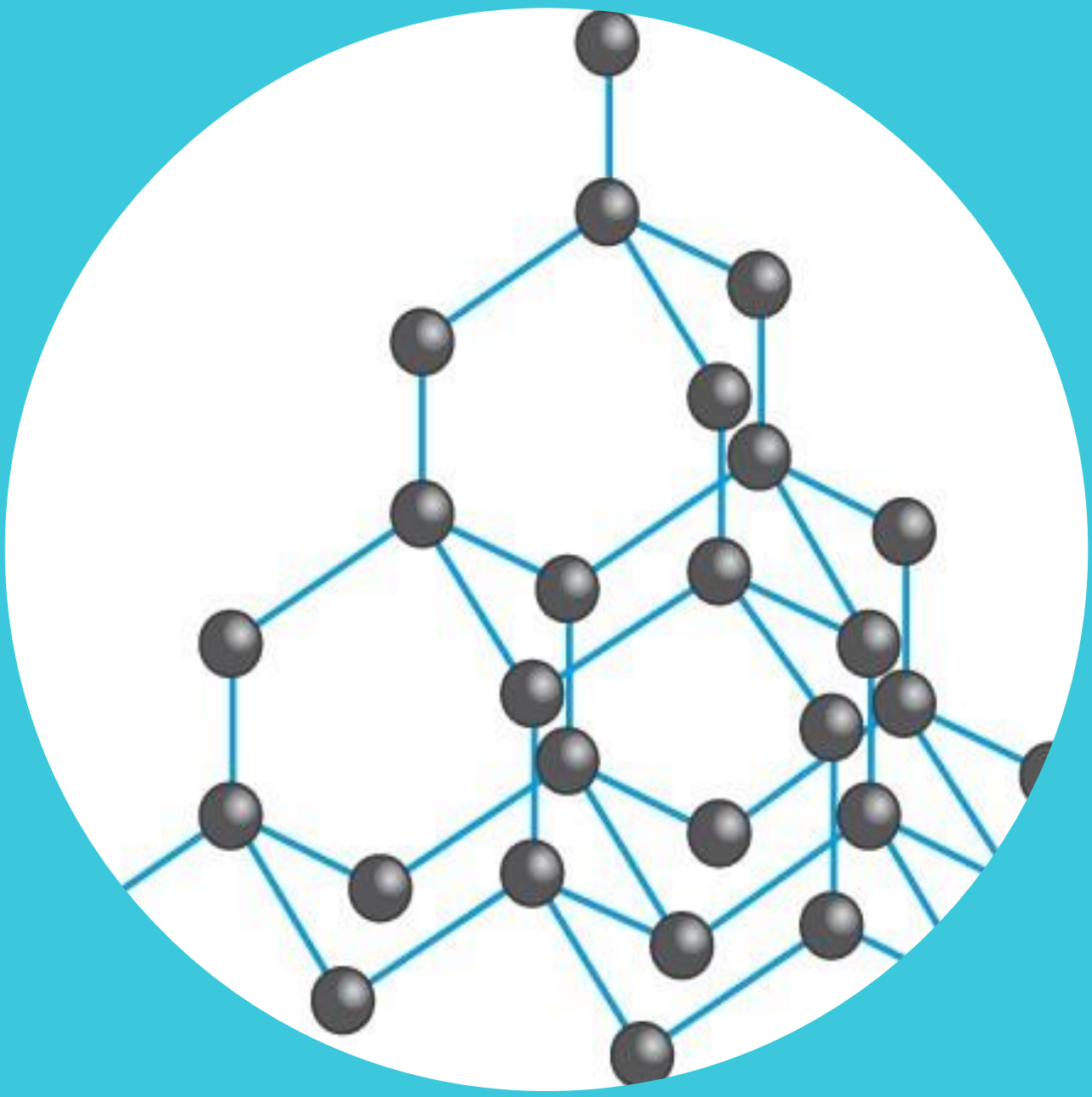

Bonding and Structure

Key Stage 4 Revision Programme

Pupil Name

Handbook Designed by Dr Ambrose

Timetable and Assignment Submission

Timetable – Tutorials

Tutorial	Date	Time	Location
1 Baseline assessment	09/12/2019	2:45 PM	B 25
2 Using and abusing the periodic table	13/01/2019	2:45 PM	B 25
3 Sharing is caring – simple covalent bonding	20/01/2019	2:45 PM	B 25
4 Opposites attract – ionic bonding	27/01/2019	2:45 PM	B 25
5 Metallic bonding, giant covalent and identification	03/02/2019	2:45 PM	B 25
6 Final assessment	10/02/2019	2:45 PM	B 25
7 Feedback	02/03/2019	2:45 PM	B 25

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Tutorial 2 Using an abusing the Periodic Table **p9**

Objective 1 How to interpret the Periodic Table p10

Objective 2 Electronic Structure of an Atom p12

Objective 3 Understanding the rules of ion formation and their electronic structure p10

Tutorial 3 Sharing is caring – simple covalent bonding **p17**

Objective 1 Simple diatomic single bond molecules p17

Objective 2 Complex diatomic multi-bonded molecules p19

Objective 3 Small covalent molecules p20

Tutorial 4 Opposites attract – ionic bonding **p23**

Objective 1 Revision. Draw the bonding process. Before and after p23

Objective 2 Empirical formula p27

Objective 3 Giant lattice structures in ionic compounds p28

Tutorial 5 Metallic bonding, giant covalent and identification **p32**

Objective 1 Metallic bonding p32

Objective 2 Recognise giant covalent structures (diamond, graphite, graphene) p34

Objective 3 Identification of bonding from given information p37

Tutorial 6 Final Assessment **p42**

Tutorial 7 Feedback **p43**

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Dos and don’ts p48

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Course Rationale

What is Uni Pathways Year 2?

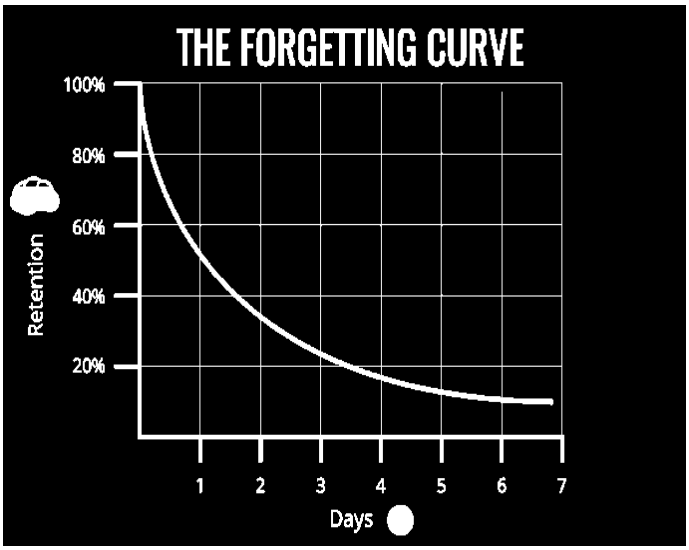
In year one of Uni Pathways we looked at an example of the type of research being undertaken by scientists in research laboratories across the world. By looking into mass spectrometry of proteins we gained some insight into the more complex scientific ideas involved and explored its applications towards drug discovery in order to answer our question "how big is the cure?".

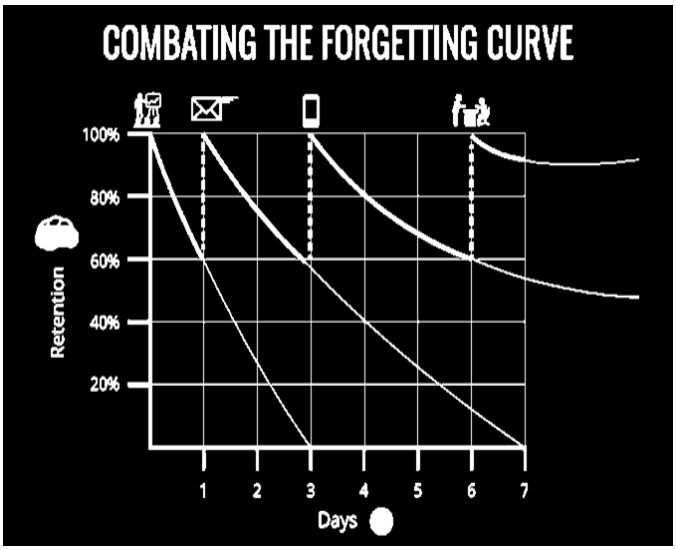
In year two of Uni Pathways we are going to revisit a GCSE topic that you have already encountered in your normal lessons, namely "Bonding, Structure and the Properties of Matter". Through revisiting this topic, we will be able to both reinforce and deepen your current understanding of the concepts involved in the topic. This will be done through a series of tutorials similar to year one in which our small group will be able to discuss the topic in a university style environment. We will have four content tutorials which will be supported by a workbook, as well as three extra tutorials to assess your understanding of the topic before and after the tutorial series and complete evaluations about the Uni Pathways tutorial series.

Why revisit a GCSE topic?

The primary goal of our tutorial series is to reinforce the knowledge you have discussed during the science course, address any areas you may have struggled with and extend your understanding of the topic.

Studies in cognitive psychology (the science of memory) have shown us that real learning takes place when you are actively using the knowledge, engaging your neurones and forming new connections in the brain. While we do this as much as possible within lessons, a lot of the time is spent introducing the content, leaving limited time to practice it. Research into memory also shows that memories decay over time (see "The Forgetting Curve"), and spaced review and practice of the knowledge the most effective way to promote long-term retention (see "Combating the Forgetting Curve").





