	1	3	Metal	11	23	11	11	12 (23-11)
Magnesium		2	3	Metal					12 (24-12)
	O	6			8	16			
Potassium		1		Metal		39			
	S			Non-metal		32		16	
Silicon		4				28			
Germanium		4	4			73	32	32	

Boron						11	5		
Aluminium						27		13	
Iron									
	Ne								
		2	3						
					53				
		3		Non-metal					
Carbon						12			
Carbon						14			

Question: What are the similarities and differences for the last two examples?

Question: What term is used to describe this?

Assessment

Use the periodic table to help you to answer these questions.
The following is a list of symbols of some elements.

Sb	Se	Si	Sn	Sr

Choose your answers **only** from the symbols shown in the box above.
Which symbol represents

(i) a Group 5 element

(1)

(ii) the element in the same group as oxygen (O)

(1)

(iii) the element with atomic (proton) number of 50

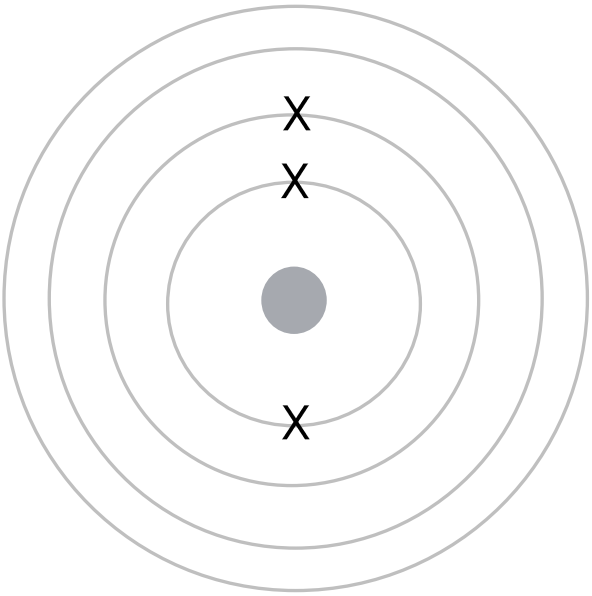
(1)

(iv) silicon?

(1)

Objective 2- Electronic structure of an atom

Lithium



Electronic Structure Rules

- 2 electrons can go in the first shell
  8 electrons can go in shell 2 and 3
- Same number of electrons as protons
- Group number = number of electrons in the outer shell
  Period number = number of electron shells
- Electronic configuration numbers separated by ,.
- Use dots or crosses to draw the electron configuration

E.g. Lithium
Group 1, so one electron in the outer shell
Period 2, so 2 electron shells
3 protons = 3 electrons
Electronic configuration 2,1

Practice- complete the electronic structure diagrams for the first 20 elements, and write the electronic structure as shown for lithium

Hydrogen	Helium	Lithium 2,1	Beryllium
Boron	Carbon	Nitrogen	Oxygen 2,6
Florine	Neon	Sodium	Magnesium

Aluminium	Silicon	Phosphorous	Sulfur
Chlorine	Argon	Potassium	Calcium

Assessment

Build an atom of the group 2, period 3 element.

Element:	Symbol:
Proton:	
Neutron:	
Electrons:	

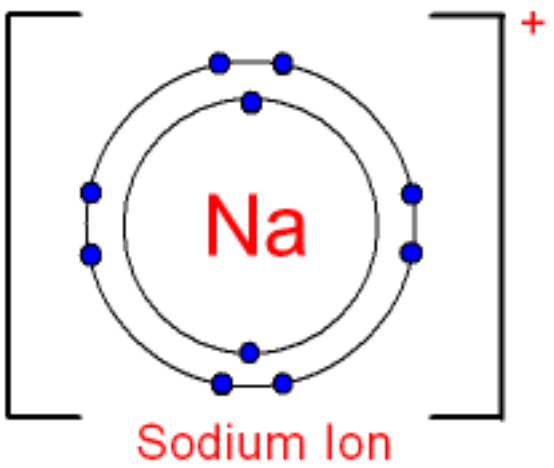
Objective 3- Understanding the rules of ion formation and their electronic structure

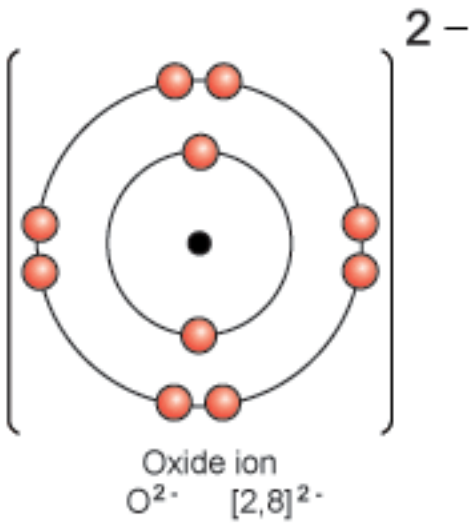
Ion Formation Rules	
Ion	An atom or molecule with a net electric charge due to the loss or gain of one or more electrons
Cation	Positive ion. An atom or molecule that has lost electrons
Anion	Negative ion. An atom or molecule that has gained electrons
Metal	Form cations. Loses electrons
Non-metal	Forms anions. Gain electrons
Hydrogen	Special case. Can form cation and anion, due to only one electron
Ions from non-transition elements will form full outer shell	

Examples of Ion notation allowed in exams

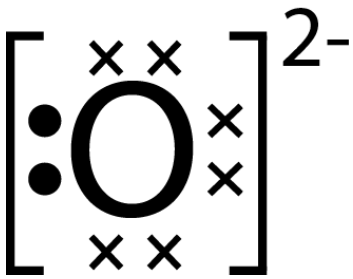
Sodium Cation	Oxygen Anion

Shell diagram

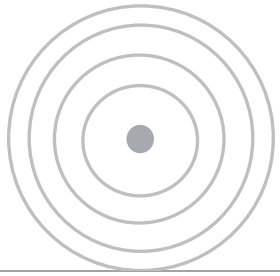
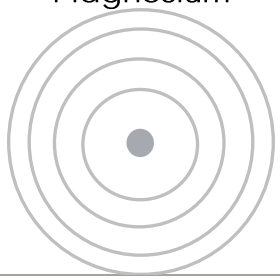
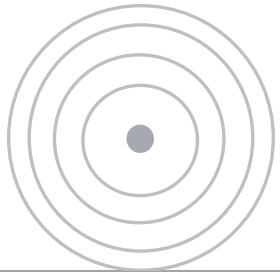
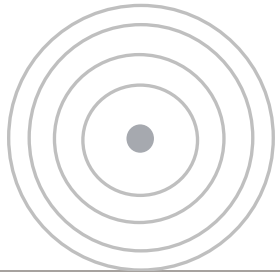
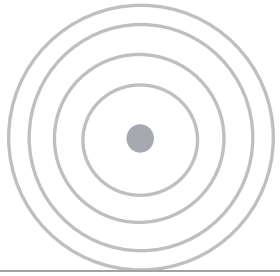




