With 2019 NCEA Exam included

Part One

2020 Version

NCEA Science 1.5
Acids and Bases AS 90944

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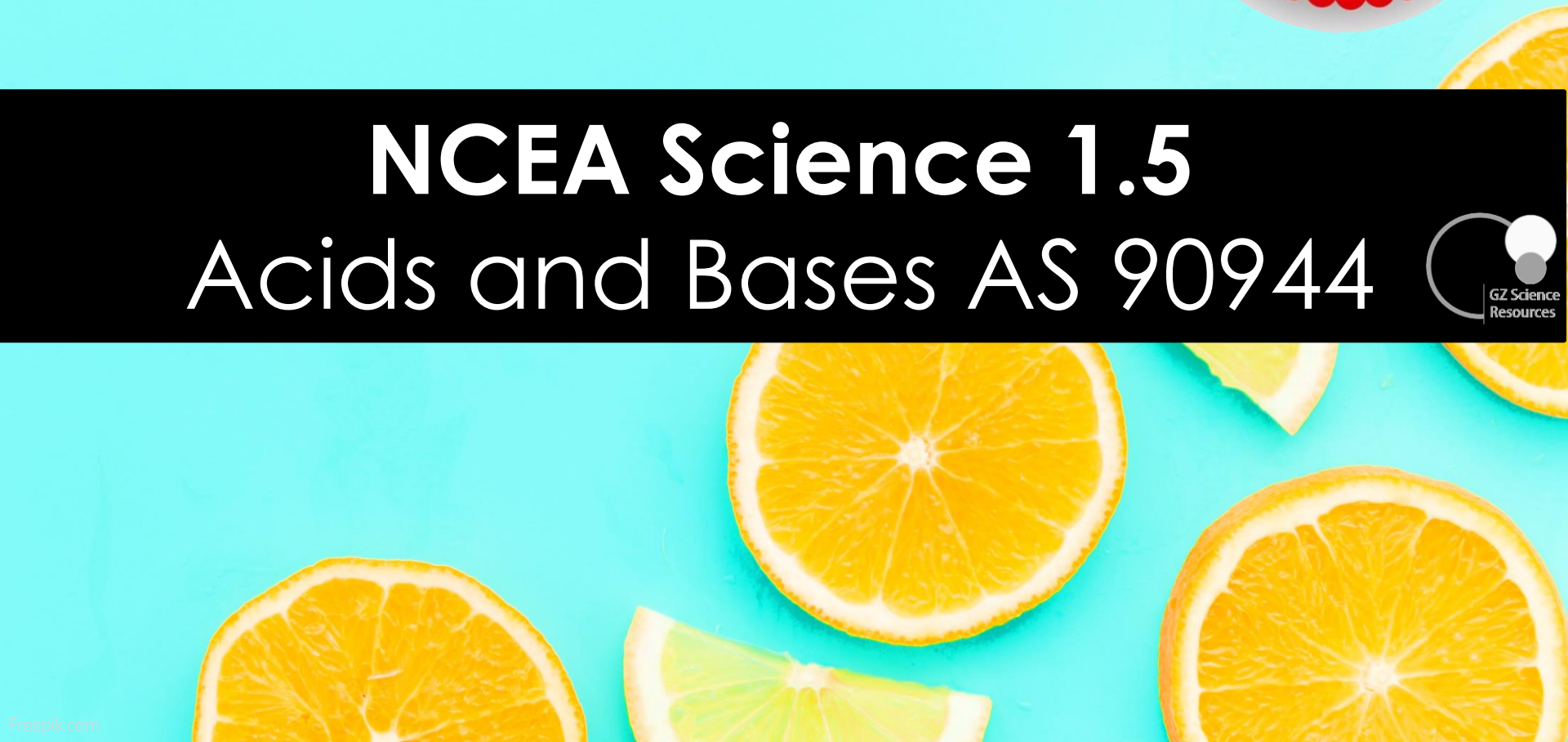

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Achievement Criteria

AS 90944
S1.5

Aspects of acids and bases will be selected from:

Atomic structure

- ❑ electron arrangement of atoms and monatomic ions of the first 20 elements (a periodic table will be provided)
- ❑ ionic bonding
- ❑ names and formulae of ionic compounds using a given table of ions.