Revisiting this topic will both be beneficial to your direct understanding of the topic, better preparing you for GCSE examinations, but also help you access further material that you will encounter in lessons across the remainder of your science education, as the concepts discussed are fundamental to the broader study of science and you will encounter them in further topics. As such, ensuring a good understanding of these important concepts will have wide benefits to your whole study of the GCSE science course and beyond.

Subject Vocabulary

Word	Definition	In a sentence
Atom	The smallest particle of a chemical element that can exist	Substance are made up of atoms of different elements
Proton	A subatomic particle found in the nucleus with a relative charge of +1 and a relative mass of 1	A helium atom contains 2 protons in its nucleus
Neutron	A subatomic particle found in the nucleus with a relative charge of 0 and a relative mass of 1	A lithium atom contains 4 protons in its nucleus
Electron	A subatomic particle orbiting the nucleus with a relative charge of -1 and a relative mass of 1/1840	A hydrogen atom contains 1 electron
Ion	An atom or molecule with an overall charge due to the loss or gain of electrons	When a sodium atom reacts it forms an ion
Cation	A positively charged ion	An atom that has lost an electron will form a cation
Anion	A negatively charged ion	An atom that has gained an electron will form an anion
Isotope	Atoms of the same element with the same number of protons but a different number of neutrons	Deuterium is an isotope of hydrogen with 1 neutron instead of 0.
Molecule	Two or more atoms chemically bonded together	Nitrogen exists as the N_2 molecule containing 2 nitrogen atoms
Compound	Two or more atoms of different elements chemically bonded together	Water is a compound containing 2 hydrogen and 1 oxygen atoms
Periodic Table	A table listing all the known chemical elements in order of atomic number	Lithium, gold, fluorine and Mendelevium are elements that can be found on the periodic table
Group	Vertical columns in the periodic table that contain elements of similar chemical properties	Fluorine, chlorine, bromine and iodine are all group 7 elements.
Period	Horizontal columns in the periodic table that contain elements with the same number of electron shells	Potassium, calcium, cobalt and selenium are all period 4 elements.

Subject Vocabulary

Word	Definition	In a sentence
Dot and Cross	A model used to show the electronic configuration of atoms and the transfer of them during ion formation	As sodium and chlorine react the electron transfer can be shown in a dot and cross diagram
Metal	An element that readily forms cations (positive ions) and has metallic bonds	Sodium, calcium, iron, aluminium and mercury are all metals
Non-Metal	An element that readily forms anions (negative ions).	Carbon, helium, bromine, silicon and tellurium are all non-metals
Alloy	A metal containing atoms of two or more metallic elements	Bronze is an alloy containing copper, tin and other metals
Ionic Bonding	The bonding that forms between metals and non-metals, which involves the formation of ions	In sodium chloride, sodium and chlorine are bonded together by ionic bonding
Covalent Bonding	The bonding that forms between non-metals, which involves the sharing of electron pairs	In methane (CH_4), carbon and hydrogen share electrons.
Diatomic	A molecule consisting of two atoms	Oxygen exists as the diatomic molecule O_2
Empirical Formula	A chemical formula that gives the proportions of the elements present in a compound	Glucose ($C_6H_{12}O_6$) has an empirical formula of CH_2O
Lattice Structure	The three-dimensional arrangement of ions in an ionic compound	The sodium and chloride ions in sodium chloride exist in a lattice structure
Electrostatic Forces	The force that exists between charged particles, opposites attract and like-charges repel	The ions in an ionic compound are attracted by electrostatic forces
Delocalised Electrons	Electrons that are not associated with a particular atom	The electrons in metallic bonding are delocalised and do not 'belong' to one particular metal ion

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.

Insert for GCSE Chemistry (8462), Combined Science: Trilogy (8464), and Combined Science: Synergy (8465) papers v1

Tutorial 1 – Baseline Assessment

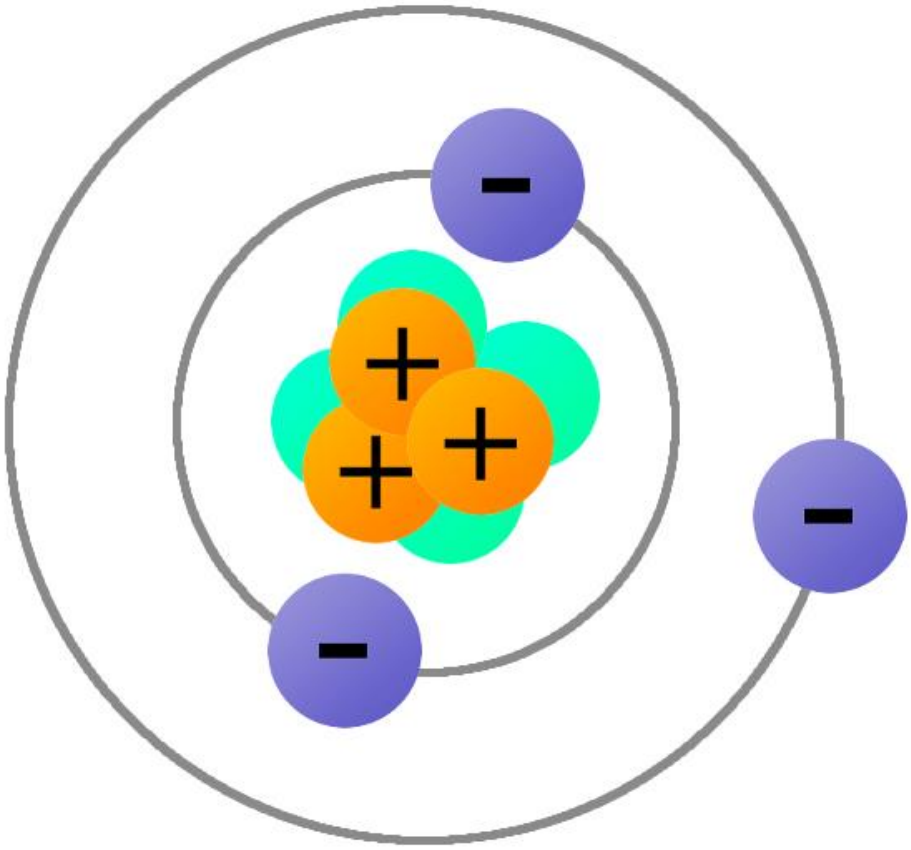
What is the Purpose of Tutorial 1?

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

Tutorial 2 – Use and abuse the Periodic Table

Starter – On the diagram below label the following components of an atom:

Proton, neutron, electron, shell (orbit), nucleus



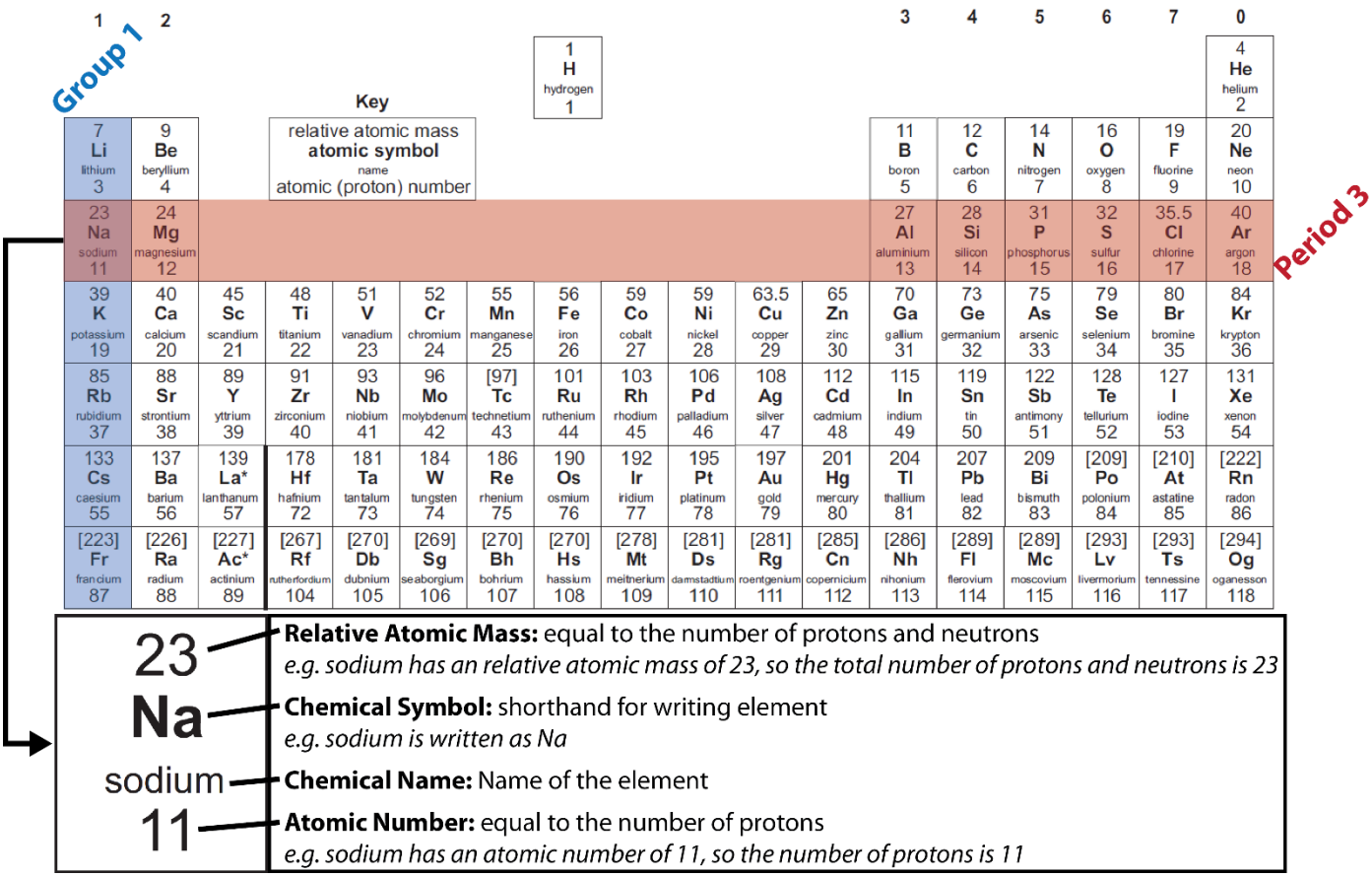
Fill in the table for the mass and charge of the subatomic particles

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 similarities and differences for the last two examples?