Dot-cross diagram



Practice – Drawing and identifying ions

Ion shell diagram	Ion dot-cross diagram	Type (cation/anion)
Lithium 		
Magnesium 		
Chlorine 		
Nitrogen		
Aluminium 		
Boron 		

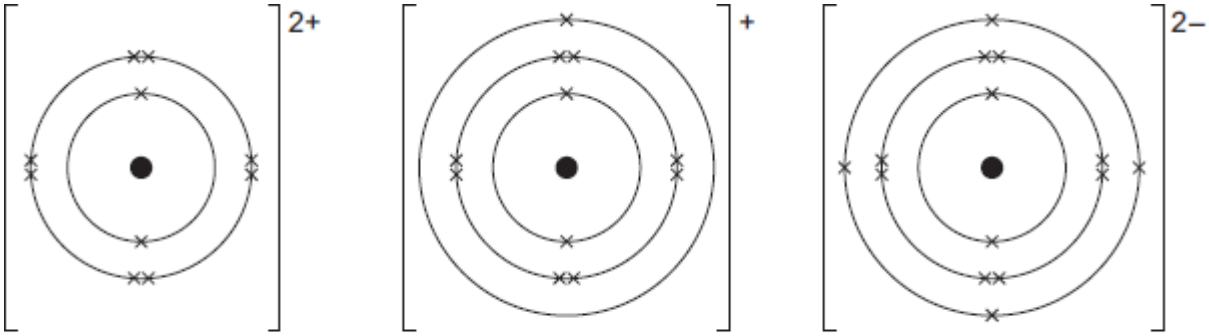
Assessment

This question is about magnesium.

A magnesium atom reacts to produce a magnesium ion.

Which diagram shows a magnesium ion?

Tick (✓) **one** box.



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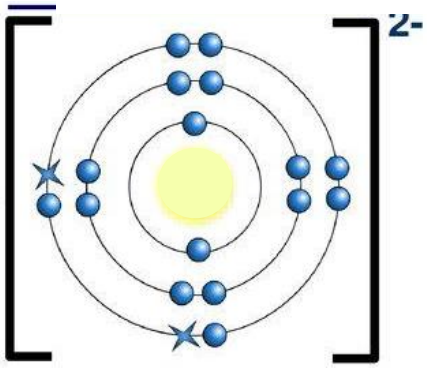
(1)

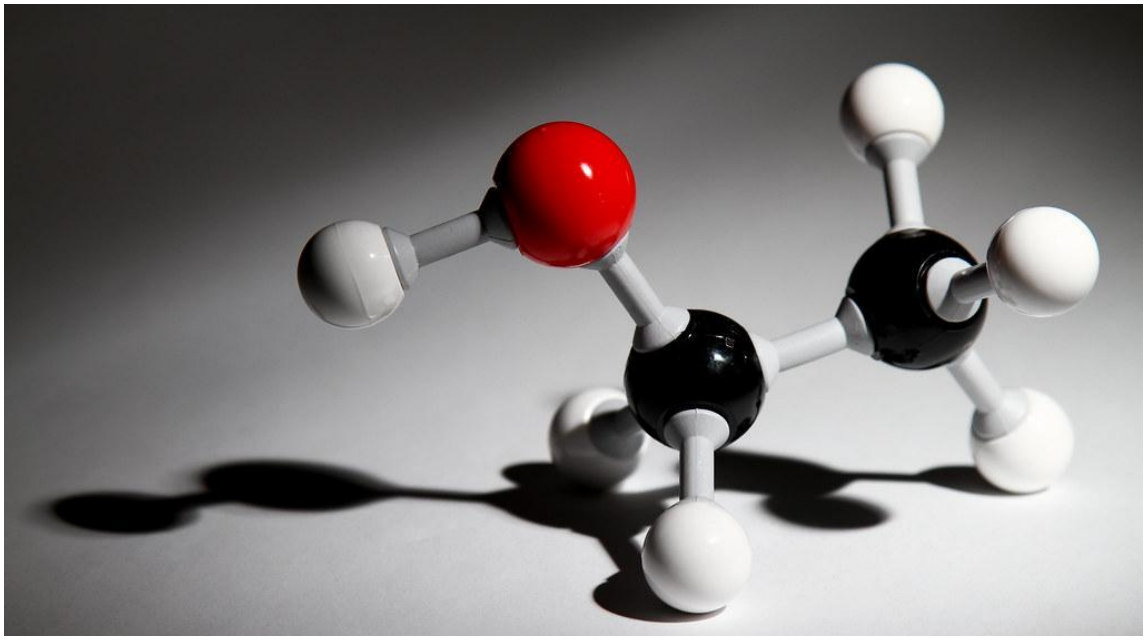
Plenary



For the above ion, identify the element and which of these statements is correct-**tick the correct statements.**

a) The ion is a cation
b) The ion is a group 2 element
c) The element is oxygen
d) The element is magnesium
e) The ion is an anion
f) The ion is a group 6 element
g) The ion is a metal
h) The ion is a non-metal
i) The element is sulfur
j) The element is calcium

