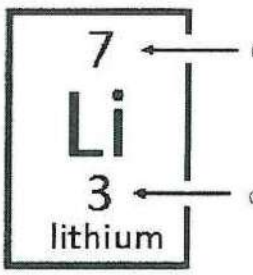
Electron Configuration

Learning Outcomes:

1) Describe how electrons are arranged in an atom
2) Deduce (work out) the electron configurations of the first 20 elements from their positions in the Periodic Table

Reviewing Atomic Structure



mass number = No of $p^+ + n^0$ $p^+ = 3$, $n^0 = 4$

atomic number = No of p^+ and No of e^- $p^+ = 3$, $e = 3$

12 C 6 carbon — Number $p^+ = 6$, Number $n^0 = 6$, Number $e^- = 6$	27 Al 13 aluminium — $p^+ = 13$, $n^0 = 14$, $e^- = 13$	16 O 8 oxygen — $p^+ = 8$, $n^0 = 8$, $e^- = 8$
40 Ca 20 calcium — $p^+ = 20$, $n^0 = 20$, $e^- = 20$	24 Mg 12 magnesium — $p^+ = 12$, $n^0 = 12$, $e^- = 12$	11 B 5 boron — $p^+ = 5$, $n^0 = 6$, $e^- = 5$
14 N 7 nitrogen — $p^+ = 7$, $n^0 = 7$, $e^- = 7$	39 K 19 potassium — $p^+ = 19$, $n^0 = 20$, $e^- = 19$	4 He 2 helium — $p^+ = 2$, $n^0 = 2$, $e^- = 2$
19 F 9 fluorine — $p^+ = 9$, $n^0 = 10$, $e^- = 9$	35 Cl 17 chlorine — $p^+ = 17$, $n^0 = 18$, $e^- = 17$	1 H 1 hydrogen — $p^+ = 1$, $n^0 = 0$, $e^- = 1$

How to arrange electrons in an atom

Electrons are found in shells around the nucleus of an atom.

Each shell can only hold a certain number of electrons. Shells close to the nucleus always fill up first.

The arrangement of the electrons around the atom is called the **electron configuration**

Rules for working out the configuration of electrons:

Example – chlorine (Cl)

1) Use the periodic table to look up the atomic number. Chlorine's atomic number (number of protons) is 17.

2) Remember the number of protons = number of electrons. Therefore chlorine has 17 electrons.

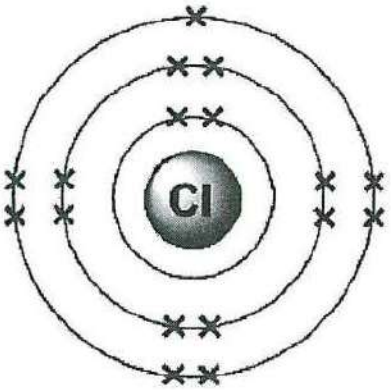
3) Arrange the electrons in shells:

- 1st shell can hold a maximum of 2
- 2nd can hold a maximum of 8
- 3rd can also hold 8

4) Check to make sure that the electrons add up to the right number:

2 + 8 + 7 = 17

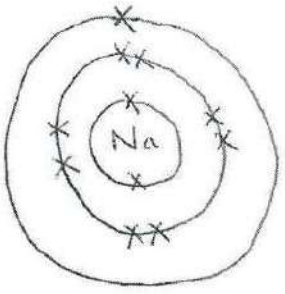
The electron configuration for chlorine can also be written as **2, 8, 7**



Chlorine
2,8,7

Draw and write the electron configuration for Sodium:

23 $p^+ = 11$
Na $n^o = 12$
11 $e^- = 11$

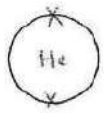
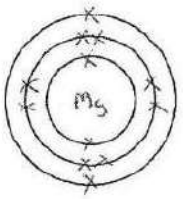
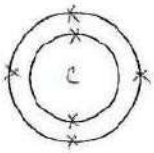
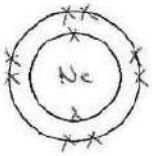
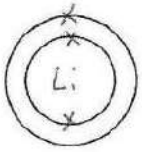
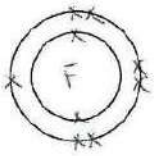
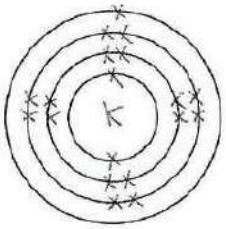
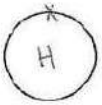
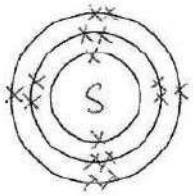
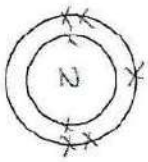
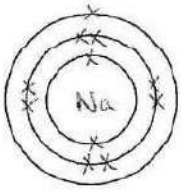
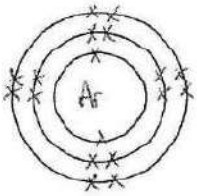


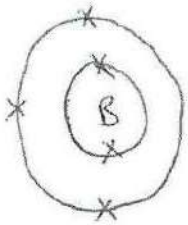
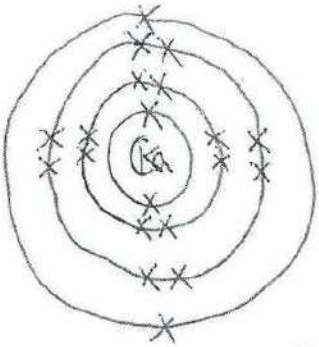
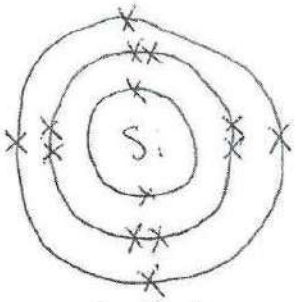
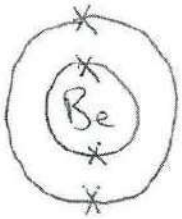
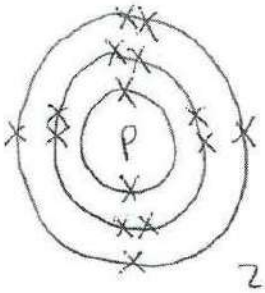
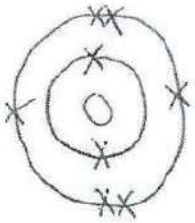
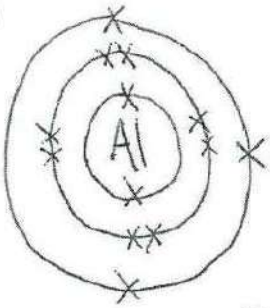
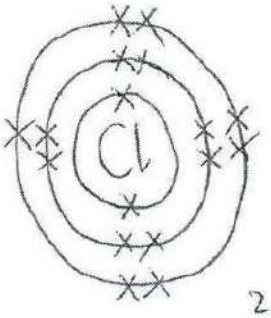
2, 8, 1

Task: Drawing the electron configurations.

Complete the table below to show diagrams of the electron configurations for the first 20 elements.

- Use a periodic table to help you
- Remember:
  - no more than two electrons in the first shell and no more than eight in the next
  - shells closest to the nucleus are filled first

helium  2	magnesium  2,8,2	carbon  2,4	neon  2,8
lithium  2,1	fluorine  2,7	potassium  2,8,8,1	hydrogen  1
sulfur  2,8,6	nitrogen  2,5	sodium  2,8,1	argon  2,8,8

boron  2,3	calcium  2,8,8,2
silicon  2,8,4	beryllium  2,2
phosphorous  2,8,5	oxygen  2,6
aluminium  2,8,3	chlorine  2,8,7

The Periodic Table

Learning Outcomes:

1) Describe how the electron configuration of an element is related to its position in the Periodic Table.
2) Explain why elements in the same group of the Periodic Table have similar chemical properties.
3) Explain why the noble gases (Group 0) are inert (do not easily react).
4) Identify group 1 and 7 elements as alkali metals and halogens.

Task: Write the electron configurations in Periodic Table below for the first 20 elements. The first 3 have been done for you.

group	1	2	3	4	5	6	7	0
period								
1	H 1							He 2
2	Li 2,1	Be 2,2	B 2,3	C 2,4	N 2,5	O 2,6	F 2,7	Ne 2,8
3	Na 2,8,1	Mg 2,8,2	Al 2,8,3	Si 2,8,4	P 2,8,5	S 2,8,6	Cl 2,8,7	Ar 2,8,8
4	K 2,8,8,1	Ca 2,8,8,2						

1) What is the relationship between the electron configuration of an atom and its group number?