Question: What term is used to describe this?

<u>Assessment</u>

Q1. Use the periodic table to help you to answer these questions.
(a) The following is a list of symbols of some elements.
(b)

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

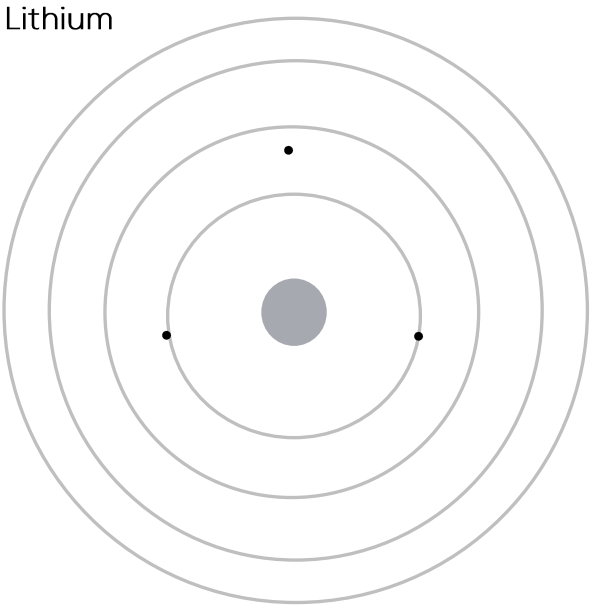
(1)

(iv) silicon?

(1)

Objective 2 – Electronic structure of an atom

Lithium



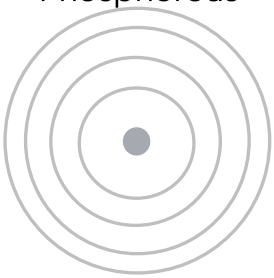
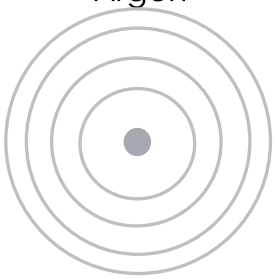
2 electrons can go in the first shell
8 electrons can go in shell 2 and 3
Same number of electrons as protons
Group number = number of electrons in the outer shell
Period number = number of electron shell
Electronic configuration number.
Dots or crosses

E.g. Lithium $^{7}_{3}Li$
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

Electron Configuration of the first 20 elements

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:

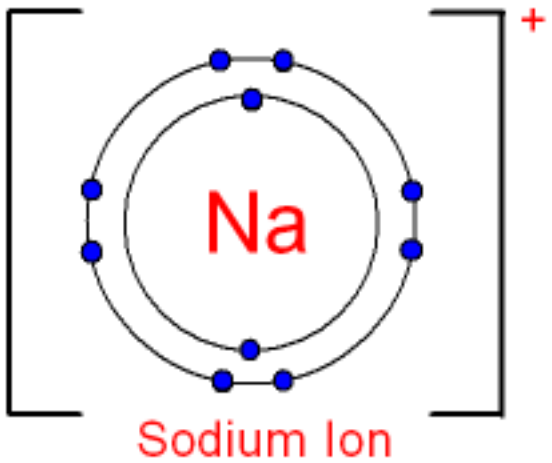
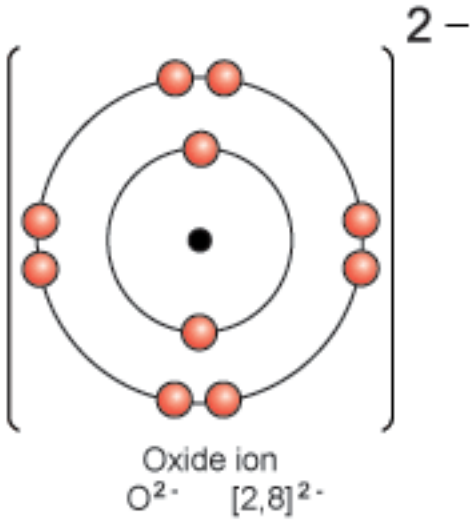
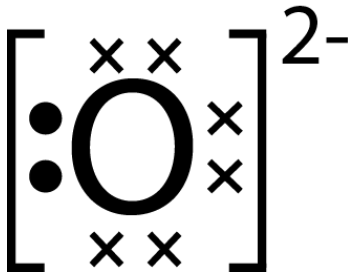
Neutron:

Electrons:

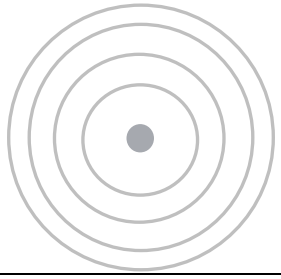
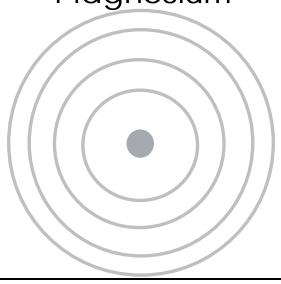
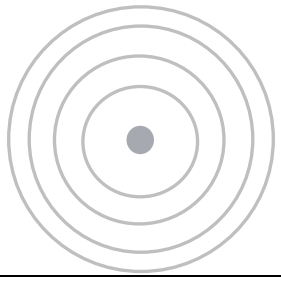
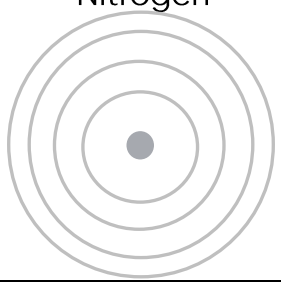
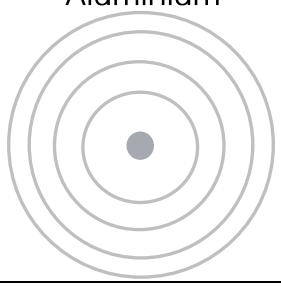
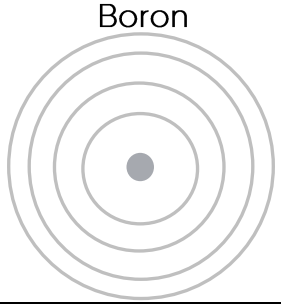
Objective 3 - Understanding the rules of ion formation and their electronic structure

Ion	An atom or molecule with a net electric charge due to the lose 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	Oxygen
Cation	Anion
Shell diagram	
	
Dot-cross diagram	
	

Practice – Complete the dot and cross diagrams and ion type in the table below

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

Assessment

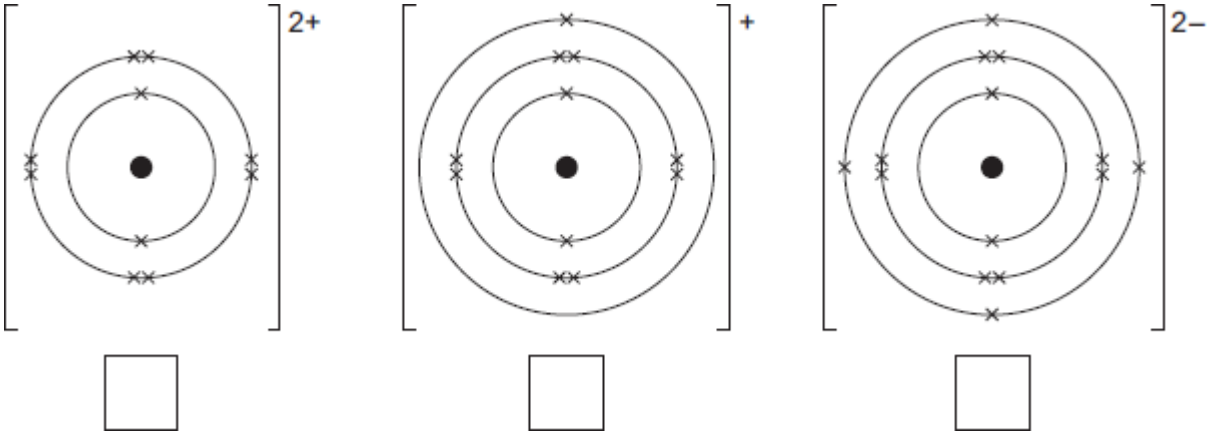
Q1.