Tutorial 3 – Sharing is caring- simple covalent bonding



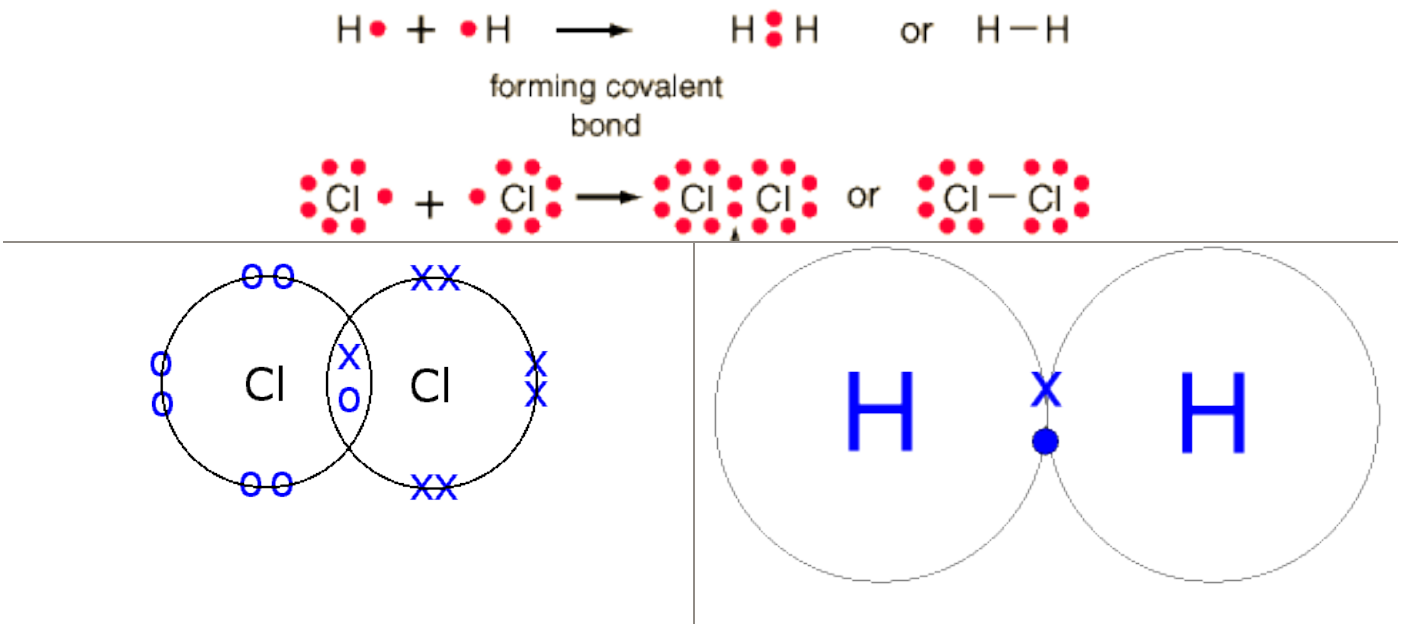
What is the Purpose of Tutorial 3?

- Drawing single diatomic covalent bonds
- Identifying number of bonds in a multi-bond diatomic covalent bond
- Applying your knowledge of covalent bonds to small covalent molecules of more than one element

Objective 1 - Simple diatomic single bond molecules

Simple Covalent Bonding Rules
- Non-metal to non-metal bonding
- Sharing of outer shell electrons to form full outer shells
- Diatomic molecules are two atoms of the same element bonded together. Common gases.

Example of electron notation allowed in exam



Practice – Using information answer the questions

1) What is covalent bonding?

2) Which elements form covalent bonds

3) Draw a representation of the bonding in the following diatomic molecules and write the formula for that molecule
   a. hydrogen

   b. fluorine

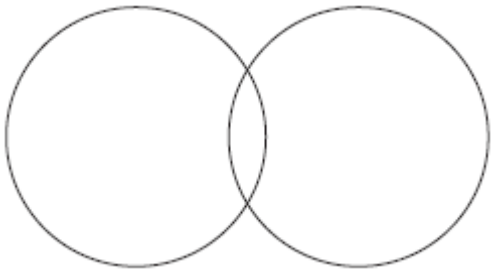
   c. bromine

4) Can you think of any other elements that would form a diatomic bond

Assessment

Iodine is a group 7 element

Complete the diagram to show the outer electrons in an iodine molecule (I_2).



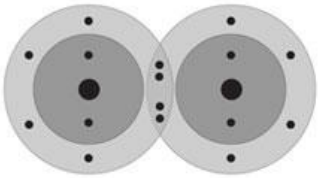
(2)

Objective 2 - Complex diatomic multi-bonded molecules

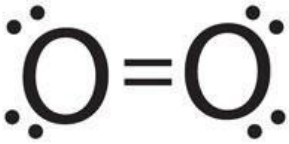
Complex Covalent Bonding Rules

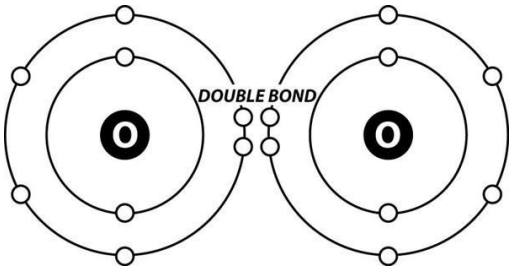
- Diatomic molecules can form more than one covalent bond between the atoms
- Sharing of outer shell electrons to form full outer shells
- Diatomic molecules are two atoms of the same element bonded together. Common gases.

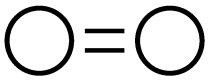
E.g. Oxygen
In group 6.
Needs two more electrons for full outer shell
Forms two covalent bonds with another oxygen



Oxygen Molecule (O_2)







Practice – Use information above to answer questions

a) How many covalent bonds will N_2 (diatomic nitrogen) form?

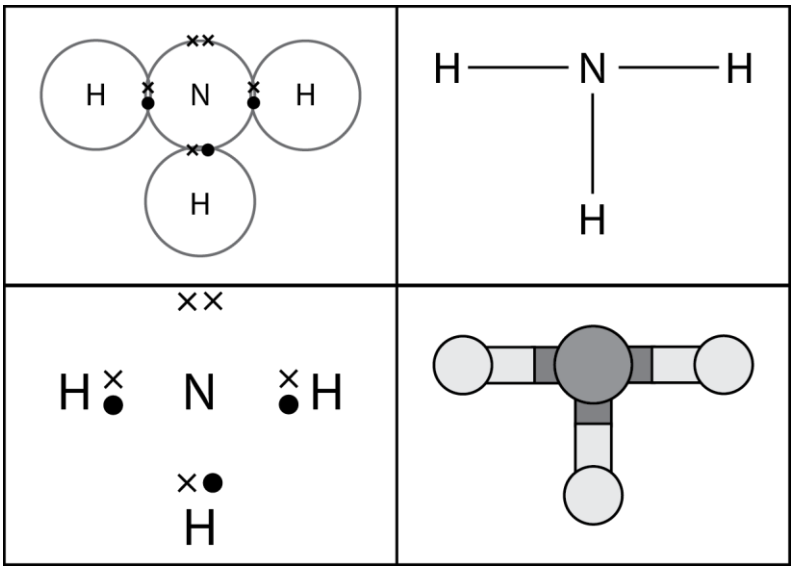
b) Draw the bonding present in diatomic nitrogen, in each of the four formats shown above?