The number of electrons in the outer shell is equal to the group number

2) What is the relationship between the electron configuration of an atom and its period?

The number of shells equals the period number

* Diatomic molecules
H_2, N_2, O_2 F_2
Cl_2
Br_2
I_2

Task: Complete this Periodic Table to show the positions of:
Groups, Periods, alkali metals, halogens, noble gases, diatomic molecules, metals, non-metals and transition metals.

Group → 1 2 3 4 5 6 7 0

Period ↓ 1 2 3 4 5 6 7

halogens →

← Noble gases chemically unreactive ⇒ Inert

Key: relative atomic mass / atomic symbol / name / atomic (proton) number

							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	← Transition metals →										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	Elements with atomic numbers 112-116 have been reported but not fully authenticated						

non-metals / metals

↑ alkali metals

110

Task: Answer the following the questions using the periodic table.

1) Which group in the Periodic Table will you find the following elements?
   a) Sodium ...1...
   b) Xenon ...0...
   c) Selenium ...6...
   d) Niobium ...Transition metals

2) Which period in the Periodic Table will you find the following elements?
   a) Silicon ...3...
   b) Iridium ...6...
   c) Barium ...6...
   d) Gallium ...4...

3) How many electrons are in the outer shell of the following elements?
   a) Caesium ...1...
   b) Arsenic ...5...
   c) Lead ...4...
   d) Argon ...8...

4) How many shells do the following elements have?
   a) Helium ...1...
   b) Iodine ...5...
   c) Strontium ...5...
   d) Manganese ...4...

5) Name the element in group 2, period 4 ...calcium...

6) Name the halogen in period 3 ...chlorine...

7) Name the alkali metal in period 5 ...~~strontium~~ rubidium...

8) Name the noble gas in period 6 ...radon...

9) How many elements have a symbol containing only one letter? ...13...

10) How many elements begin with the letter C? ...8...

11) Divide the list into metals and non-metals:

Caesium, Chlorine, Molybdenum, Neon, Nickel, Nitrogen, Strontium, Tin

Metals	Non-metals
Caesium Molydenum Strontium Nickel Tin	Chlorine Neon Nitrogen

12) Sodium and potassium both react vigorously with water producing hydrogen gas and an alkaline solution. Suggest why the two metals show a similar chemical reaction.

- They are in the same group in the Periodic Table
- They have the same No. of e^- in the outer shell

13) Suggest why light bulbs are filled with argon gas. Explain your answer fully.

Argon is inert because it has a full outer shell. This prevents the metal filament from burning away.

14) Find out why some of the elements on the periodic table have brackets around their relative atomic masses.

These elements have no stable isotopes. The mass number in brackets represents the isotopes with the longest half-life

15) On your Periodic Table it states that elements with atomic numbers 112-116 have been reported but not fully authenticated. Find out what this statement means.

These are newly synthesised elements which are awaiting to be verified by IUPAC (112-118 have all now been verified).

Ions

Learning Outcomes:

1) Describe the formation of ions by the gain or loss of electrons
2) Draw & write the electron configurations of ions formed from the first 20 elements
3) Relate the charge on the ion to the element's position in the periodic table

Forming ions

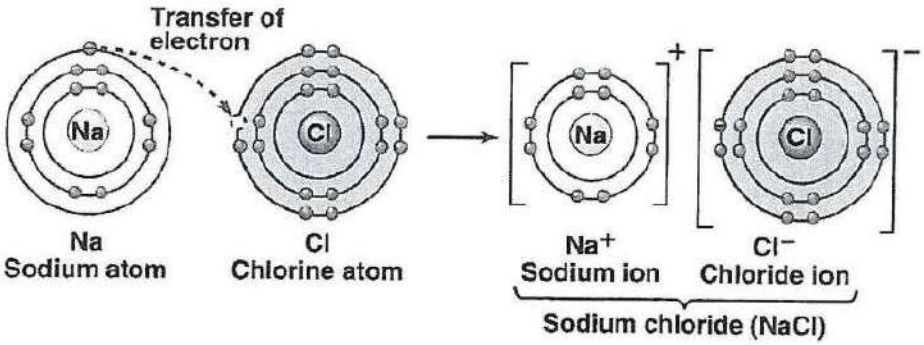
Atoms will try to achieve a full outer shell by either gaining or losing electrons during a chemical reaction.

Key definition

An ion is an atom or group of atoms that carries a charge.

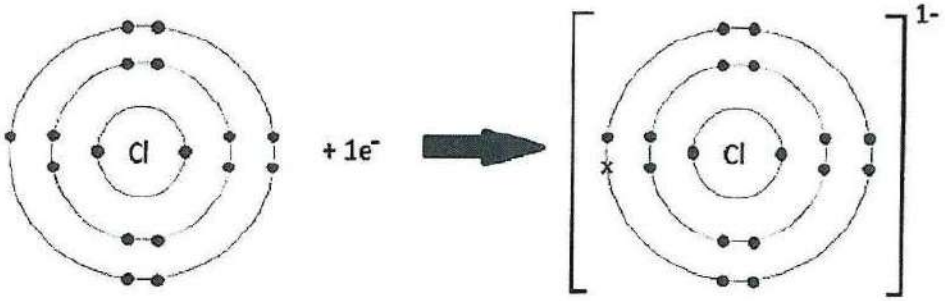
Sodium reacts with chlorine to produce sodium chloride as follows:

sodium + chlorine → sodium chloride



When the chlorine atom reacts with the sodium atom it gains an outer electron and becomes a chloride ion.

The electron configuration of a chloride ion is as follows:



Chlorine atom with
17 protons = +17 charge
17 electrons = -17 charge
Overall charge = zero

Chloride ion with
17 protons = +17 charge
18 electrons = -18 charge
Overall charge = -1

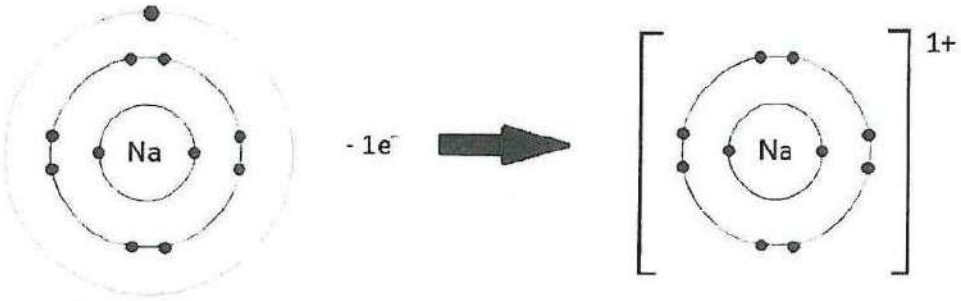
Writing the electron configuration:

Cl = 2, 8, 7 → Cl^- = [2, 8, 8]$^-$

Notice that the chloride ion has the symbol Cl^-

When the sodium atom reacts with the chlorine atom it loses an outer electron and becomes a sodium ion.

The electron configuration of a sodium ion is as follows:



Sodium atom with
11 protons = +11 charge
11 electron = -11 charge
Overall charge = zero

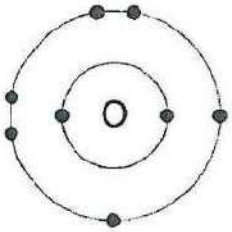
Sodium ion with
11 protons = +11 charge
10 electrons = -10 charge
Overall charge = +1

Writing the electron configuration:

Na = 2, 8, 1 → $Na^+ = [2, 8]^+$

Notice that the sodium ion has the symbol Na^+

Draw the electron configuration of an oxide ion:



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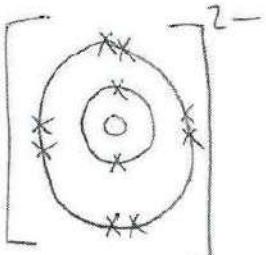
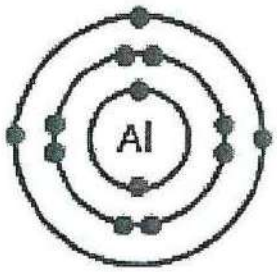


O = 2, 6

$O^{2-} = [2, 8]^{2-}$

Draw the electron configuration of an aluminium ion:



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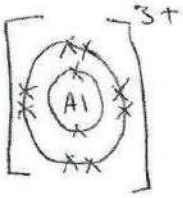
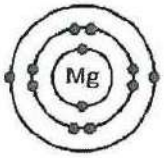
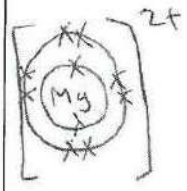
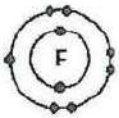
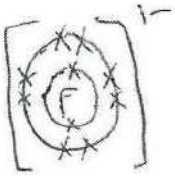
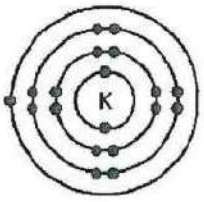
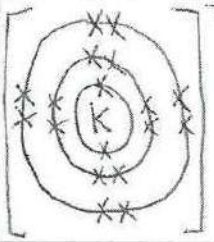
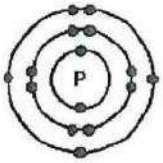
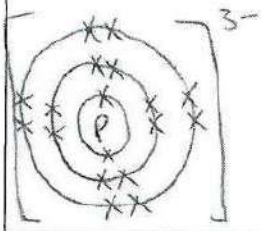
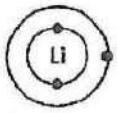
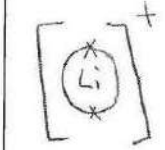
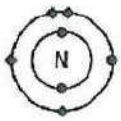
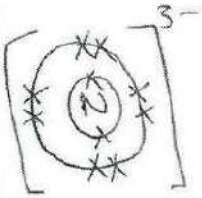


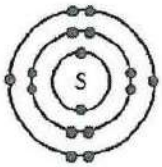
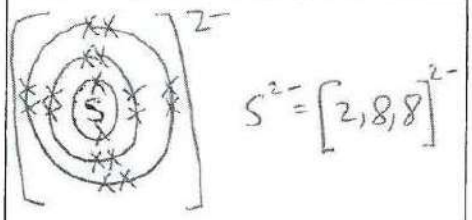
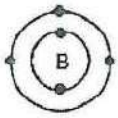
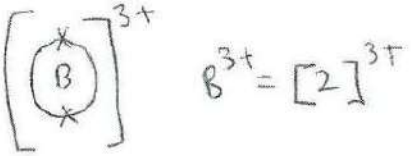
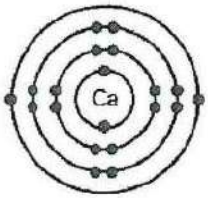
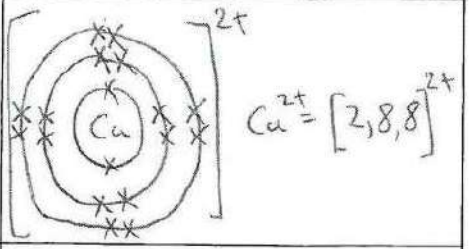
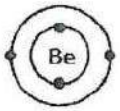
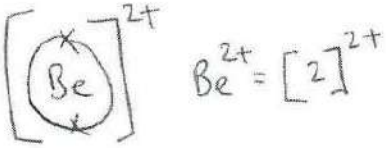
Al = 2, 8, 3

$Al^{3+} = [2, 8]^{3+}$

Metal atoms usually have 1, 2 or 3 electrons in their outer shell. It is easier for them to achieve a full outer shell by losing electrons than by gaining them.

Non-metal atoms usually have 5, 6 or 7 electrons in their outer shell. It is easier for them to achieve a full outer shell by gaining electrons than by losing them.

Atom	How many electrons will the atom lose or gain?	What is the charge on the ion?	Formula of ion	Draw & write the electron configuration of the ion
	lose 2	2+	Mg^{2+}	 $Mg^{2+} = [2,8]^{2+}$
	gain 1	1−	F^{1-}	 $F^{-} = [2,8]^{-}$
	lose 1	1+	K^{+}	 $K^{+} = [2,8,8]^{+}$
	gain 3	3−	P^{3-}	 $P^{3-} = [2,8,8]^{3-}$
	lose 1	1+	Li^{+}	 $Li^{+} = [2]^{+}$
	gain 3	3−	N^{3-}	 $N^{3-} = [2,8]^{3-}$

Atom	How many electrons will the atom lose or gain?	What is the charge on the ion?	Formula of ion	Draw & write the electron configuration of the ion
	gain 2	2−	S^{2-}	 $S^{2-} = [2,8,8]^{2-}$
	lose 3	3+	B^{3+}	 $B^{3+} = [2]^{3+}$
	lose 2	2+	Ca^{2+}	 $Ca^{2+} = [2,8,8]^{2+}$
	lose 2	2+	Be^{2+}	 $Be^{2+} = [2]^{2+}$
	lose 1	1+	H^{+}	 $H^{+} = [0]^{+}$

1) All the ions formed above, apart from the hydrogen ion, have the same electron configuration as which group of elements in the periodic table? ..... 0 - Noble gases

2) A hydrogen ion consists of only which subatomic particle? ..... proton

Ions and the Periodic Table

Task: Research the charge that each of the ions that each element forms and write it in the space provided. Ignore the ones that have been greyed out. The second periodic table is to help you identify which space relates to which element.

1	2											3	4	5	6	7	0
					+1												
+1	+2											+3		-3	-2	-1	
+1	+2											+3		-3	-2	-1	
+1	+2													-3	-2	-1	
+1	+2														-2	-1	
+1	+2															-1	

					H												He
Li	Be											B	C	N	O	F	He
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Cb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn

1) Are there any patterns?

Ions in the same group have the same charge.

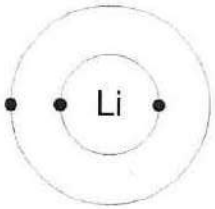
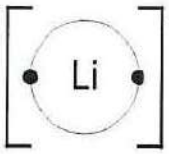
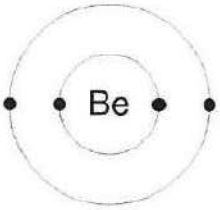
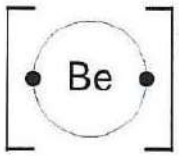
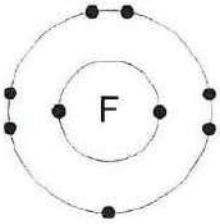
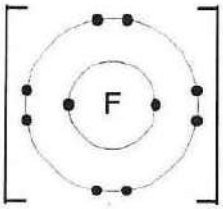
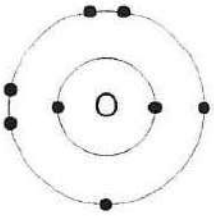
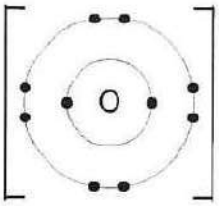
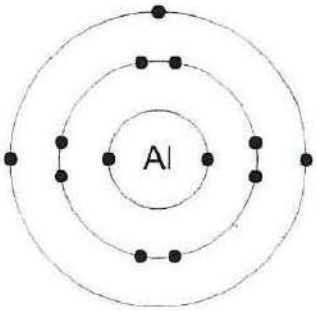
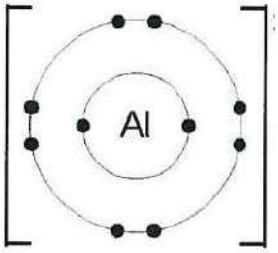
2) How could this help you to know the charge of an ion?

Identifying which group an element is in will help you work out the charge on the ion.

3) Why do you think you were ask to ignore the greyed out elements?

These elements have variable charges on their ions.

Task: Complete the table by filling in the missing information and writing the charge of the ion onto the electron configuration.

ATOMS		IONS	
	3 protons 3 electrons = no charge		3 protons 2 electrons = + 1 charge
	4 protons 4 electrons = no charge		4 protons 2 electrons = 2+ charge
	9 protons 9 electrons = no charge		9 protons 10 electrons = 1- charge
	8 protons 8 electrons = no charge		8 protons 10 electrons = 2- charge
	13 protons 13 electrons = no charge		13 protons 10 electrons = 3+ charge

Task: Complete the table and work out whether the element is an atom or an ion?