This question is about magnesium.

(a) (i) A magnesium atom reacts to produce a magnesium ion.

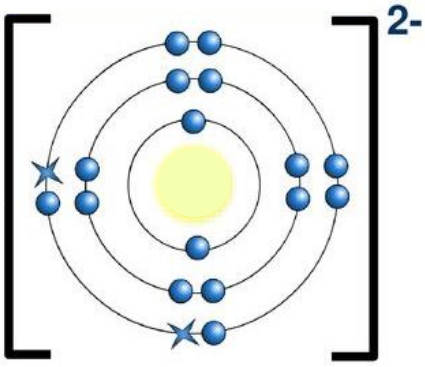
Which diagram shows a magnesium ion?

Tick (✓) **one** box.



(1)

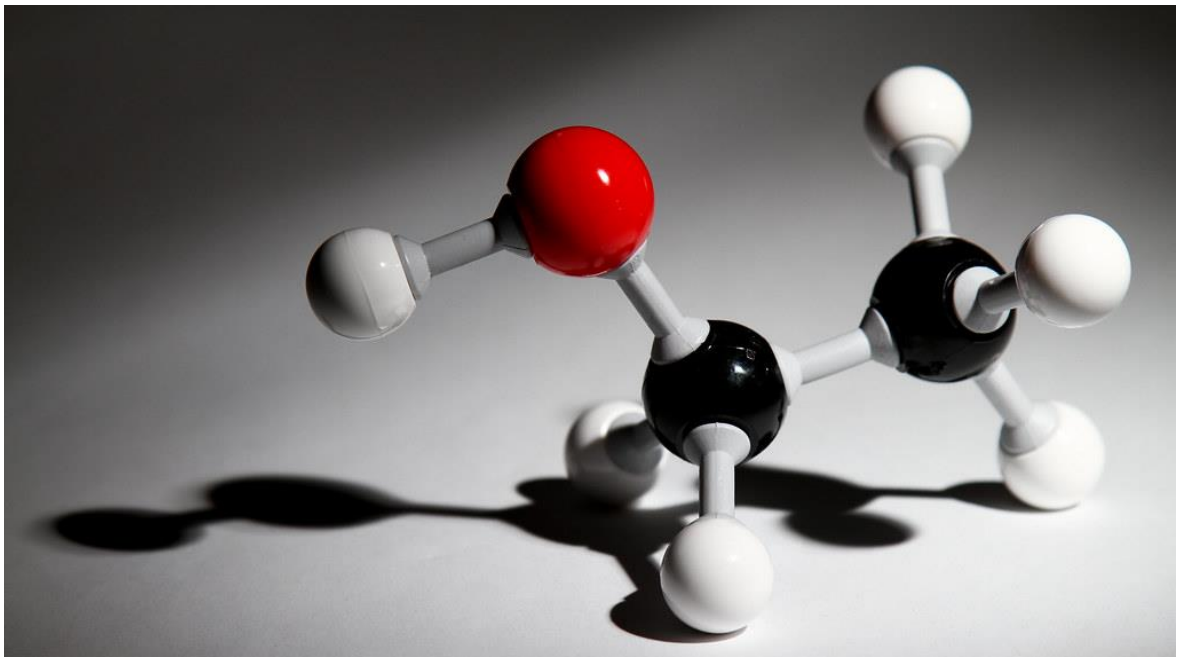
Plenary



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

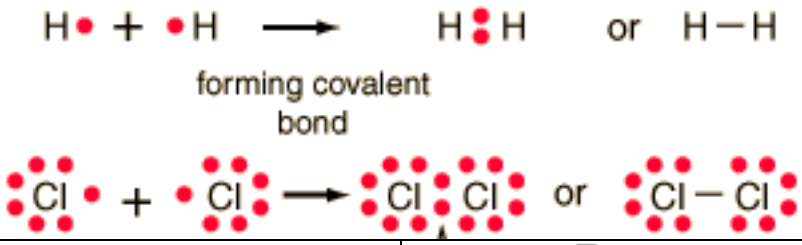
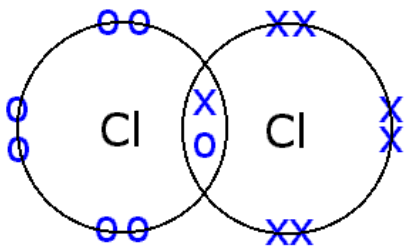
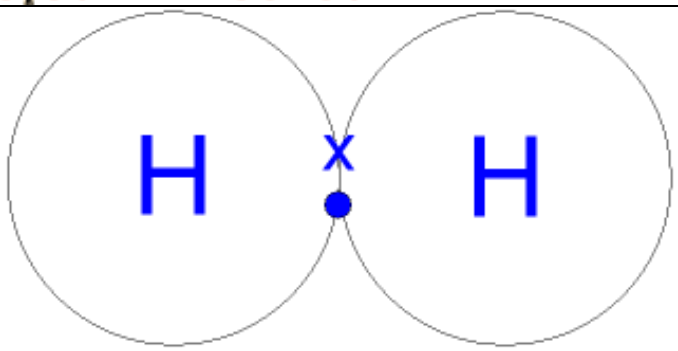
a) The ion is a cation
b) The ion is a group 2 element
c) The element is oxygen
d) The element is magnesium
e) The ion is an anion
f) The ion is a group 6 element
g) The ion is a metal
h) The ion is a non-metal
i) The element is sulfur
j) The element is calcium

Tutorial 3 – Sharing is caring- simple covalent bonding



What is the Purpose of Tutorial 3?

Objective 1 - Simple diatomic single bond molecules

Covalent Bonding
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.

 

Practice – Answer the questions below

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

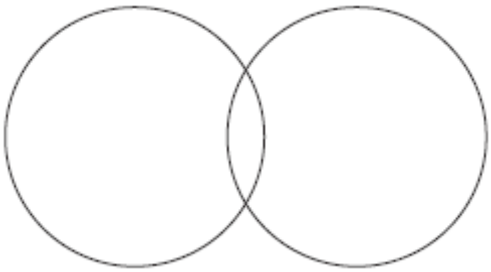
   c. bromine

4) Can you think of any other elements that would diatomic bonds

Assessment

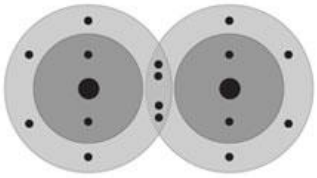
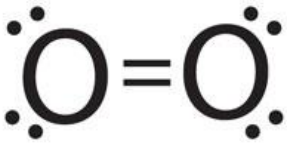
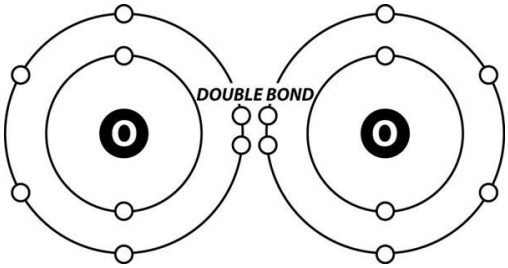
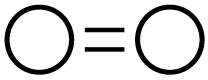
(a) Iodine is a group 7 element

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



(2)

Objective 2 - Complex diatomic multi-bonded molecules

Covalent Bonding
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.
 Oxygen Molecule (O_2)  Oxygen is group 6. Needs two more electrons for full outer shell Forms two covalent bonds with another oxygen



Practice – Answer the questions below

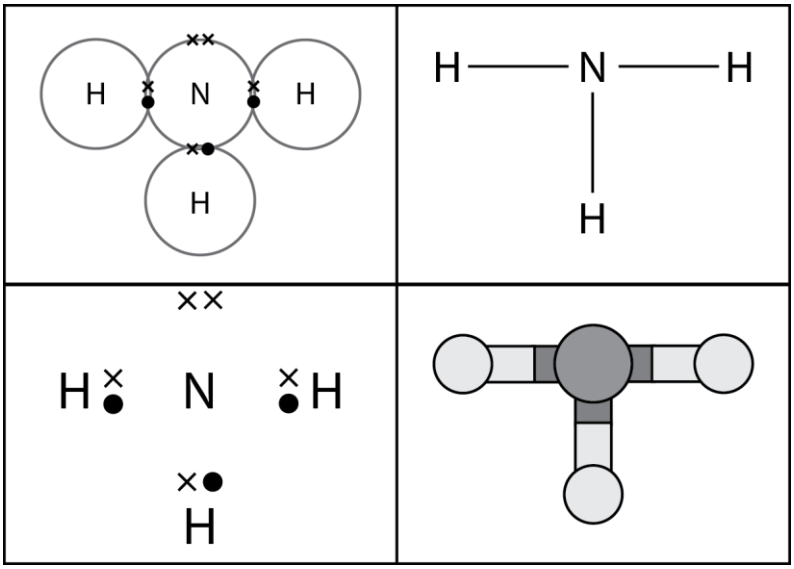
a) How many covalent bonds will N_2 (diatomic nitrogen) form?

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

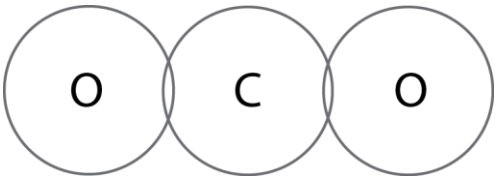
Assessment

Q1) What is the number of unshared electrons in each nitrogen atom of N_2.