Properties

- ❑ acids release hydrogen ions in water (HCl ; hydrochloric acid, H_2SO_4 : sulphuric acid, HNO_3 : nitric acid)
- ❑ reactions (of acids with bases) to form salts (Bases include metal oxides, hydroxides, carbonates and hydrogen carbonates)
- ❑ pH and effects on indicators.

Uses

- ❑ neutralisation
- ❑ carbon dioxide formation
- ❑ salt formation.

- ❑ Rates of reaction and particle theory.

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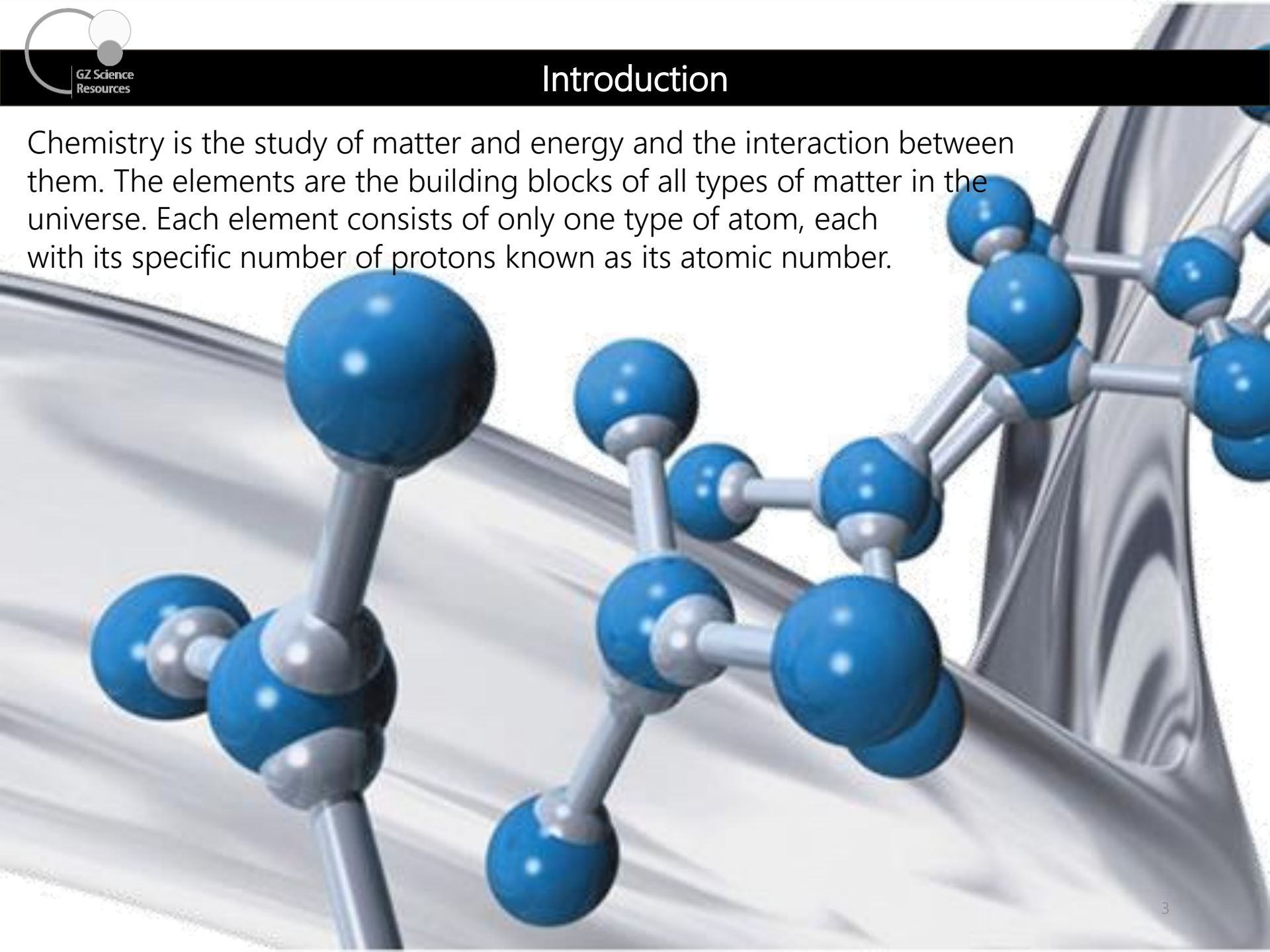
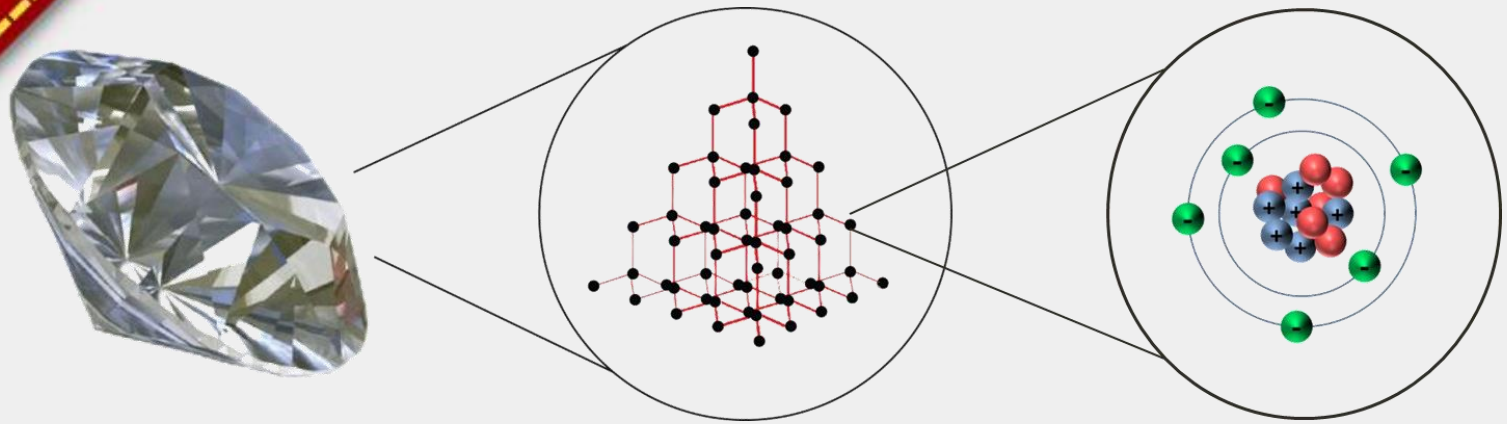
Introduction