Assessment

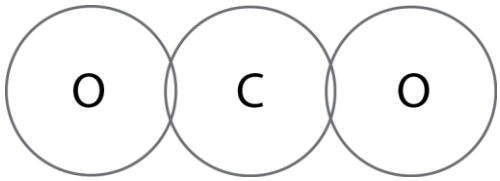
What is the number of unshared electrons in each nitrogen atom of N_2.

Objective 3 - Small covalent molecules

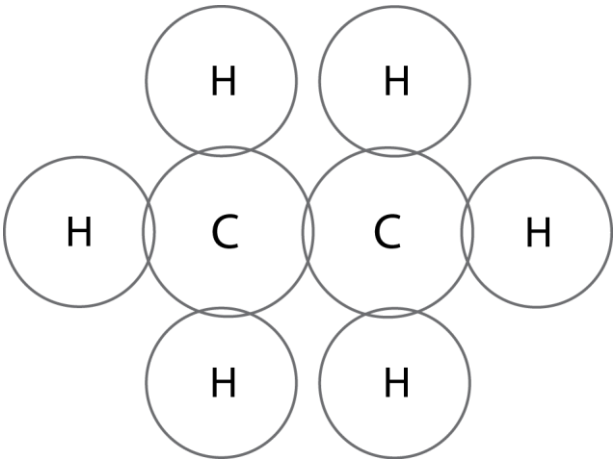
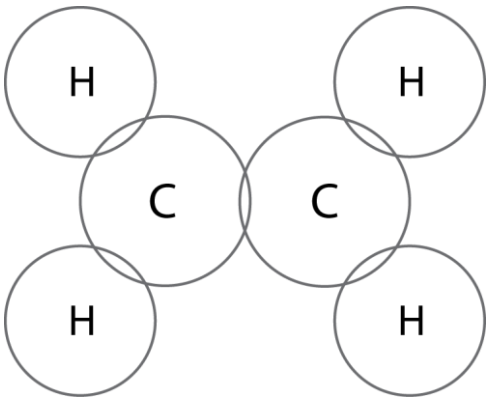
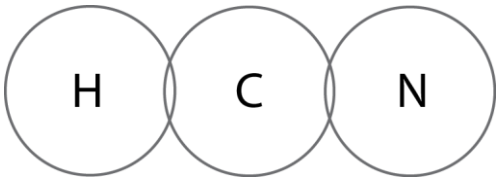
Covalent Molecule Rules
- Non-metals can form small covalent molecules with other non-metals
- These simple molecules can have single, double or triple bonds



Practice A - Complete the table filling In the missing Information and bonding diagrams

Molecule name	Stick diagram	Shell diagram	Formula
Methane			
			H_2O
Carbon dioxide			

Practice B – Complete the table filling In the missing Information and bonding diagrams

Ethane			C_2H_6
Ethene			C_2H_4
Hydrogen cyanide			HCN

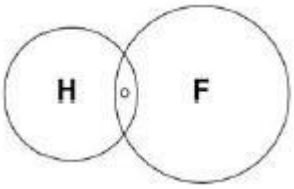
Assessment

This question is about compounds of fluorine.

A fluorine atom has 7 electrons in the outer shell.

Figure 1 shows part of a dot and cross diagram of a molecule of hydrogen fluoride (HF). Complete the dot and cross diagram in **Figure 1**. You should show only the electrons in the outer shells.

Figure 1



Plenary

Discuss the limitations of using dot and cross, ball and stick, two and three dimensional diagrams to represent covalent molecules.

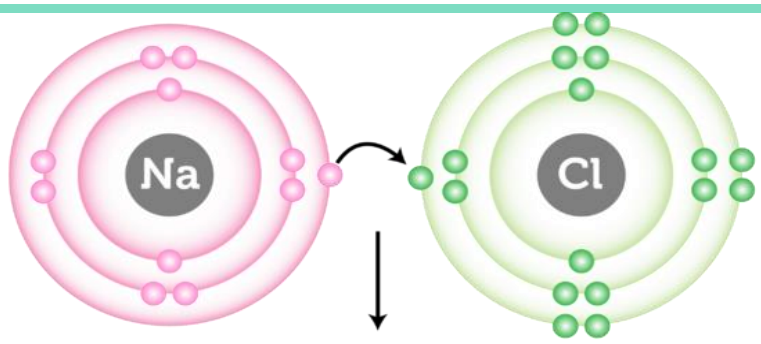
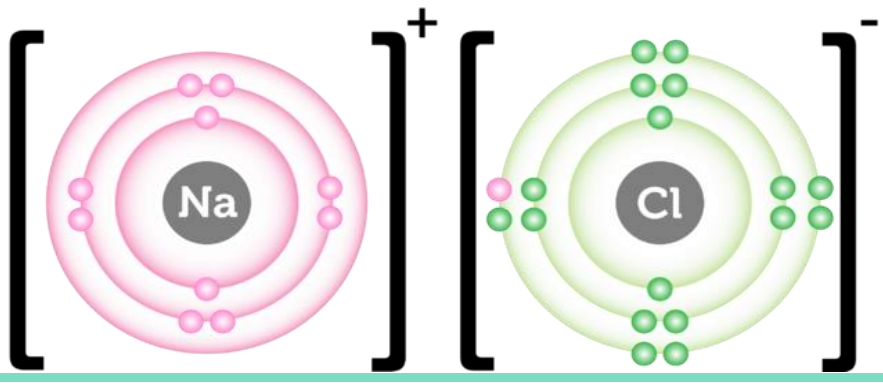
Tutorial 4 – Opposites attract- ionic bonding

What is the Purpose of Tutorial 4?