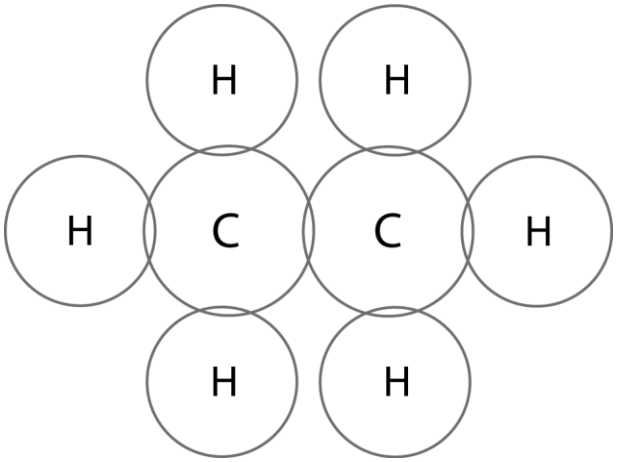
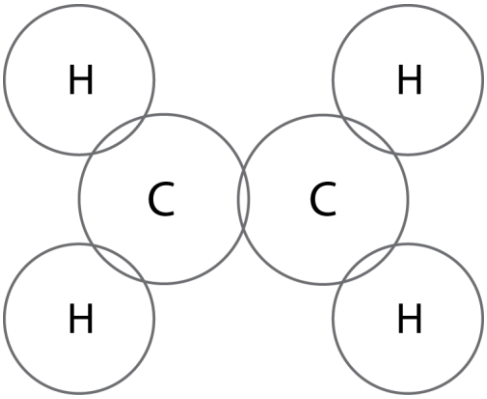
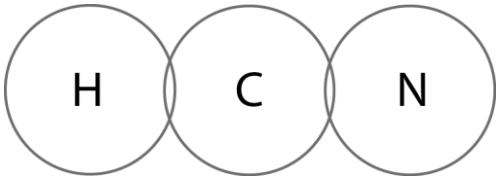
Objective 3 - Small covalent molecules

Non-metals can form small covalent molecules

These simple molecules can have single, double or triple bonds

Practice – Complete the table filling in the missing Information and bonding diagrams

Molecule name	Stick diagram	Shell diagram	Formula
Methane			
			H_2O
Carbon dioxide			

Complete the table filling In the missing Information and bonding diagrams

Ethane			C_2H_6
Ethene			C_2H_4
Hydrogen cyanide			HCN

Assessment

Q1.

This question is about compounds of fluorine.

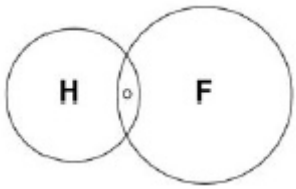
(a) A fluorine atom has 7 electrons in the outer shell.

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



(1)

Plenary

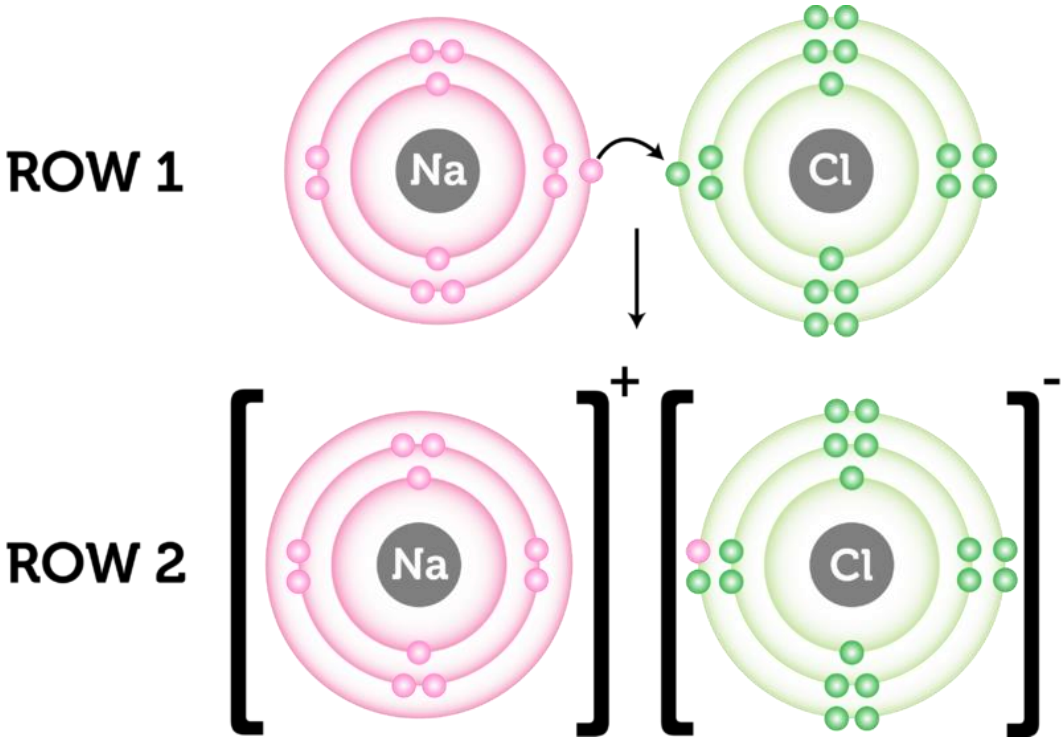
Discuss the limitations of using dot and cross, ball and stick, two and three dimensional diagrams to represent covalent molecules.

Tutorial 4 – Opposites attract- ionic bonding

What is the Purpose of Tutorial 4?

<u>Objective 1</u> - Revision. Draw the bonding process. Before and after

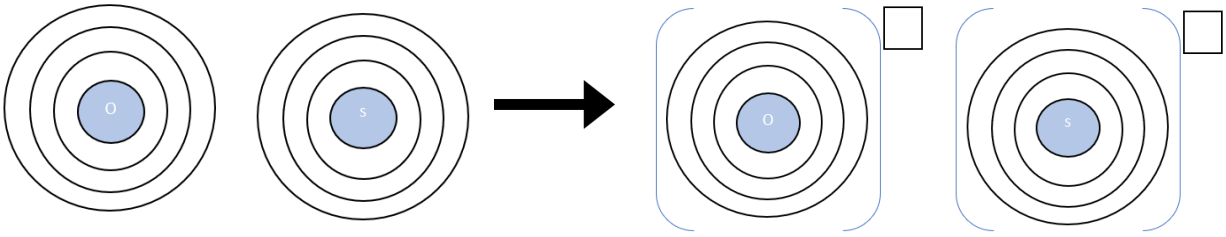
Metals form cations
Non-metals mostly form anions



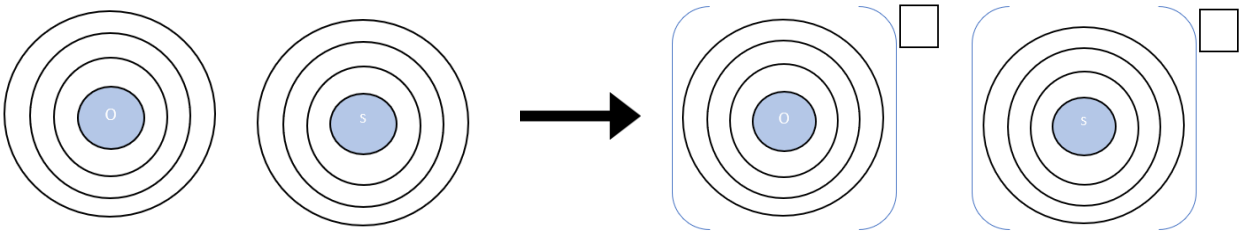
Practice – Answer the questions below

Ionic bonding - group 1 & 7 elements

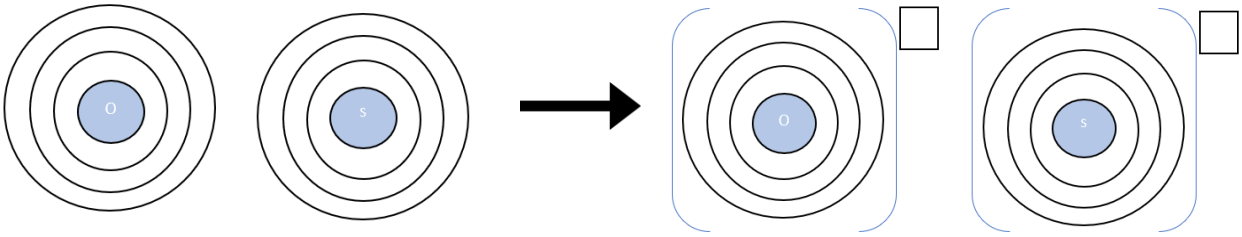
1. Draw a diagram to represent the bonding between Li and F



2. Draw a diagram to represent the bonding between K and Cl



3. Draw a diagram to represent the bonding between Na and Br



Ionic bonding – group 2 & 6 elements

4. Draw a diagram to represent the bonding between Mg and O

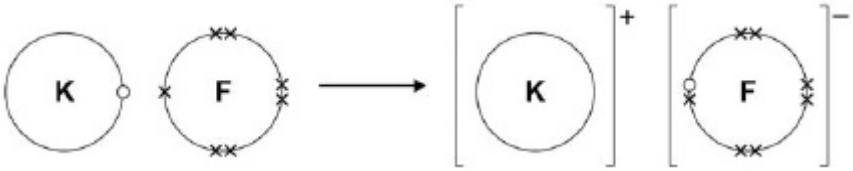
5. Draw a diagram to represent the bonding between Be and S

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



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

Write about electron transfer in your answer.