Chemistry is the study of matter and energy and the interaction between them. The elements are the building blocks of all types of matter in the universe. Each element consists of only one type of atom, each with its specific number of protons known as its atomic number.



Background Knowledge

All Matter is made up of particles called atoms



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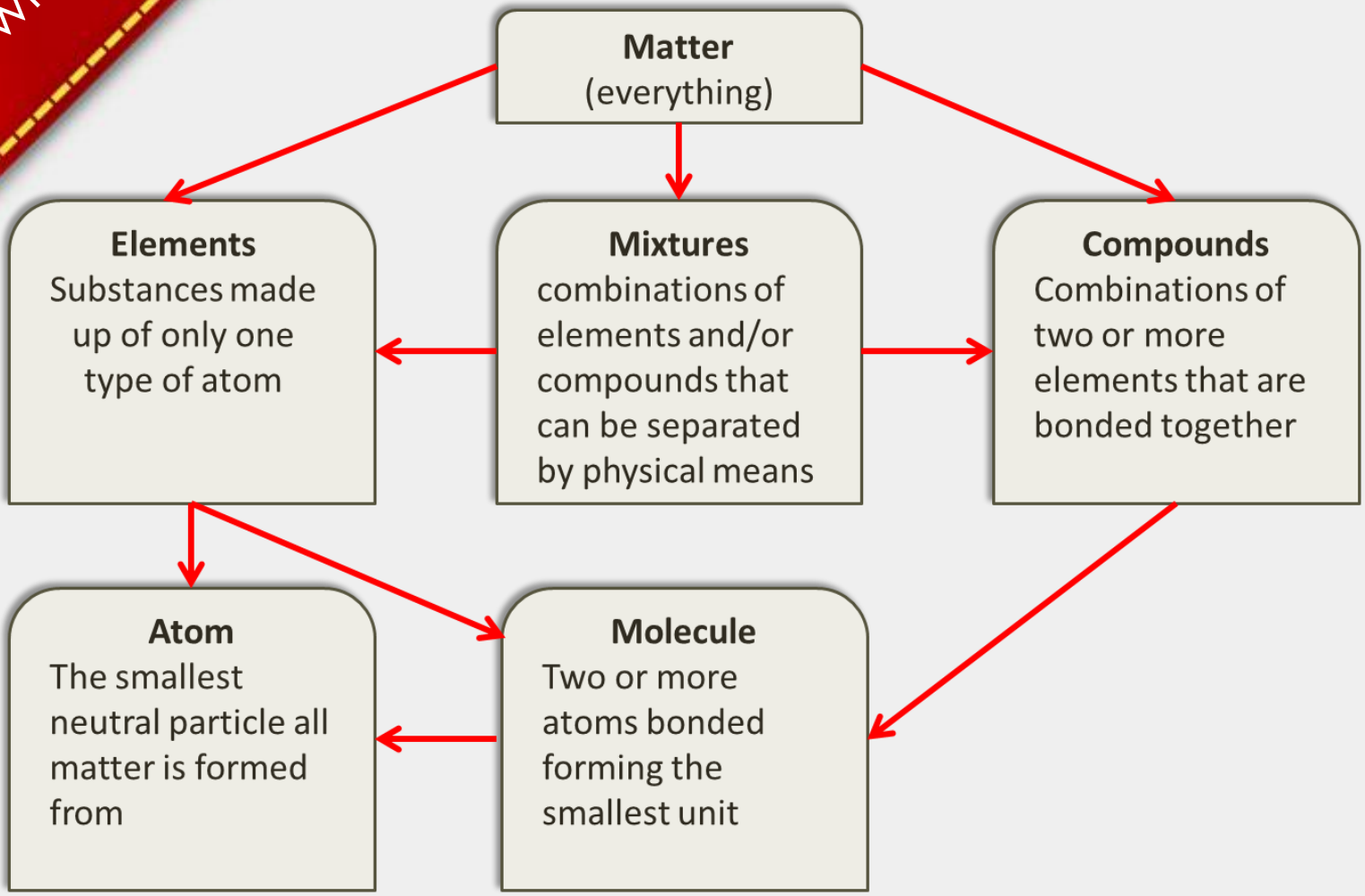
An **atom** is the smallest neutral particle that makes up matter.

The type of atom and the way these atoms are arranged and connected to each other determines the type of matter – and therefore the **physical** and **chemical** properties of the matter.