- Drawing simple ionic bonds
- Interpreting empirical formula of ionically bonded molecule
- Representing giant ionic compounds

Objective 1 – Revise drawing the bonding process, before and after

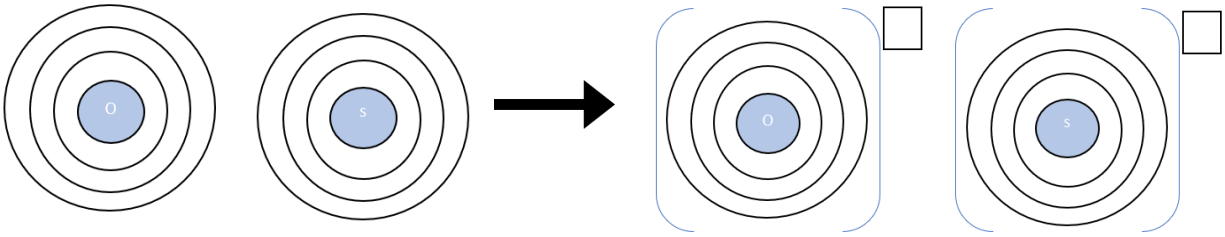
- Metals form cations
- Non-metals mostly form anions

Before the arrow = electronic structure of the element	
After the arrow = diagram of the ion formed	

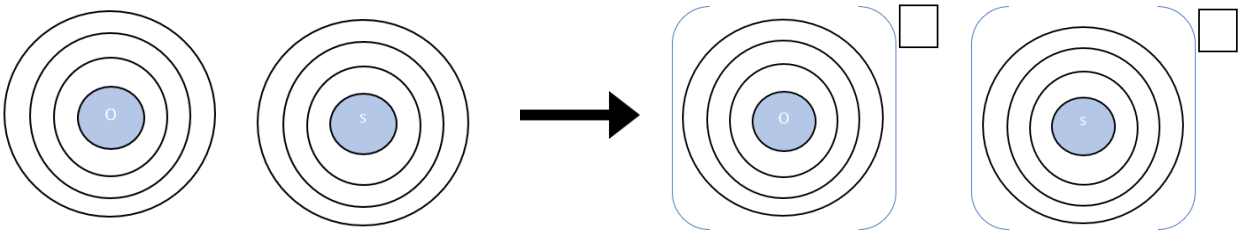
Practice – Drawing ionic bonds

Ionic bonding - group 1 & 7 elements

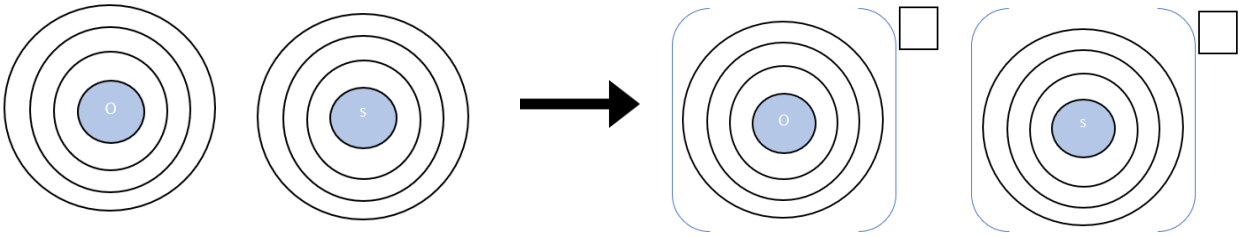
Draw a diagram to represent the bonding between Li and F



Draw a diagram to represent the bonding between K and Cl



Draw a diagram to represent the bonding between Na and Br



Ionic bonding - group 2 & 6 elements

Draw a diagram to represent the bonding between Mg and O

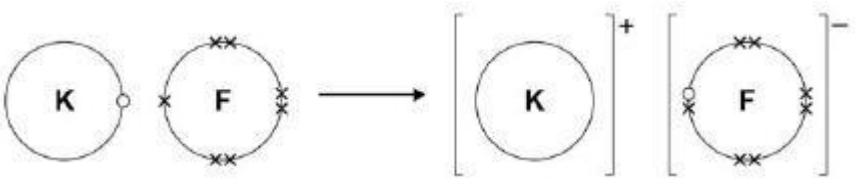
Draw a diagram to represent the bonding between Be and S

Assessment

Potassium reacts with fluorine to produce the ionic compound potassium fluoride (KF).

Figure 3 shows the transfer of electrons during the reaction.

Figure 3



Describe what happens when potassium reacts with fluorine to produce potassium fluoride.

Write about electron transfer in your answer.

_____

_____

_____

_____

_____

_____

_____

_____

_____

Objective 2 – Writing empirical formula

Empirical formula Rules

- The formula of ionic compounds can be predicted by the ions the elements form.
- Charges must balance (compound must be electrically neutral/no overall charge).
- Name of the non-metal changes to -ide (.e.g oxide, chloride, bromide, fluoride, nitride)

E.g. Oxygen and lithium react to produce lithium oxide.
Oxygen forms a 2^- ion. Lithium produces a 1^+ ion. It takes two lithium ions to balance the charge of one oxygen ion. The formula must contain twice as much lithium as oxygen.
Empirical formula would be Li_2O

E.g. Aluminium and oxygen react to produce aluminium oxide.
Oxygen forms a 2^- ion. Aluminium produces a 3^+ ion. It takes two lithium ions to balance the charge of three oxygen ions. The formula must contain two aluminium ions for every three oxygen ions
Empirical formula would be Al_2O_3.

Practice – Derive the formula for these compounds by considering the charges of the ions of the elements

Elements in compound	Ions of these elements		Number of atoms of each element required to make compound neutral		Formula for compound	Name of compound
Li & F	Li^+	F^-	Li: 1	F: 1	LiF	lithium fluoride
Na & O	Na^+	O^{2-}	Na: 2	O: 1	Na_2O	sodium oxide
Mg & Cl	Mg^+	Cl^-	Mg: 1	Cl: 1	MgCl	magnesium chloride
Ca & O						
K & F						
Li & S						
Na & Br						
Be & Cl						
Ca & Cl						
Ca & S						
Li & N						
Fe & O	Fe^{2+} Fe^{3+}					

Assessment

Rubidium reacts with phosphorous to form an ionic compound

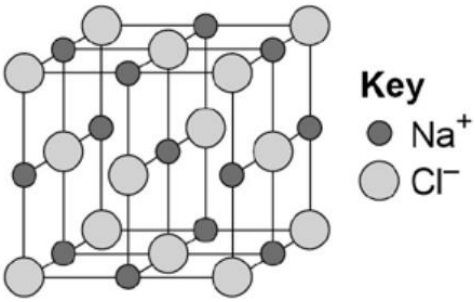
a) What is the name of the compound formed

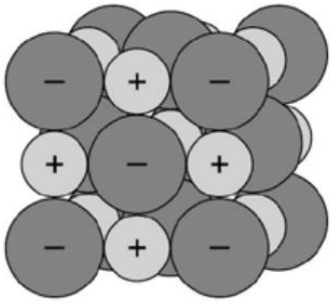
b) What is the empirical formula for the ionic compound formed?