Remember:

- In an atom, the number of protons and electrons is equal
- An ion has a charge (i.e. the number of electrons is different from the number of protons)

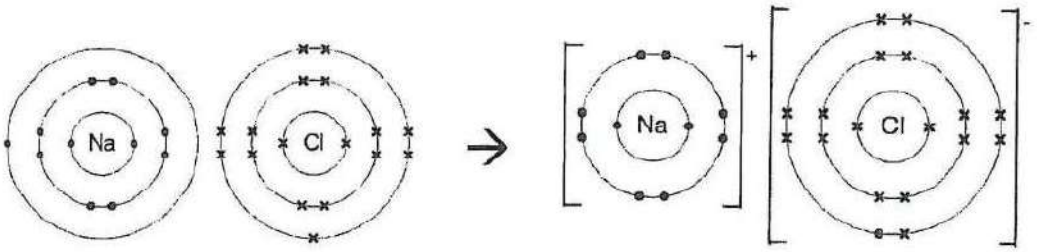
Element	Number of protons	Number of electrons	Charge	Atomic number	Atom or Ion?
H	1	1	0	1	atom
O	8	8	zero	8	atom
Mg	12	10	+2	12	ion
Al	13	10	+3	13	ion
O	8	10	- 2	8	ion
Mg	12	12	0	12	atom
F	9	10	-1	9	ion
Ne	10	10	zero	10	atom
Na	11	10	+1	11	ion
Li	3	3	zero	3	atom
Be	4	2	+2	4	ion
Ca	20	18	+ 2	20	ion
S	16	18	-2	16	ion

Ionic Bonding

Learning Outcomes:

1) Recall the definition of an ionic bond
2) Explain, using dot and cross diagrams, the formation of ionic compounds by electron transfer, limited to combinations of elements from groups 1,2,3 and 5,6,7

Ionic bonding in sodium chloride

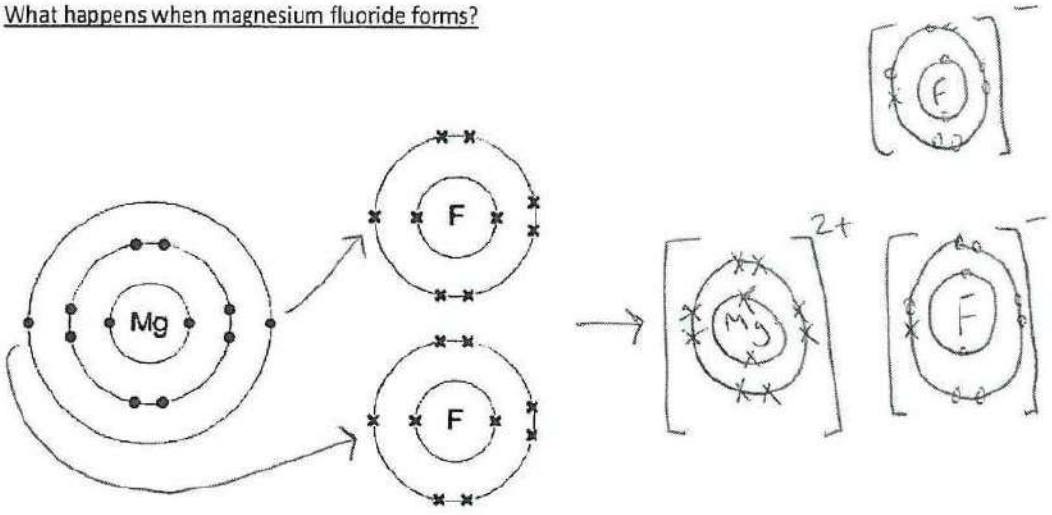


The single electron in the outer energy level of the sodium atom has been transferred to the chlorine. The sodium chloride is held together by the strong electrostatic attractions between the positive sodium ion and the negative chloride ion.

Key definition

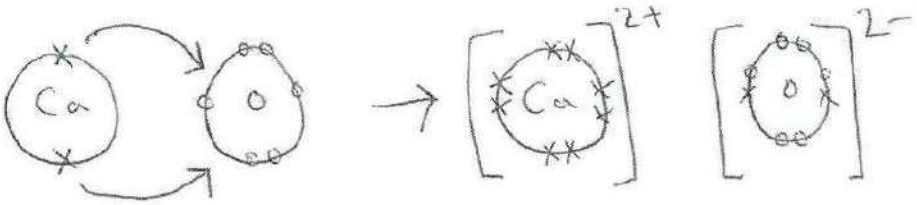
An **Ionic Bond** is the electrostatic attraction between oppositely charged ions.

What happens when magnesium fluoride forms?



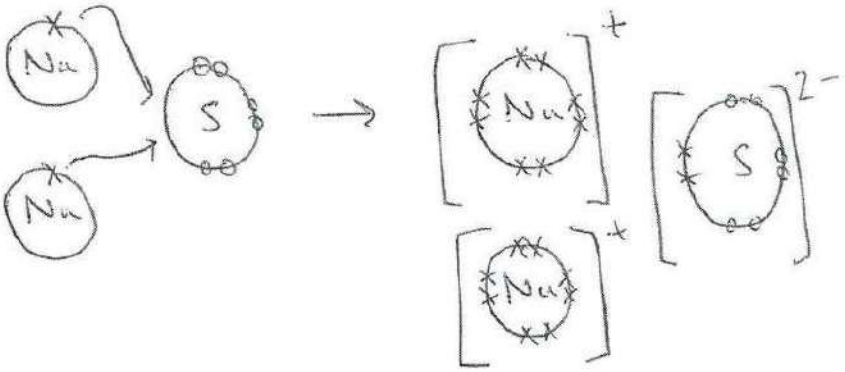
Formula = MgF_2

Ionic bonding in calcium oxide



Formula = CaO

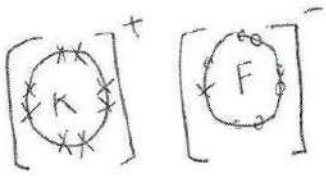
Ionic bonding in sodium sulfide



Formula = Na_2S

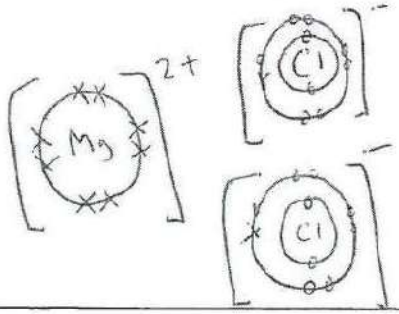
Task: Draw the dot & cross diagrams for the following ionic compounds and deduce (work out) their formula:

Potassium fluoride



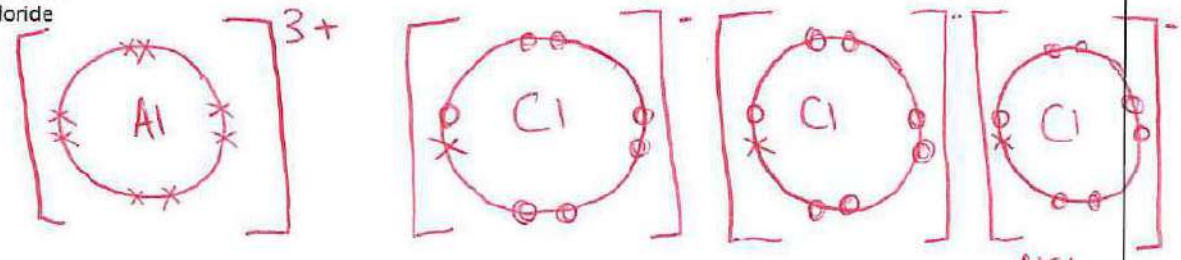
Formula = KF

Magnesium chloride



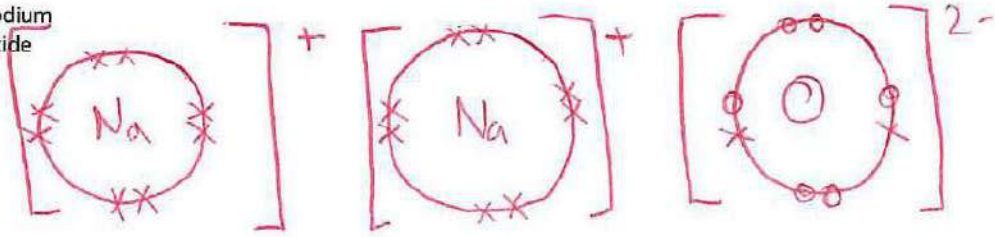
Formula = $MgCl_2$

Aluminium chloride



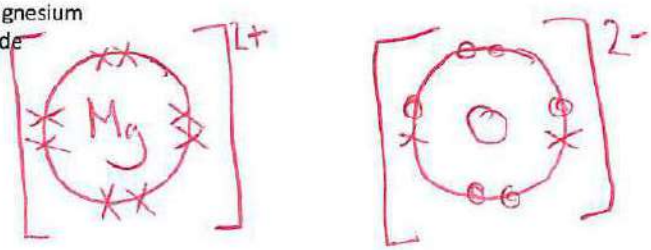
Formula = $AlCl_3$

Sodium oxide



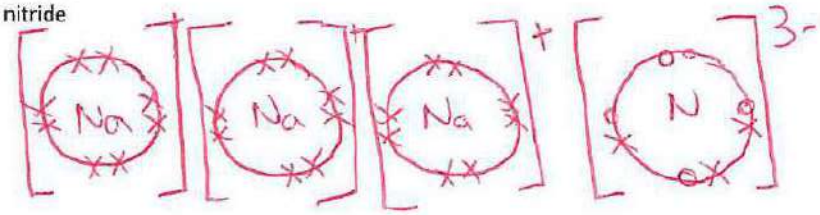
Formula = Na_2O

Magnesium oxide



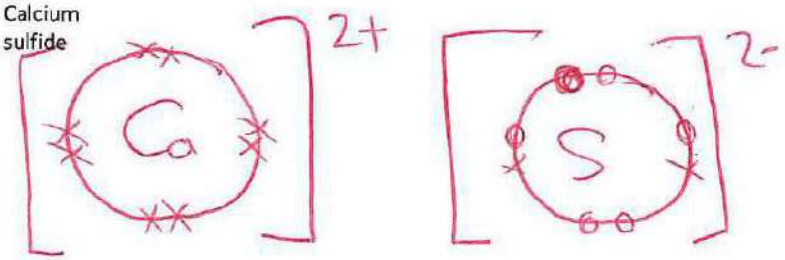
Formula = MgO

Sodium nitride



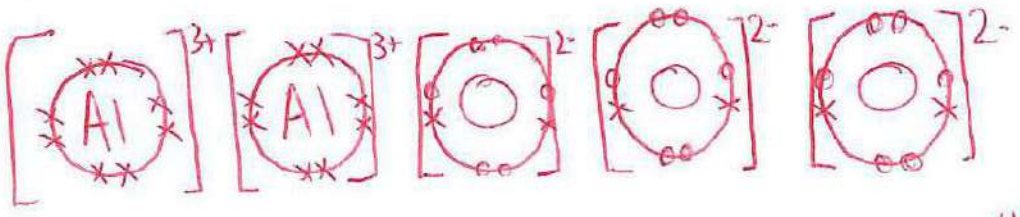
Formula = Na_3N

Calcium sulfide



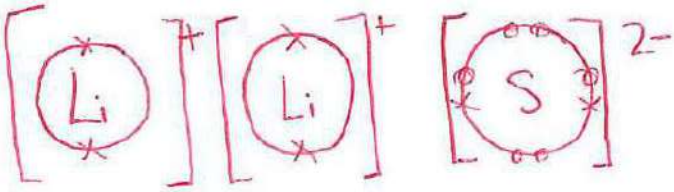
Formula = CaS

Aluminium oxide



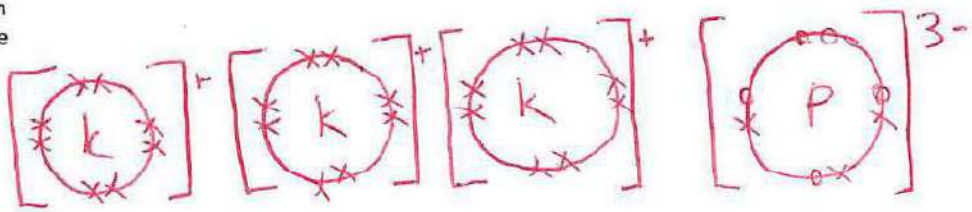
Formula = Al_2O_3

Lithium sulfide



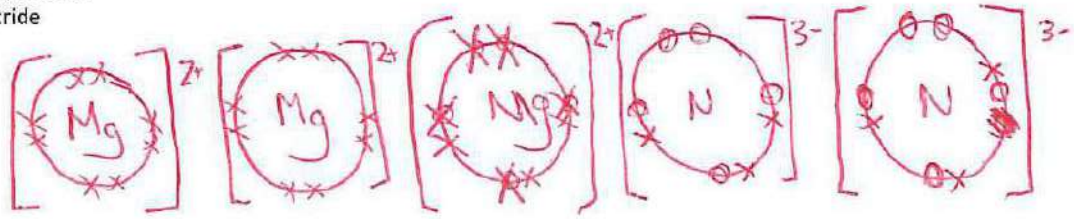
Formula = Li_2S

Potassium phosphide



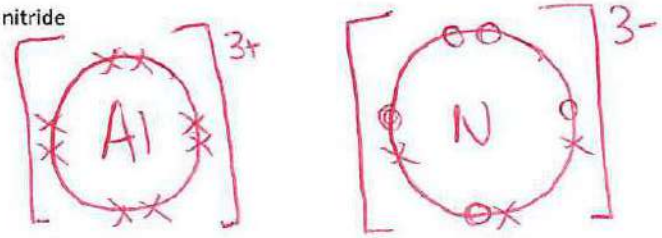
Formula = K_3P

Magnesium nitride



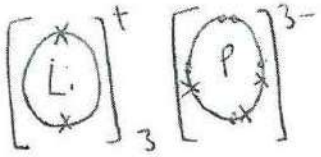
Formula = Mg_3N_2

Aluminium nitride



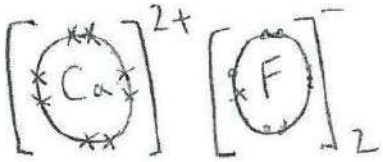
Formula = AlN

Lithium phosphide



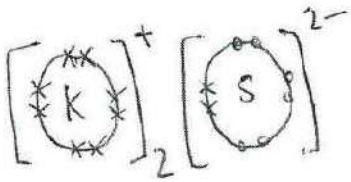
Formula = Li_3P

Calcium fluoride



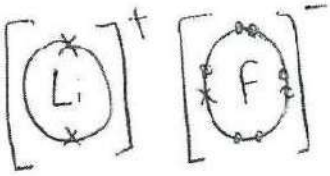
Formula = CaF_2

Potassium sulfide



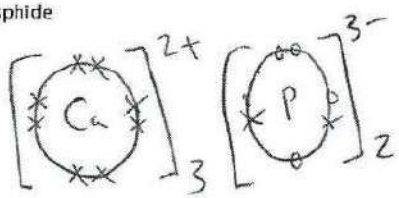
Formula = K_2S

Lithium fluoride



Formula = LiF

Calcium phosphide



Formula = Ca_3P_2

Describing the formation of an ionic bond in words

The chemical equation for the reaction of magnesium with chlorine is shown below

$$Mg + Cl_2 \rightarrow MgCl_2$$

By reference to electrons, describe how magnesium and chlorine atoms form magnesium chloride.

Magnesium loses two outer electrons to form Mg^{2+} ion.

Two chlorine atoms each gain an electron to form 2 Cl^- ions.

Hence, Magnesium Chloride, $MgCl_2$ forms.

The chemical equation for the reaction of sodium with oxygen is shown below

$$4Na + O_2 \rightarrow 2Na_2O$$

By reference to electrons, describe how sodium and oxygen atoms form sodium oxide.

Two sodium atoms lose an outer electron to form two Na^+ ions.

An oxygen atom gains an electron to form O^{2-} ion.

Hence, Sodium Oxide, Na_2O, forms.