Background Knowledge

Matter is made up of particles /atoms



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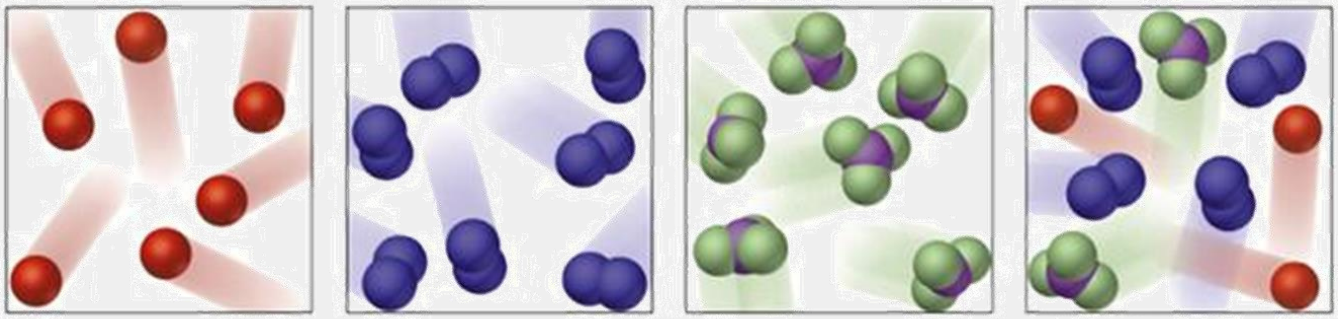
Background Knowledge

Elements are pure substances that combine to make mixtures & compounds



Atoms of an element | Molecules of an element | Molecules of a compound | Mixture of elements and a compound

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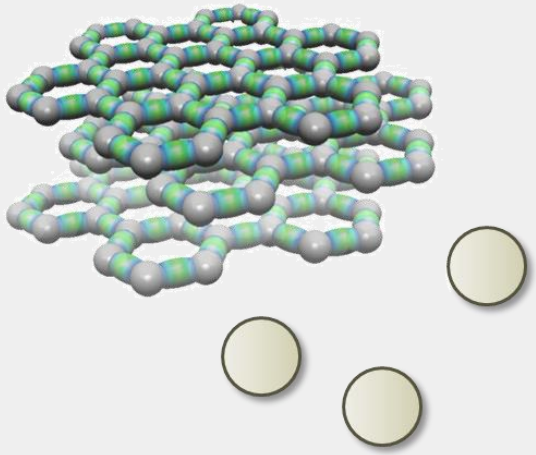
There are approximately 100+ different elements but many millions of substances. Most matter around us is made up of combinations of elements. If different elements and compounds are just jumbled up, yet not bonded together, then they form a **mixture**. If different elements have chemically reacted together and bonded then they form a **compound**.

A **molecule** forms when atoms join together – either the same to form a molecule of an element or different to form a molecule of a compound.

Background Knowledge

The Particle Theory of Matter

extra info



Carbon in the form of graphite

1. All matter is made up of **very small particles** (atoms, ions or molecules)
2. Each substance has **unique particles** that are different from particles of other substances
3. There are **spaces between the particles** of matter that are very large compared to the particles themselves
4. There are **forces** holding particles together
5. The **further apart** the particles, the **weaker** the forces holding them together
6. Particles are in **constant motion**
7. At **higher temperatures** particles on average **move faster** than at lower temperatures.