_____

_____

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(5)

Objective 2 - Empirical formula

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).

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.

Name of the non metal changes to -ide (.e.g oxide, chloride, bromide, fluoride, nitride)

Practice – Complete the table below

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
1.	Li & F	Li^+	F^-	Li: 1	F: 1	LiF	lithium fluoride
2.	Na & O	Na^+	O^{2-}	Na: 2	O: 1	Na_2O	sodium oxide
3.	Mg & Cl	Mg^+	Cl^-	Mg: 1	Cl: 1	MgCl	magnesium chloride
4.	Ca & O						
5.	K & F						
6.	Li & S						
7.	Na & Br						
8.	Be & Cl						
9.	Ca & Cl						

10.	Ca & S						
11.	Li & N						
12.	Fe & O	Fe^{2+} Fe^{3+}					

Assessment

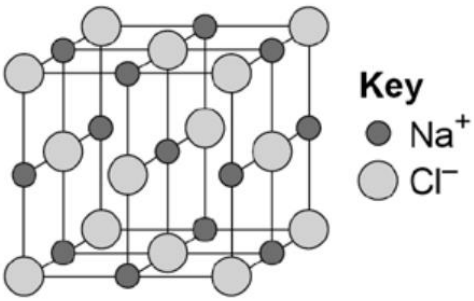
Rubidium reacts with phosphorous to form an ionic compound

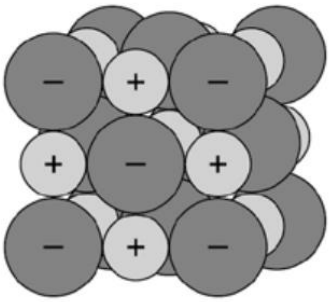
a) What is the name of the compound formed

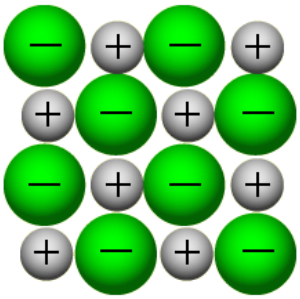
b) What is the empirical formula for the ionic compound formed?

Objective 3 – Giant lattice structure in ionic compounds

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

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

<u>Practice</u> – Answer the questions below

1) Which ions are positively charged?

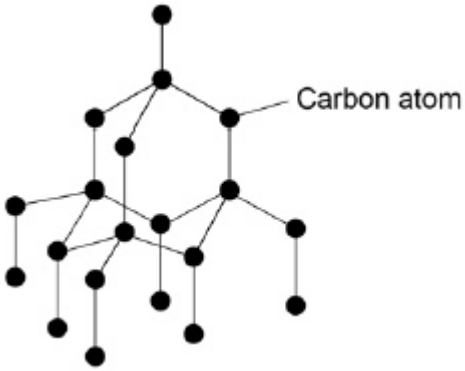
2) What is the structure that ionic compounds form called?

3) What forces hold the ions together?

Assessment

(a) Which structure is an ionic lattice?

Tick **one** box.



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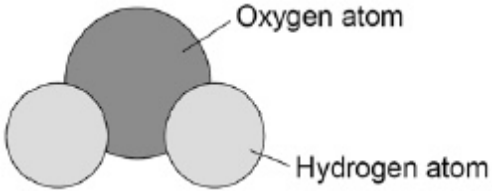

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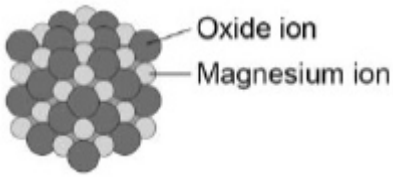

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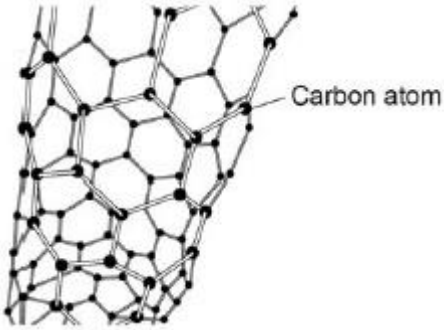


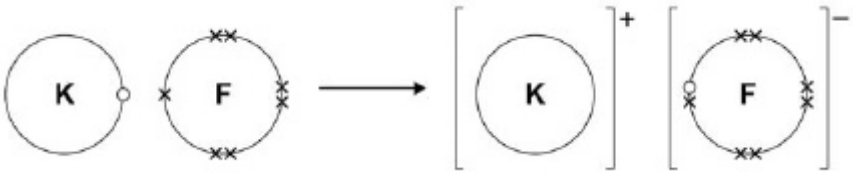
☐

(1)

Plenary

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

Figure 3



(d) What is a strength and a shortcoming of this model?

Write about the structure of ionic compounds in your answer.

_____

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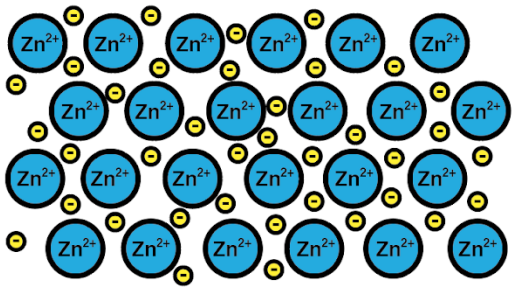
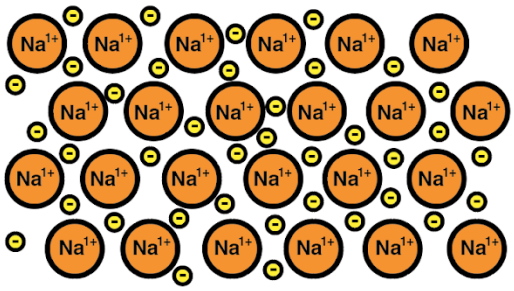
Tutorial 5 – Metallic bonding, giant covalent and identification



Zinc

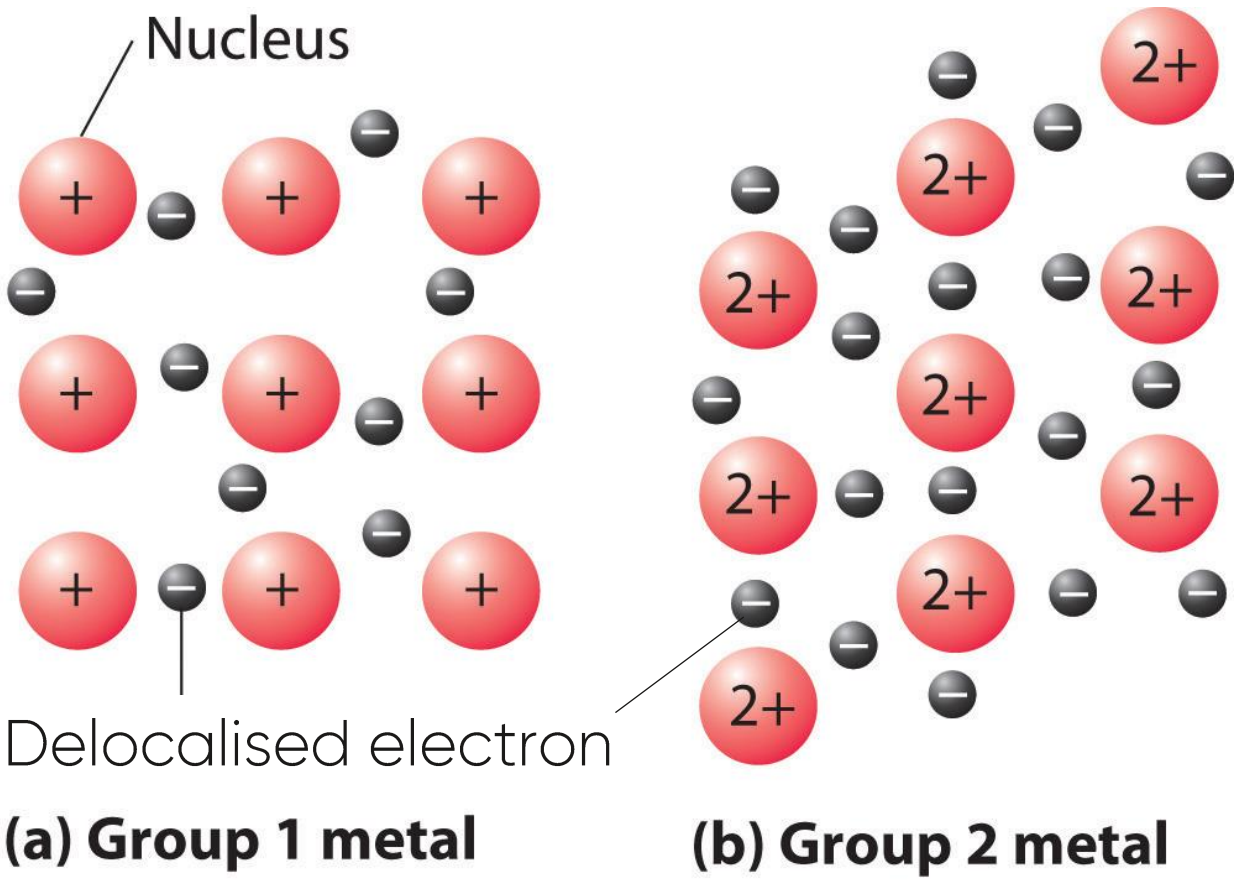


Sodium

What is the Purpose of Tutorial 5?