Giant Ionic structure

Learning Outcomes:

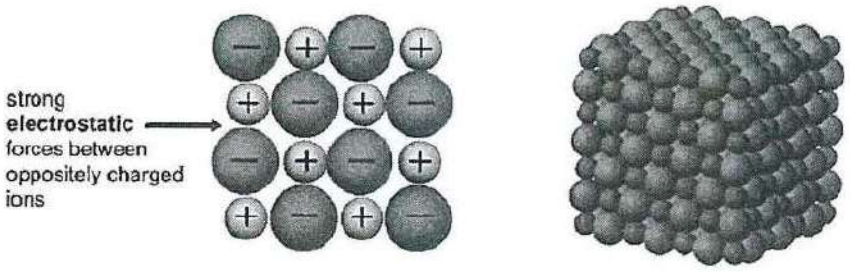
1) Describe the structure of an ionic compound
2) Explain why ionic compounds have high melting points

Key definition

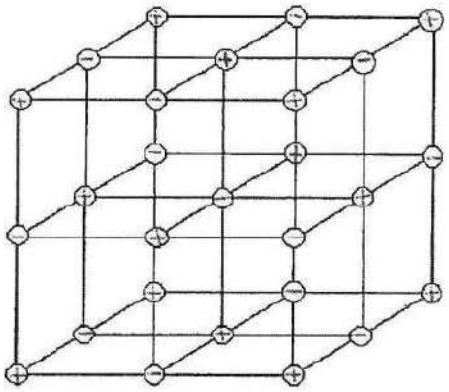
A **lattice** is a regular and repeating structure of particles.

All ionic compounds have the structure of a giant ionic lattice.
The lattice is held together by strong electrostatic attractions between positively and negatively charged ions.

Structure of sodium chloride: 2D Structure 3D Structure



Task: Draw positive and negative ions onto the diagram below to show the arrangement of sodium and chloride ions in sodium chloride. Create a key to show which ions are sodium and chloride.

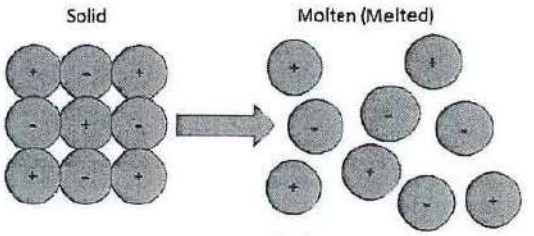


Key
⊖ Chloride ions (Cl^-)
⊕ Sodium ions (Na^+)

Melting points of ionic compounds

Ionic compounds, for example sodium chloride, have high melting points because they have:

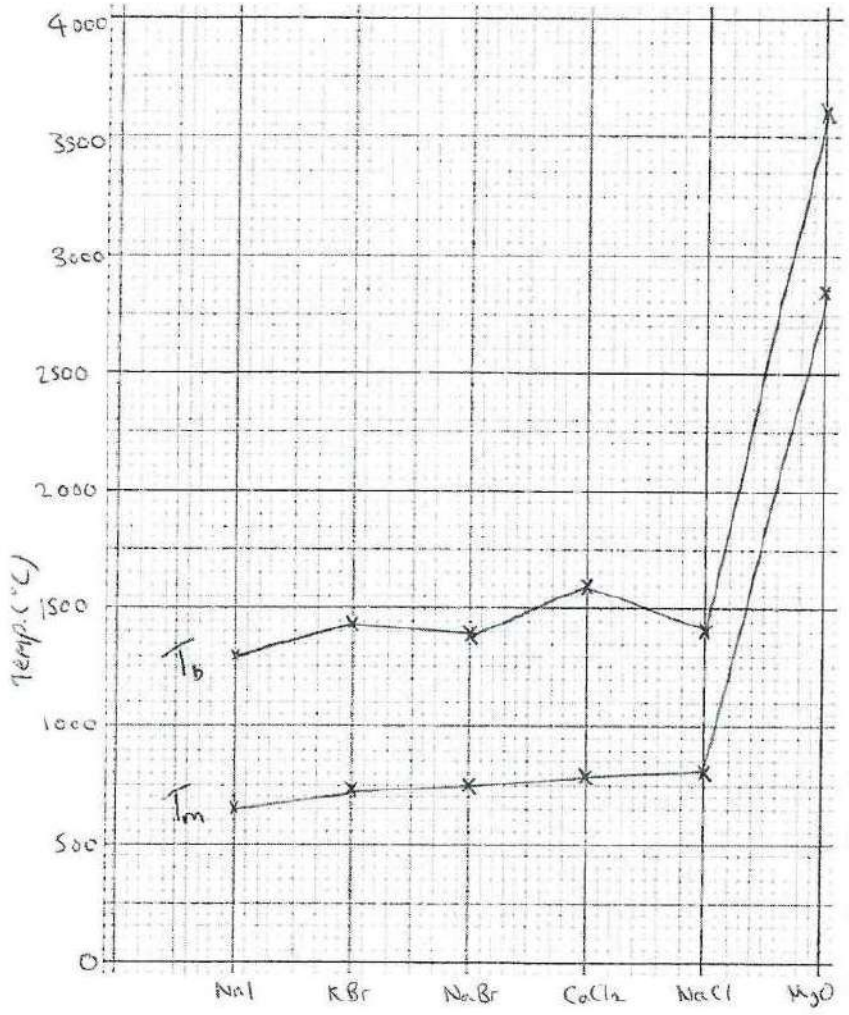
1) a giant ionic lattice
2) with strong electrostatic forces between oppositely charged ions
3) that requires a lot of energy to break



Not an accurate diagram of a

Task: Plot a graph to show the melting and boiling points of the ionic compounds in the table below and answer the questions.

Compound	Formula	Melting Point (°C)	Boiling Point (°C)
Sodium iodide	NaI	660	1304
Potassium bromide	KBr	734	1435
sodium bromide	NaBr	747	1390
calcium chloride	$CaCl_2$	782	1600
sodium chloride	NaCl	801	1413
magnesium oxide	MgO	2852	3600



Questions

1) Complete the table above by adding the names of compounds.

2) What temperature does calcium chloride freeze? 782°C

3) What temperature does potassium bromide condense? 1435°C

4) Write a chemical equation with state symbols to show the state change for sodium chloride at 801°C.

$NaCl(s) \rightarrow NaCl(l)$

5) Which ionic compounds will be liquids at 746°C? NaI + KBr

6) Give the states of the last 3 compounds at 1500°C.

$CaCl_2$ Liquid

NaCl Gas

MgO Solid

7) Suggest why magnesium oxide has a much higher melting point than all the other compounds.

This is because $Mg^{2+} + O^{2-}$ ions have a higher charge than the other ions therefore the electrostatic forces between the ions are much stronger, requiring more energy to break.

Writing Chemical Formulae

Learning Outcomes:

1) Know the charges of these ions:, Ag^{+}, Cu^{2+} ,Fe^{2+}, Fe^{3+}, Pb^{2+}, Zn^{2+}, hydrogen ion (H^{+})
2) Write formulae for compounds formed between the ions listed above and those formed between metals in Groups 1, 2 3, and non-metals in Groups 5, 6 and 7

Task: Name these ionic compounds

a) ZnO ..... zinc oxide .....

b) AgF_2 ..... silver fluoride .....

c) Fe_2S_3 ..... iron sulfide .....

d) Cu_3N_2 ..... copper nitride .....

e) $PbBr_2$ ..... lead bromide .....

f) Na_2Se ..... sodium selenide .....

g) Ca_3As_2 ..... calcium arsenide .....

As you know you can use the periodic table to work out the charges on the ions from group 1,2,3,5,6 & 7. There are however 7 monoatomic ions that you will come across at GCSE in which you cannot use the periodic to work out their charges.

Ion	Formula
hydrogen	H^{+}
silver	Ag^{+}
zinc	Zn^{2+}
copper (II)	Cu^{2+}
lead (II)	Pb^{2+}
iron(II)	Fe^{2+}
iron(III)	Fe^{3+}

← ***Memorise these***

What is the meaning of the Roman numeral after an ion's name?

Indicates the charge on the metal ion.

Once you know the charges on the two ions in a compound you can work out the formula.