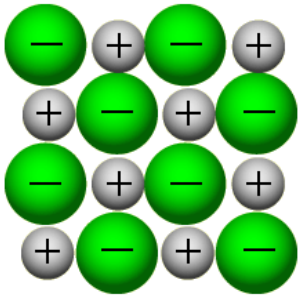
Objective 3- Giant lattice structure in ionic compounds

Giant Ionic Compound Rules

- Oppositely charged ions form a repeated pattern of ions, called a lattice. There a multiple ways to show this lattice structure
- Giant lattices are held together by electrostatic forces between the cations and anions







E.g. A crystal of table salt (NaCl) is an example of an ionic lattice

Practice – Use the information to answer questions

1) Which ions are positively charged?

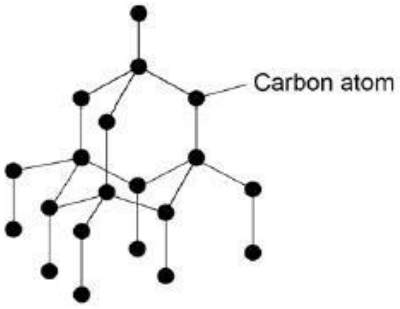
2)
3) What is the structure that ionic compounds form called?

4) What forces hold the ions together?

Assessment

Which structure is an ionic lattice?

Tick **one** box.



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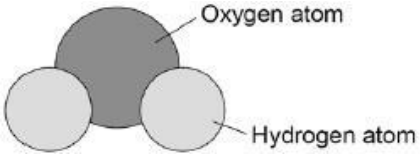

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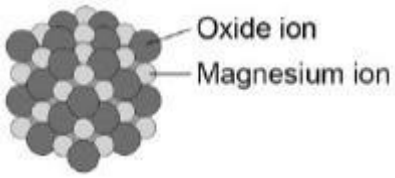

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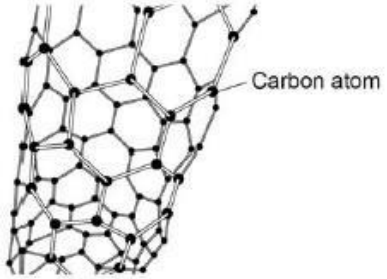

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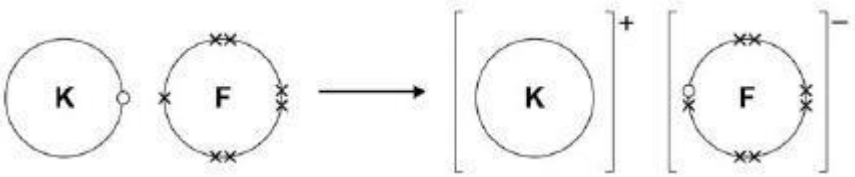
Plenary

Figure 3 shows the transfer of electrons during the reaction to form an ionic compound.

Figure 3



What is a strength and a shortcoming of this model?

Write about the structure of ionic compounds in your answer.

_____

_____

_____

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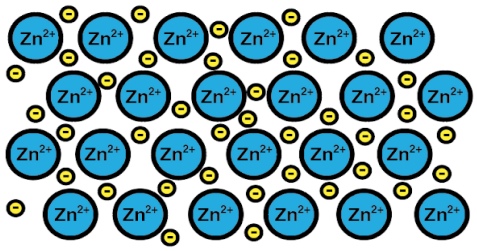
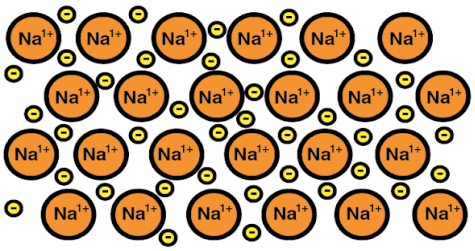
Tutorial 5 – Metallic bonding, giant covalent and identification

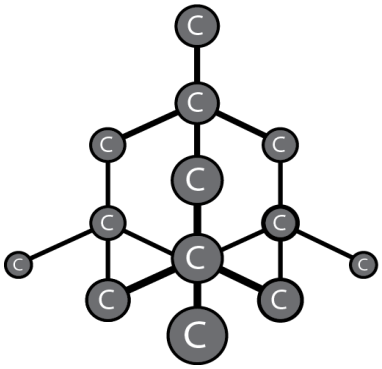


Zinc

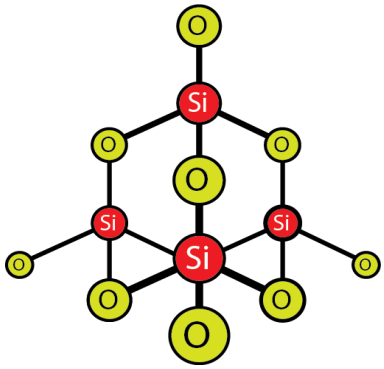


Sodium

Diamond



Silica



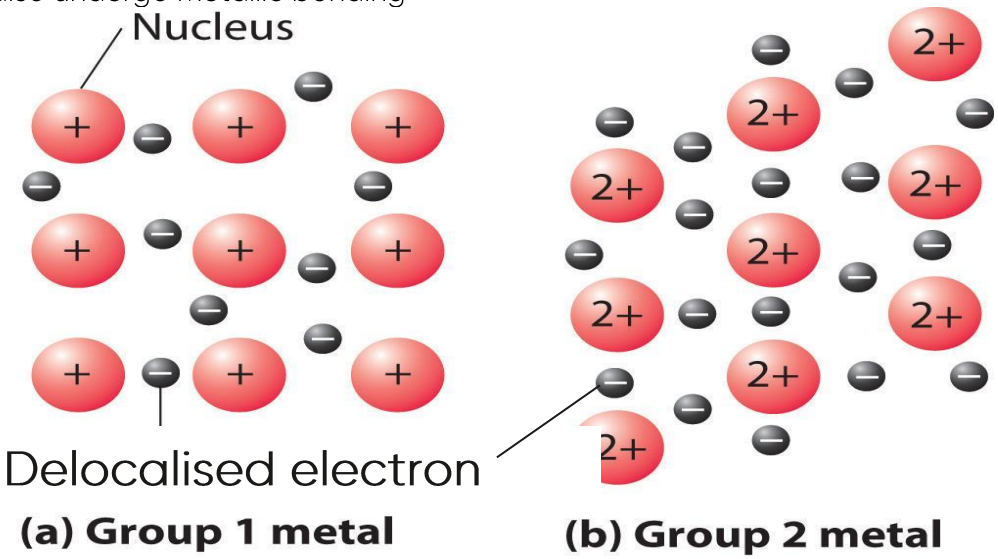
What is the Purpose of Tutorial 5?