Objective 1 –Metallic bonding

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



(a) Group 1 metal **(b) Group 2 metal**

Practice – Answer the questions below

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?

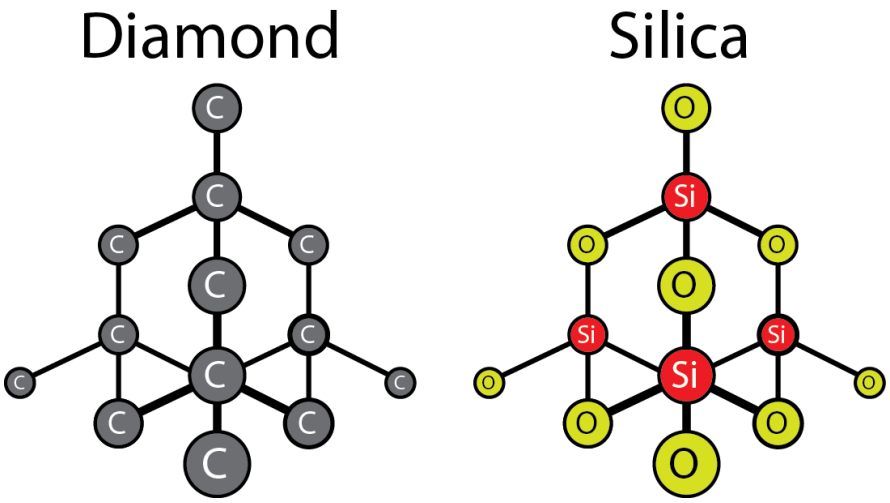
3. The electrons in the outer shell of metallically bonded atoms are _____.

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

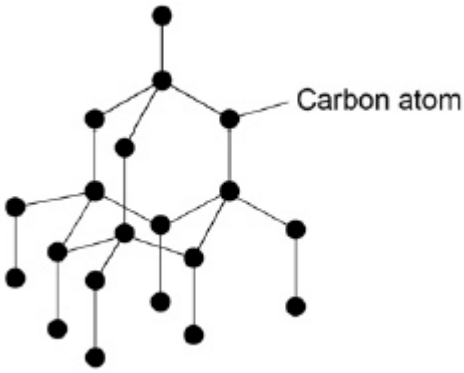
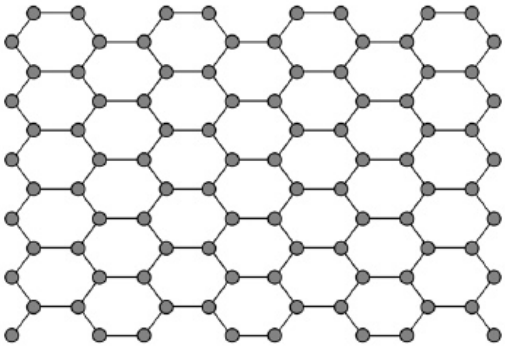
5. The sharing of electrons give rise to strong m_____ bonds.

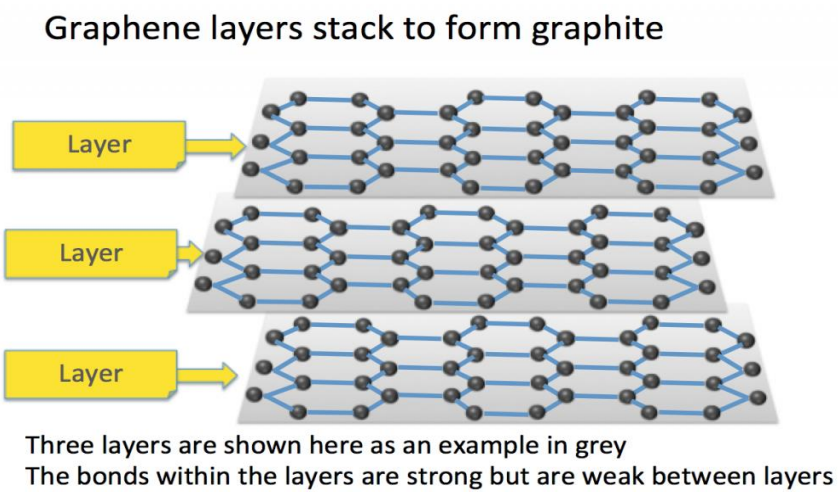
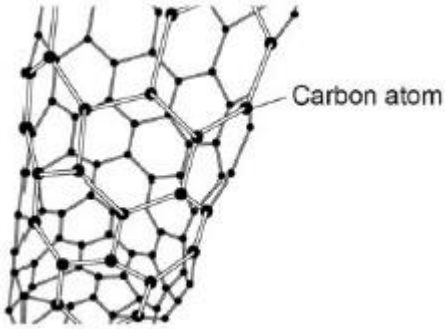
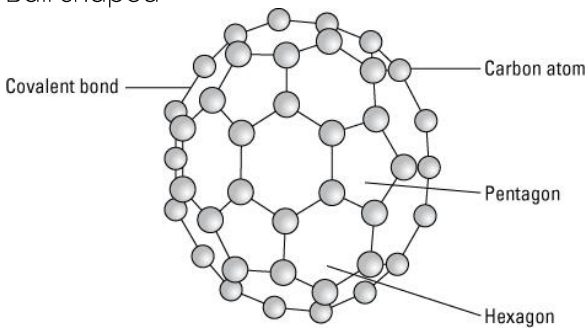
Objective 2 – Recognise giant covalent structures (diamond, graphite, graphene)

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 

<u>Practice</u> – Answer the questions below

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

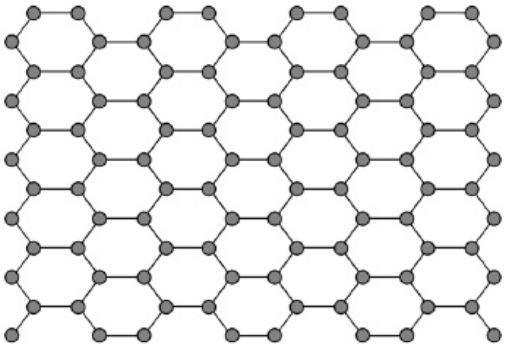
b) Compare and contrast the structure and composition of diamond, graphite, graphene and fullerenes? **(6)**

Assessment

Q1 This question is about structure and bonding.

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

Figure 1



Which element is graphene made from?

Tick **one** box.

Carbon ☐

Copper ☐

Hydrogen ☐

Sodium ☐

(1)

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

Complete the sentence.

Choose the answer from the box.

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

Delocalised electrons allow graphene to _____ .

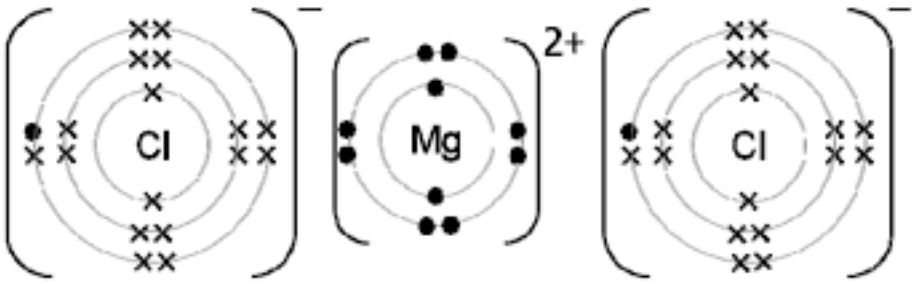
(1)

Objective 3 – Identification of bonding from given information.