Writing the chemical formula for magnesium chloride:

Step 1 - Write down the symbols: Mg Cl

Step 2 - Add the charges: Mg^{2+} Cl^{-}

Step 3 - Balance the charges: Mg^{2+} Cl^{-} Cl^{-}

Step 4 - Write the formula: **$MgCl_2$**

Ionic compound	Ions	formula
Sodium chloride	Na^{1+} Cl^{1-}	NaCl
Sodium oxide	Na^{1+} O^{2-} Na^{1+}	Na_2O
Magnesium oxide	Mg^{2+} O^{2-}	MgO
Beryllium fluoride	Be^{2+} F^- F^-	BeF_2
Calcium chloride	Ca^{2+} Cl^- Cl^-	$CaCl_2$
Aluminium oxide	Al^{3+} O^{2-} Al^{3+} O^{2-} O^{2-}	Al_2O_3
Potassium chloride	K^+ Cl^-	KCl
Lithium bromide	Li^+ Br^-	LiBr
Magnesium iodide	Mg^{2+} I^- I^-	MgI_2
Aluminium chloride	Al^{3+} Cl^- Cl^- Cl^-	$AlCl_3$
Calcium oxide	Ca^{2+} O^{2-}	CaO
Lithium oxide	Li^+ Li^+ O^{2-}	Li_2O
Potassium oxide	K^+ K^+ O^{2-}	K_2O
Lithium nitride	Li^+ Li^+ Li^+ N^{3-}	Li_3N
Magnesium nitride	Mg^{2+} Mg^{2+} Mg^{2+} N^{3-} N^{3-}	Mg_3N_2
Beryllium oxide	Be^{2+} O^{2-}	BeO

Ionic compound	Ions	Formula
Rubidium Bromide	Rb^{+} Br^{-}	RbBr
Strontium Arsenide	Sr^{2+} As^{3-}	Sr_3As_2
Caesium Sulfide	Cs^{+} S^{2-}	Cs_2S
Barium Astatide	Ba^{2+} At^{-}	$BaAt_2$
Gallium Selenide	Ga^{3+} Se^{2-}	Ga_2Se_3
Zinc Oxide	Zn^{2+} O^{2-}	ZnO
Lead Iodide	Pb^{2+} I^{-}	PbI_2
Silver Chloride	Ag^{+} Cl^{-}	AgCl
Zinc Nitride	Zn^{2+} N^{3-}	Zn_3N_2
Hydrogen Bromide	H^{+} Br^{-}	HBr
Iron(II) Chloride	Fe^{2+} Cl^{-}	$FeCl_2$
Iron(III) Chloride	Fe^{3+} Cl^{-}	$FeCl_3$
Copper(II) Phosphide	Cu^{2+} P^{3-}	Cu_3P_2
Copper(II) Chloride	Cu^{2+} Cl^{-}	$CuCl_2$
Iron(II) Oxide	Fe^{2+} O^{2-}	FeO
Iron(III) Oxide	Fe^{3+} O^{2-}	Fe_2O_3

Chemical Equations

Learning Outcomes:

1) Write chemical formulae for ionic compounds
2) Write word equations and balanced chemical equations

Task: Balance the following equations

a) $4\ K + O_2 \rightarrow 2\ K_2O$

b) $N_2 + O_2 \rightarrow 2\ NO$

c) $N_2 + 3\ H_2 \rightarrow 2\ NH_3$

d) $8\ H_2 + S_8 \rightarrow 8\ H_2S$

e) $2\ Cl_2O_7 \rightarrow 2\ Cl_2 + 7\ O_2$

Writing chemical equations

Note – all the non-metals in these questions are diatomic molecules, e.g. $O_2\ N_2\ F_2\ Cl_2\ Br_2\ I_2\ H_2$

Example: Magnesium reacts with oxygen to form magnesium oxide

1) Write the word equation: magnesium + oxygen → magnesium oxide

2) Write the chemical formulae: $Mg + O_2 \rightarrow MgO$

3) Balance the equation: $2Mg + O_2 \rightarrow 2MgO$

a) Sodium reacts with fluorine gas producing sodium fluoride

$$2Na + F_2 \rightarrow 2NaF$$

b) A piece of magnesium strip reacts with iodine to form magnesium iodide

$$Mg + I_2 \rightarrow MgI_2$$

c) Barium reacts with oxygen to produce barium oxide

$$2Ba + O_2 \rightarrow 2BaO$$

d) Aluminium nitride is formed when aluminium reacts with nitrogen

$$2Al + N_2 \rightarrow 2AlN$$

e) Potassium reacts with bromine to form potassium bromide

$$2K + Br_2 \rightarrow 2KBr$$

f) When a piece of magnesium strip is dropped into hydrochloric acid (HCl), hydrogen gas is given off and a solution of magnesium chloride is formed.

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$

g) Chlorine gas reacts with potassium iodide to produce potassium chloride and iodine

$$Cl_2 + 2KI \rightarrow 2KCl + I_2$$

h) Fluorine reacts with copper produce copper(II) fluoride

$$F_2 + Cu \longrightarrow CuF_2$$

i) Iron reacts with bromine to form iron(II) bromide

$$Fe + Br_2 \longrightarrow FeBr_2$$

j) A piece of zinc reacts with hydrochloric acid (HCl) to form zinc chloride and hydrogen gas

$$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$$

k) On heating iron reacts with sulfur (S_8) to produce iron(II) sulfide

$$8Fe + S_8 \longrightarrow 8FeS$$

l) Iron is formed when potassium reacts with iron(III) oxide

$$6K + Fe_2O_3 \longrightarrow 2Fe + 3K_2O$$

m) Aluminium displaces silver when reacted with silver oxide

$$3Ag_2O + 2Al \longrightarrow Al_2O_3 + 6Ag$$

n) Aluminium nitride is formed when aluminium reacts with copper(II) nitride

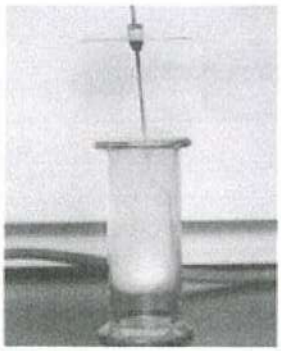
$$2Al + Cu_3N_2 \longrightarrow 2AlN + 3Cu$$

Key words

Term	Definition
Electron configuration	How the electrons are arranged in an atom.
Group	The elements found in one column of the period table
Period	The elements found in one row of the periodic table
Noble Gases	Gaseous elements occupying group 0. They are inert
Alkali Metals	Metal elements occupying group 1 of the periodic table.
Halogens	Non-metal elements occupying group 7 of the periodic table.
Inert	Chemically unreactive
Ion	An atom or group of atoms that carries a charge
Ionic bond	The electrostatic attraction between oppositely charged ions.
Electrostatic attraction	The attraction between particles with oppositely charges.
Giant structure	Large, repeating structure that extends in 3 dimensions
Lattice	A regular and repeating structure of particles

Q1

The picture shows sodium reacting with chlorine. The reaction forms sodium chloride.



(a) Use words from the box to answer the questions.

compound	element	hydrocarbon	mixture

Which word best describes:

(i) sodium ..element.. (1)

(ii) sodium chloride? ..compound.. (1)

(b) When sodium reacts with chlorine the sodium atoms change into sodium ions.

The diagrams below represent a sodium atom and a sodium ion.

Sodium atom (Na) Sodium ion (Na^+)

Use the diagrams to help you explain how a sodium atom turns into a sodium ion.

· A sodium atom loses its outer electron

· so becomes a sodium ion with +1 charge

(2)

Q2

(a) The chemical equation for a reaction of sodium is shown below.

$$2Na + Cl_2 \rightarrow 2NaCl$$

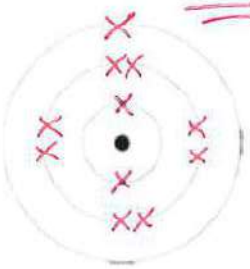
Describe this reaction in terms of electron transfer

- 2 sodium atoms each lose one electron
- 2 chlorine atoms each gain one electron.

(3)

(b) Use the periodic table on the data sheet to help you to answer this question.

(i) Complete the electronic structure of sodium. atom



(2)

(ii) How is the electronic structure of sodium different from the electronic structure of chlorine?

- Chlorine has 7 electrons in its outer shell, but sodium only has 1.

(1)

Q3

Magnesium oxide is a white solid with a high melting point.

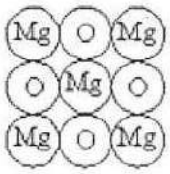
Explain how the ions are held together in solid magnesium oxide.

- There is a strong electrostatic attraction
- between the oppositely charged ions.

(2)

Q4

Magnesium oxide is a compound, made up of magnesium ions and oxide ions.



(a) What is the charge on each magnesium ion? +2

(1)

(b) Explain how the magnesium ions get this charge.

A magnesium atom loses 2 electrons

(2)

Q5

Potassium sulfide is an ionic compound.

Complete the table to show the arrangement of electrons in the ions formed when potassium and sulfur react to form potassium sulfide.