- Describe the components and their properties in a metallic bond
- Identify giant covalent compounds based on their structure
- Apply knowledge of all types of bonding to identifying bonds formed from empirical formulas

Objective 1 – Metallic bonding

Metallic Bonding Rules

- In metals, the outer electrons are free to move around positive Ions.
- Electrons are called delocalised.
- Alloys also undergo metallic bonding



Practice – Use information to answer questions

a) What is a delocalised electron?

b) What is an alloy, and give two examples?

c) Do alloys containing non-metals undergo metallic bonding? Explain your answer

d) Draw the arrangement of atoms in a pure metal and include the delocalised electrons?

Assessment

1. Metals consist of a lattice of metal ions surrounded by what?

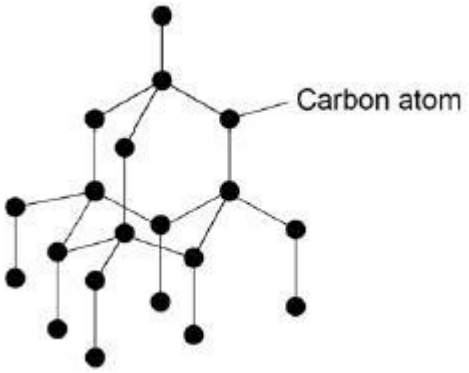
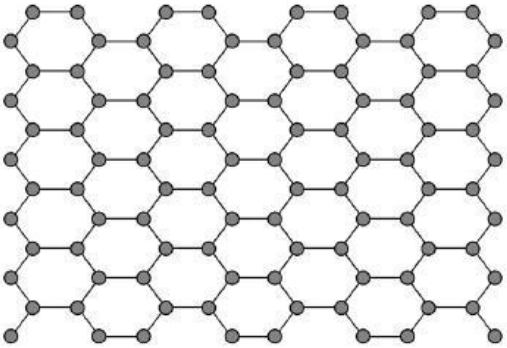
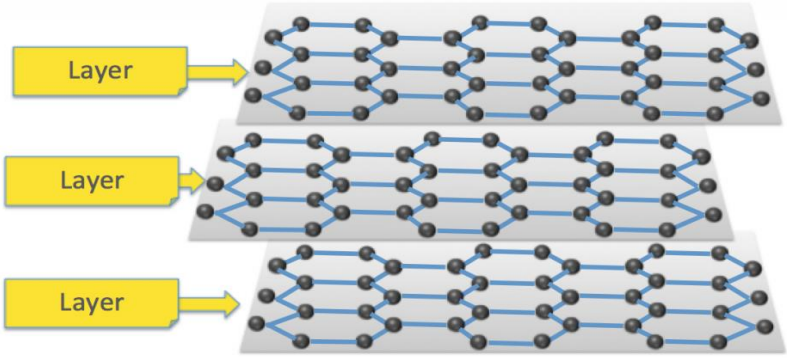
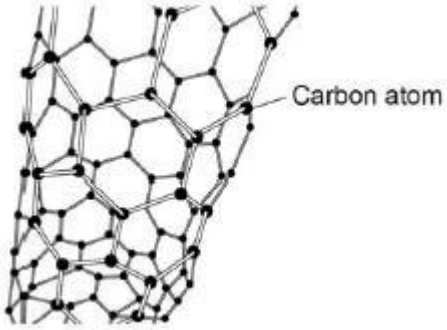
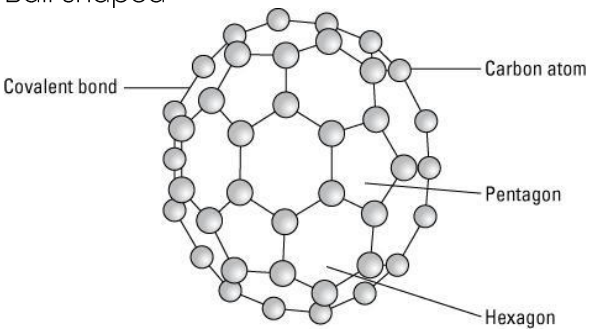
2. What type of bonding occurs between metals?

3. The electrons in the outer shell of metallically bonded atoms are _____.

4. Delocalised electrons are f____ to move through a metallic structure

5. The sharing of electrons give rise to strong m_____ bonds.

Objective 2 – Recognise giant covalent structures (diamond, graphite, graphene)

Non-metals can also form giant structures. Group 4 elements are particularly good at this. Carbon has several different giant covalent structures		
Diamond	Extremely hard. Each carbon atom is bonded to 4 more carbon atoms 	
Graphene	Sheet of carbon atoms. Each carbon atom is bonded to 3 other carbon atoms 	
Graphite	Layers of graphene sheets stacked on top of each other. Delocalised electrons allow electrical conduction 	
Fullerene	Tube shaped 	Ball shaped 

Practice – Use information to answer questions

a) Graphene and diamond are both examples of what type of structure?

b) Compare and contrast the structure and composition of diamond, graphite, graphene and fullerenes?

_____

_____

_____

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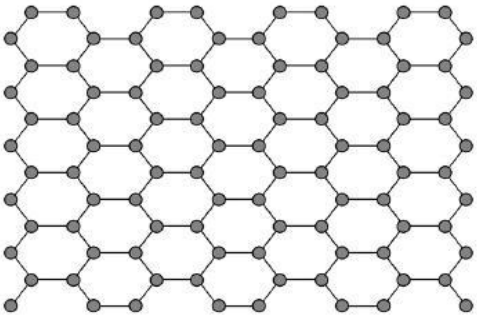
Assessment

This question is about structure and bonding. This shows part of one layer of graphene.