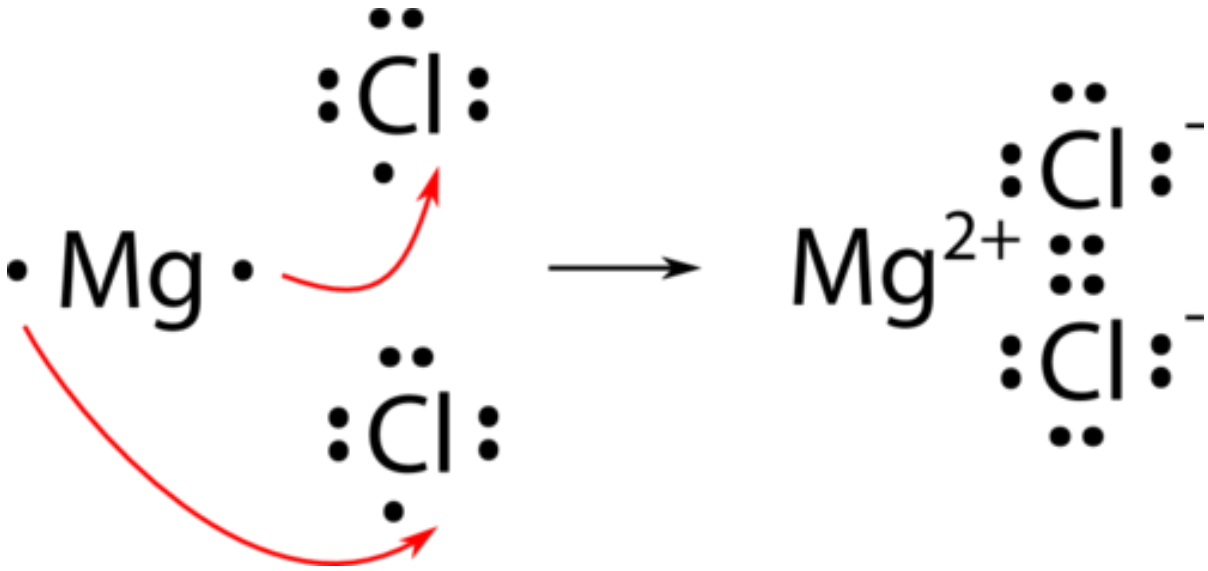
Worked example 1

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

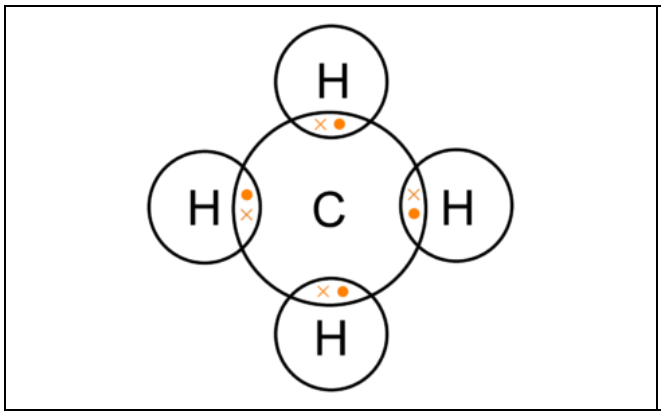


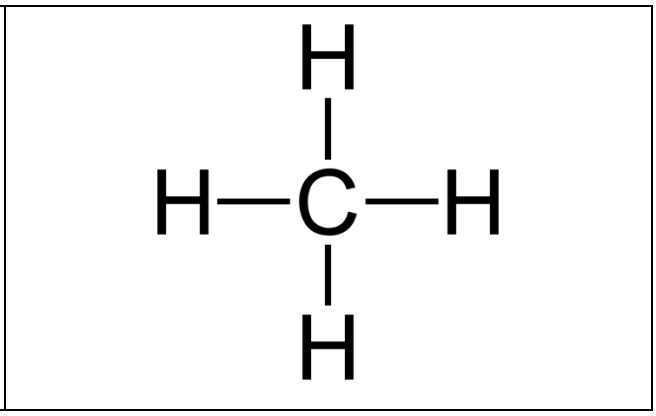
4) Name the compound formed (remember the non-metal changes suffix): Magnesium chloride

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:

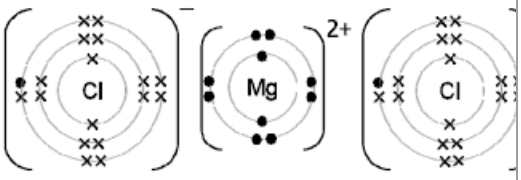


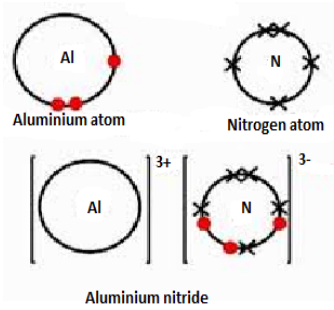


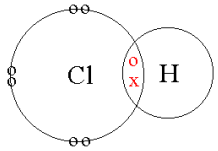
4) Name chemical formed: methane

<u>Practice</u> – Complete the table below

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

1) 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

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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?
• • •	• • •

Exam Technique

Command words

Words in a question that tell you how to answer the question are called **command words.**
It is important that you know what they all mean.

Word	What it means
Assess	See 'Evaluate' below
Calculate	Work out an answer using number. Always show your working. Always put in the units.
Compare	Describe the differences or similarities between things, or their advantages or drawbacks. You need to point out the similarities/differences between or advantages/drawbacks of all the things.
Compare and contrast	Describe the similarities and differences between the things given in the question.
Complete	Fill in answers in a space or finish writing a sentence.
Define	State briefly what something means.
Describe	Recall facts in an accurate way or say what a diagram or graph shows (e.g. what trend you can see).
Determine	Use information given in the question to work out a numerical answer.
Discuss	Identify the different points made about a certain issue or problem. The build up your own argument about the issue.
Estimate	Make a rough calculation.
Evaluate	Say how good or poor something is based on looking at a series of points (criteria). If you are asked to evaluate more than one thing then you need to compare things (see 'Compare' above) and then state which of the things is best, with reasons why you think that.
Explain	State the reasons why something happens. You must explain the links between your reasons and what you are explaining – don't just write down a list of reasons.

Exam Technique

Command Words (continued)

Word	What it means
Give	See 'Write down' below.
Identify	Look at some data or text and pick out a certain part.
Illustrate	Give examples in an explanation or description. A good way to do this is to explain/describe something and then use the words 'For example' to introduce an example.
Justify	Give some evidence or reasoning to support an answer.
List	Write down key points in a brief way.
Name	See 'Write down' below.
Outline	State the main points of an argument or of how something happens. This can be done as a list of bullet points.
Show that	Demonstrate that a statement in the question is correct.
State	See 'Write down' below.
Suggest	Use your scientific knowledge to work out what is happening in an unfamiliar situation.
Summarise	See 'Outline' below.
Use the information	Use the information given to answer the question. You won't get any marks unless you use the information given.
Write down	State a fact or give an example. If a question asks for two examples (or has two marks) write down only two. Otherwise, you risk writing something that is incorrect and losing marks.

Exam Technique

Long-answer questions

Some written answer to questions in an exam will be worth 4,5 or 6 marks. You need to plan you answer to these before writing.

When you look at an exam question, try to pick out its key features. Here are some ideas to consider when you first look at a question:

- Make sure you understand the command word (see the earlier section).
- Circle any key terms.
- Underline any information or figures that the question wants you to use.
- Look carefully at any diagrams, charts or graphs and ask yourself 'What is this telling me?'

Planning a long answer:

- Make some notes about information and key words you want to include. You could draw lines between words and phrases to link them or arrange them into a table.
- Number your notes to show the order in which you will cover the ideas or write them out in a list or a flow chart.
- Cross through the notes you have made as your write your answer.
- Think about how you will use any information given to you. Do not simply write out information that is already in the question – that does not score any marks.

Checking a long answer:

- Check that you have answered all parts of the question.
- Check that you have used the examples or information that you were asked to use.
- Check your spelling, punctuation and grammar.
- Check that you have crossed out any note that you used to help plan your answer.

Discussion Questions

Some longer-answer questions ask you to discuss an issue or problem. You are expected to:

- Identify the issues or points of view.
- Investigate the issue by saying what you think about the various points.

A good way of investigating the issue is often to structure your answer as an argument.

An argument is a way of telling people what you think and why you think it. A good argument will have the following structure:

- A statement of what you think (your point of view)
- An explanation of why you think this is, with supporting evidence (making use of the points you have identified about the issue).
- A counterargument – an explanation of why others may not agree with you.
- A response – explaining why the counterargument is wrong.
- A summary – stating your point of view again.

Exam Technique

Dos and don'ts

DO plan your revision to target the areas you're less confident about first – but mix it up with aspects of topics you like.

- Look for links between different areas of the specification.
- Make flash cards to help you learn the chemical calculations and equations included in biology, chemistry and physics topics.

DO make sure you fully understand the practical work you've done so you can refer to it in the exam where required. What you've learned in practical activities is very important.

- Be ready to explain the reasons for carrying out a particular practical technique, or the use of a particular piece of apparatus.
- Think about how you might have improved the approach you took when carrying out investigative work – evaluation is a key part of working scientifically.

DO be ready to apply what you know about the use of scientific apparatus and techniques to practical situations you may not have met before. Some questions will ask you to apply your investigative skills.

- Show that you understand the subject-specific language which applies when answering these parts of questions.
- Check that you know, and can use, the formulae needed to process the data you gather in different experiments.

DO make sure you read the question carefully, identifying the correct command word. A common error students make is writing a description when they've been asked to explain something - a description alone will not get any marks. Remember:

- Identify key words and parts of the question instruction, especially those relating to unit conversions and the command words.
- You can underline key words and circle command words to help you focus on answering the question asked.
- You can also annotate the question.

DO use appropriate scientific vocabulary to show the examiner that you understand scientific ideas and techniques.

- Proper application of knowledge is important to show understanding.
- Make sure you familiarise yourself with the vocabulary relating to practical work.
- Use the information from diagrams and tables to help you to answer the question.

DON'T panic.

- You'll know more than you think you do and everyone taking the exam is in the same boat.
- In GCSE science, 40% of the marks will be for applying knowledge in unfamiliar contexts, including asking you to link together ideas that aren't linked on the specification. You'll be asked questions in contexts that you haven't studied in class.
- Don't let this put you off – think how the science you've studied relates to the question we're asking.

DON'T start writing straight away when answering six mark questions.

- Think about what the question is asking you to write – and plan your answer so that you give a coherent, sequenced line of reasoning that answers the question.

DON'T leave any gaps.

- If you don't think you know an answer, work out what the question is asking and then make an intelligent guess.
- Remember the first part of the next question may be easier than the question you're answering. If you get stuck, don't give up – try the next question.

Notes

Notes

Notes

Bonding and Structure

Key Stage 4 Programme

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