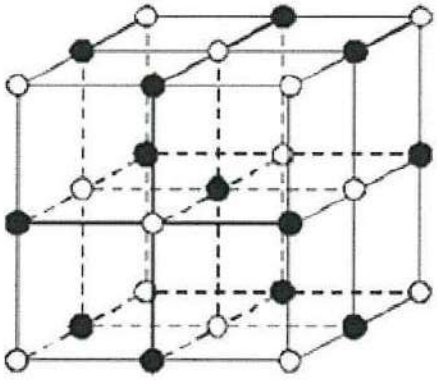
Give the charge on each of the ions.

(3)

Element	Arrangement of electrons in atom	Arrangement of electrons in ion	Charge on ion
K	2.8.8.1	2.8.8	+1
S	2.8.6	2.8.8	−2

Q6

(a) The diagram shows part of the ionic lattice of a sodium chloride crystal.



(i) Complete the spaces in the table to give information about **both** of the ions in this lattice.

Name of ion	Charge
sodium	+1
chloride	-1

(2)

(b) The symbol for a calcium atom can be shown like this: $^{40}_{20}Ca$

(i) What is the mass number of this atom?

40

(1)

(ii) What information is given by the mass number?

mass number = protons + neutrons

(1)

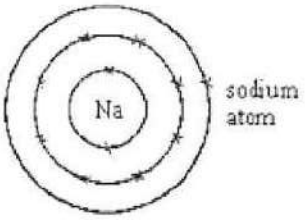
Q7

(a) The electronic structure of a sodium atom can be written 2,8,1.
Write the electronic structure of a potassium atom in the same way.

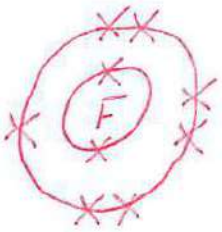
2,8,8,1

(1)

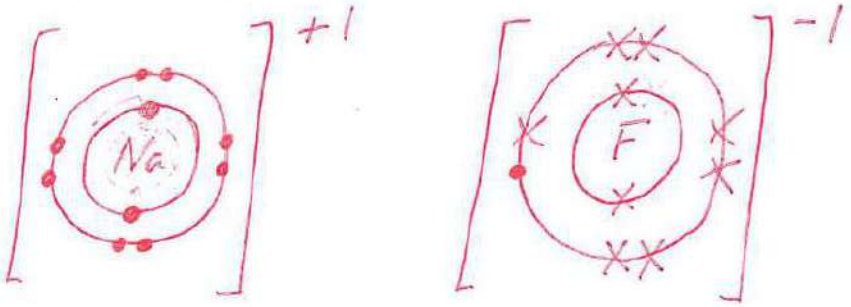
(b) The electronic structure of a sodium atom can also be represented as in the diagram below.



(i) Draw a similar diagram for a fluorine atom.



(ii) Draw similar diagrams to show the electronic structure of the particles in sodium fluoride.



(4)

Q8

The table shows the electronic configurations of four elements.

Element	Electronic configuration
chlorine	2.8.7
argon	2.8.8
potassium	2.8.8.1
calcium	2.8.8.2

(a) Why is argon an unreactive element?

(1)

Full outer shell

(b) Krypton is an unreactive element in the same group of the Periodic Table as argon, but in Period 4. It has an atomic number of 36.

Deduce the electronic configuration of krypton.

(1)

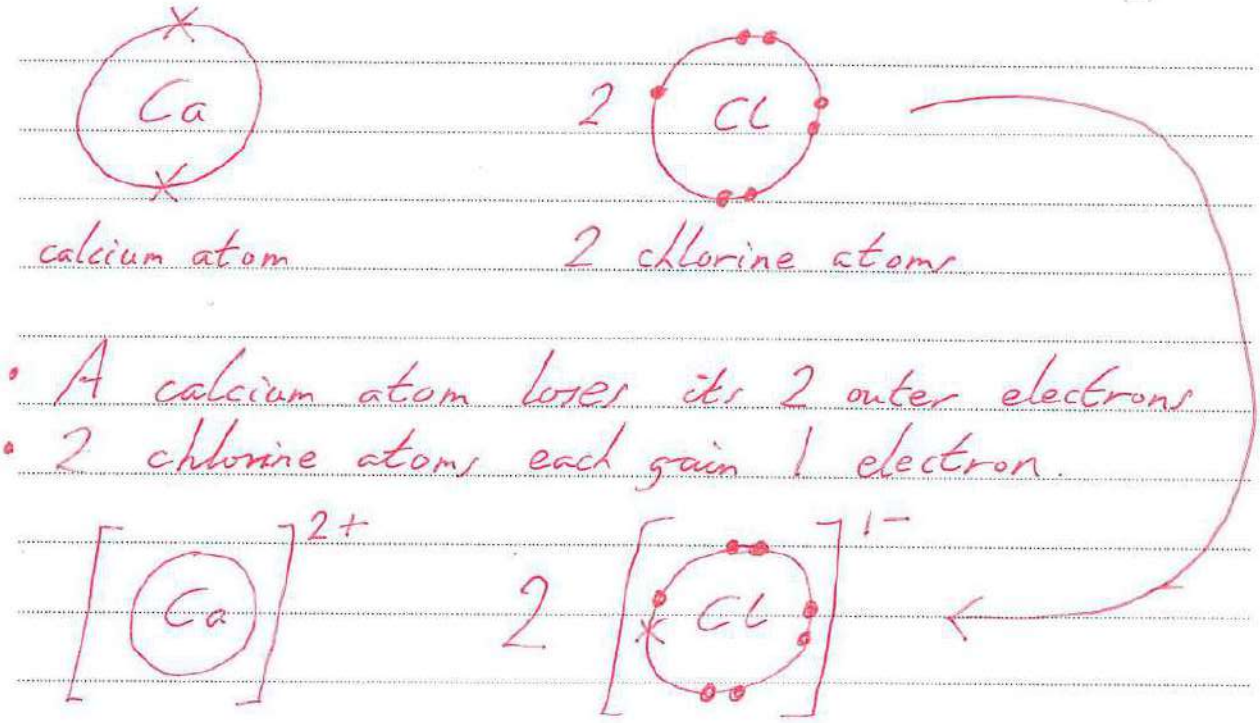
- ☐ **A** 2.8.8.8 = 26 ×
- ☐ **B** 2.8.18.8 = 27 ×
- ☒ **C** 2.8.8.2.8.8 = 36 ✓
- ☐ **D** 2.8.8.8.8.2 outer shell not full ×

(c) Calcium reacts with chlorine to form the ionic compound calcium chloride ($CaCl_2$).

(i) Describe, in terms of electrons, how an atom of calcium reacts with two chlorine atoms to form calcium chloride.

You may use a diagram in your answer.

(3)



(ii) Write the formula of a calcium ion.

(1)

Ca^{2+}

(iii) In the reaction between calcium and chlorine, both oxidation and reduction occur.

Which row shows the element that is oxidised and the element that acts as the reducing agent in this reaction?

(1)

	Element that is oxidised	Element that acts as the reducing agent
☒ A	calcium	calcium
☐ B	calcium	chlorine
☐ C	chlorine	calcium
☐ D	chlorine	chlorine

Not in topic

Q9

Magnesium and chlorine react together to form magnesium chloride, a compound with ionic bonding.

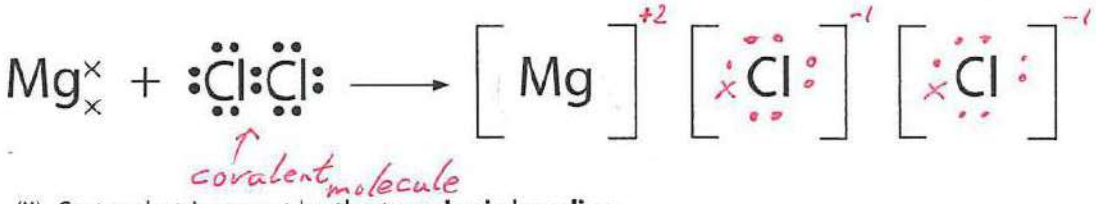
The equation for the reaction is

$$Mg + Cl_2 \rightarrow MgCl_2$$

(i) Complete the dot and cross diagram to show the arrangement of the outer electrons in the magnesium and chloride ions formed.

Show the charge on each ion.

(3)



(ii) State what is meant by the term **ionic bonding**.

(2)

Ionic bonding is the strong electrostatic attraction between oppositely charged ions.

(iii) Explain why magnesium chloride has a high melting point.

(3)

The electrostatic attraction between the oppositely charged ions is strong and takes lots of energy to break.