Which element is graphene made from? Tick **one** box.

Carbon	☐
Copper	☐
Hydrogen	☐
Sodium	☐

Each atom in graphene has one delocalised electron. Complete the sentence. Choose the answer from the box.

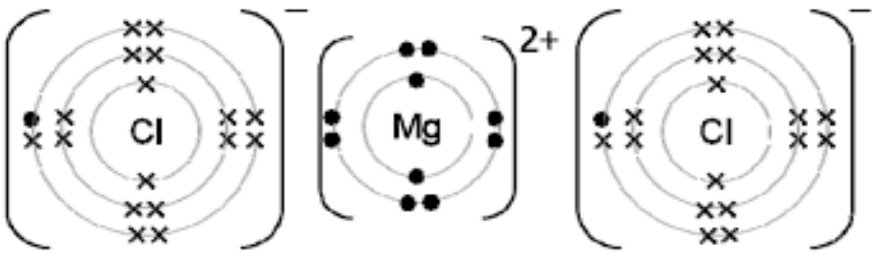
act as a lubricant	be used as a fuel
conduct electricity	dissolve in water

Delocalised electrons allow graphene to _____ .

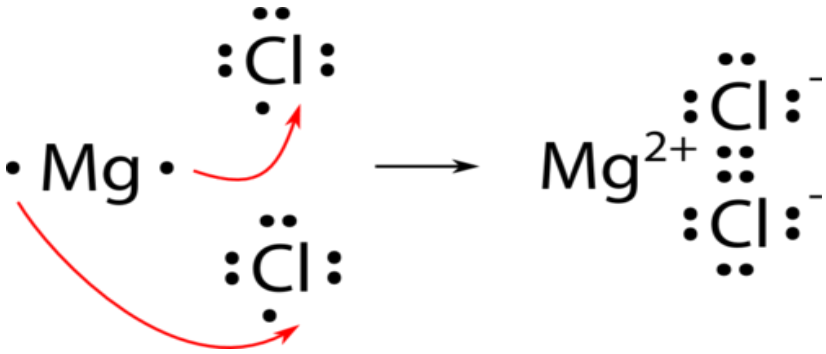
Objective 3 – Identification of bonding from given information.

Worked Example 1
If you are given the empirical formula.
E.g. $MgCl_2$

1) Identify elements using periodic table: Magnesium, chlorine
2) Identify bonding (remember to identify metals and non-metals)
   a. Metals: magnesium
   b. Non-metals: chlorine
   c. Metal to non-metal bonding is ionic
3) Bonding diagram



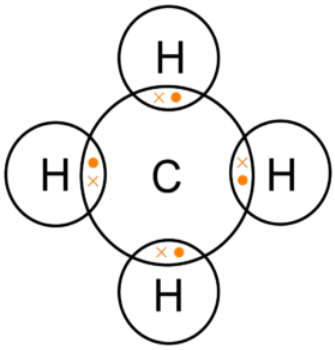
or

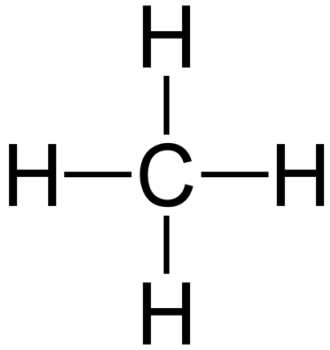


4) Name the compound formed (remember the non-metal changes suffix) = Magnesium chloride

Worked Example 2
If you are given the elements that will/have reacted or the reaction equation.
E.g. $C + 2H_2 \rightarrow CH_4$

1) Identify elements using periodic table: C= carbon, H=hydrogen
2) Identify bonding (remember to identify metals and non-metals)
   a. Metals: none
   b. Non-metals: hydrogen and carbon
   c. Non-metal to non-metal bonding is covalent
3) Bonding diagram:

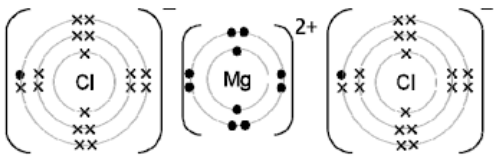
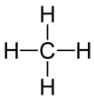


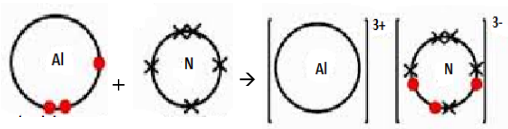
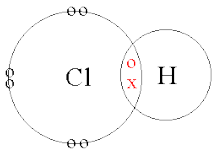


4) Name chemical formed = methane

Practice – Identifying bonding in molecules

Complete the table, identifying the missing components from: type of bonding, elements, empirical formula. Ignore greyed out boxes

Elements in compound	Element names	Type of bonding	Bonding diagram	Empirical formula	Name of compound
Mg & Cl	Magnesium, chlorine	Ionic		$MgCl_2$	Magnesium chloride
C & $2H_2$		Covalent		CH_4	Methane
H_2				H_2	Hydrogen
Ca & O		Ionic			
Al & O					
S & O			O=S=O		
				NaBr	Sodium bromide
Na & Li					

		Ionic			
Ca & S					
					water
	Iron, carbon				Steel
				Cu_2O	
					Gold
					Diamond
					Graphene
					Potassium cyanide
					

K & O					
	Oxygen, carbon				
	Oxygen, carbon				
			O=C=C=C=O		
Cu & Zn					Brass
					Hydrogen peroxide

Assessment:

Aluminium reacts with sulfur to form a new compound. Using all the information from across all the tutorials, describe this reaction and the product in as much as possible

Plenary: Why can molten NaCl conduct electricity, but solid NaCl cannot?

Tutorial 6 – Final Assessment

What is the Purpose of Tutorial 5?

- Final assessment- 30 mark exam question selection

Tutorial 7 - Feedback

What is the Purpose of Tutorial 7?

- To receive feedback on final assessments.
- To share examples of best practice with the other pupils in your group.
- To write targets for improvement in school lessons.
- To reflect on the programme including what was enjoyed and what was challenging.

Final assessment feedback

What I did well...	What I could have improved on...
•	•
•	•
•	•

My target for future work is...

Reflecting on Uni Pathways

What did you most enjoy about Uni Pathways?
•   •   •

What did you find challenging about the programme?	How did you overcome these challenges?
• • •	• • •

Notes

Notes

Notes

Bonding and Structure

Key Stage 4 Programme

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