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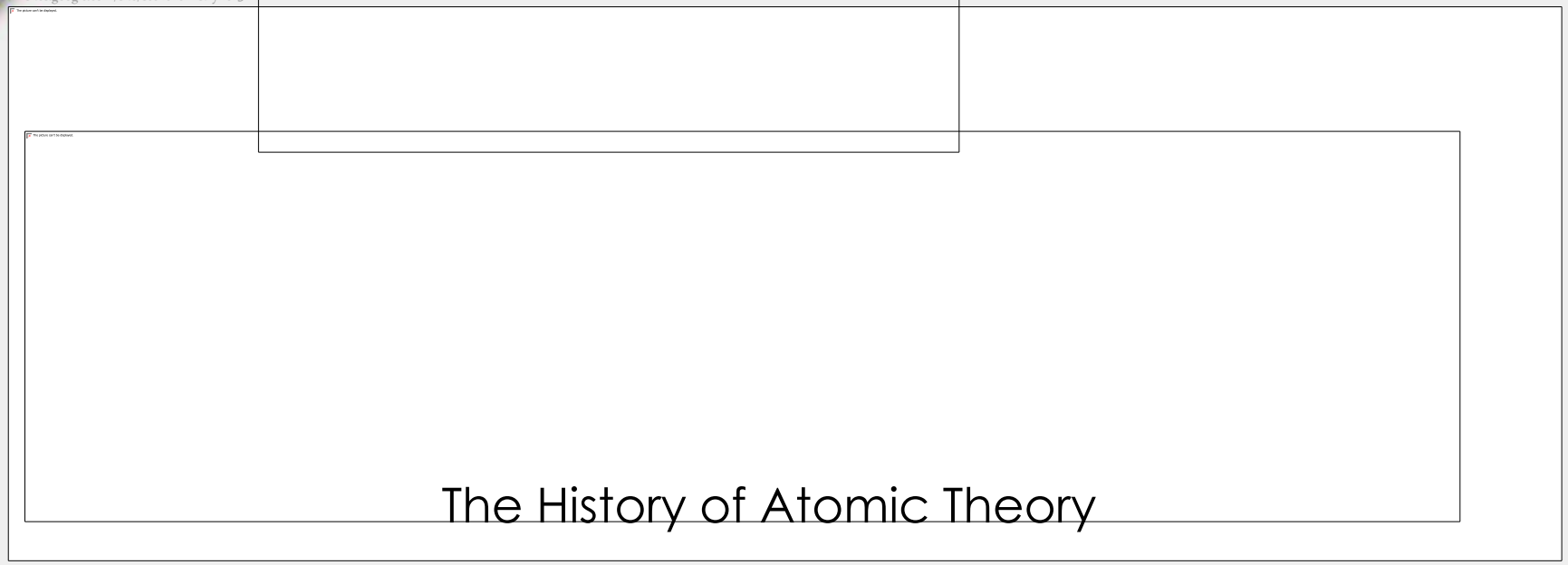
Background Knowledge

Scientists use models to show the relationship of protons, electrons and neutrons within atoms and ions

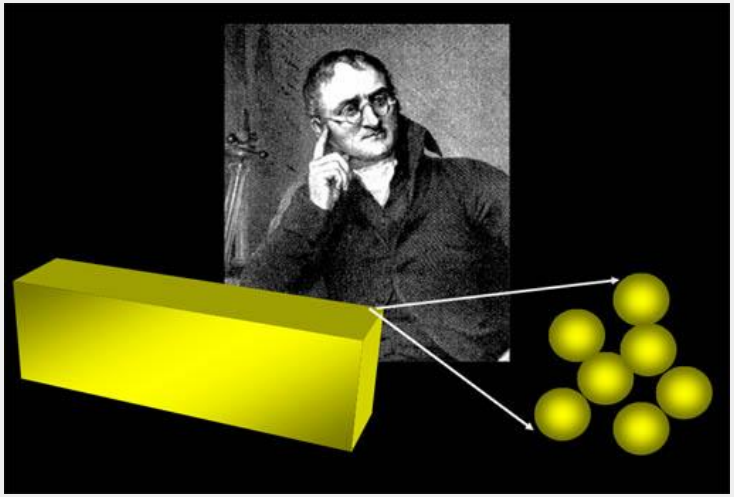
Scientists and philosophers have used **models** to represent their ideas of what an atom looks like. As more discoveries have been made, the model of the atom has changed.



Background Knowledge

Scientists use models to show the relationship of protons, electrons and neutrons within atoms and ions.

John Dalton (1766–1844) was a British chemist and physicist. In 1803 he announced his atomic theory. His atom models where represented by solid spheres.



extra info

My Theory States:

1. All Elements are made up off tiny particles called atoms.
2. Atoms of a given element are alike
3. Atoms of different elements are different
4. Chemical changes take place when atoms link up with or separate from one another
5. Atoms are not created or destroyed by chemical change

Background Knowledge

Scientists use models to show the relationship of protons, electrons and neutrons within atoms and ions.

Sir Joseph John Thomson, who had discovered (1897) the electron, and came up with a model of the atom known as the plum-pudding model.

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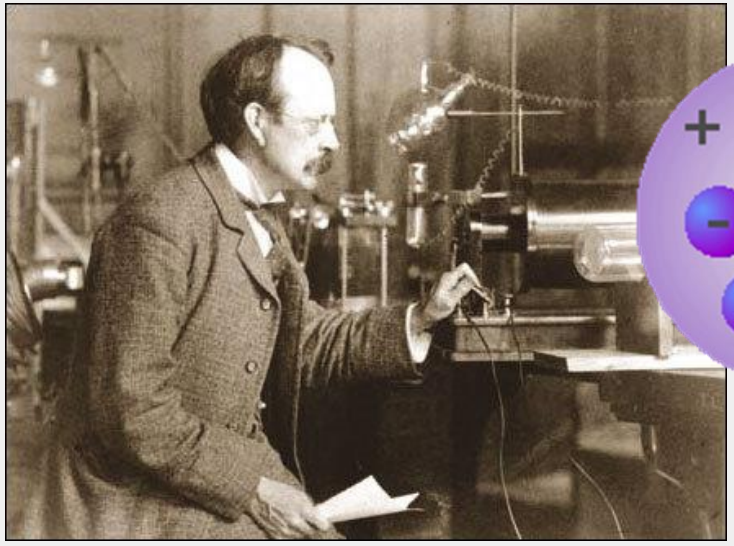
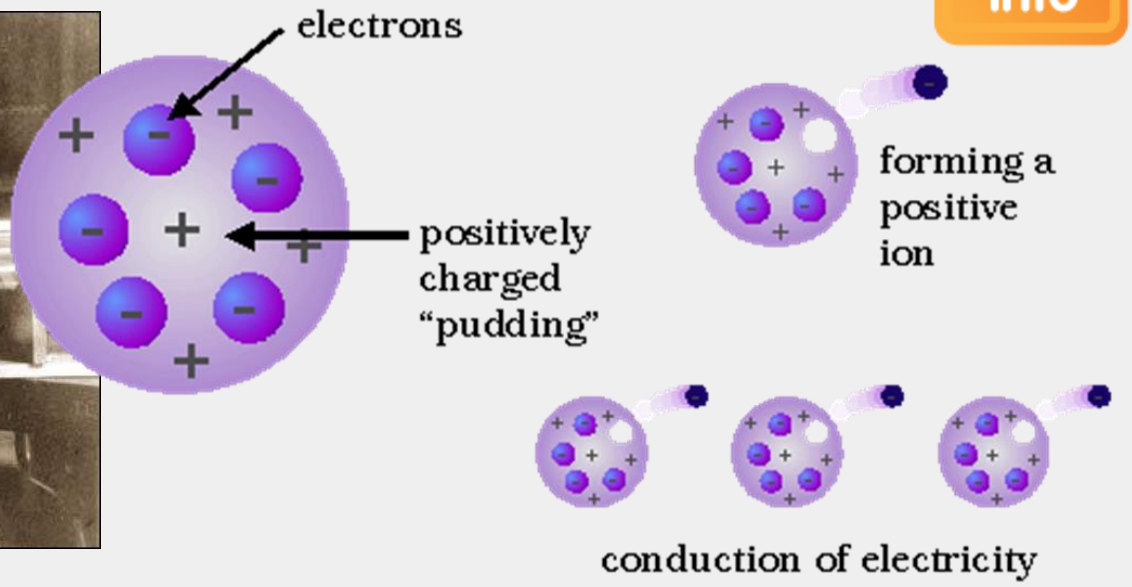
extra info

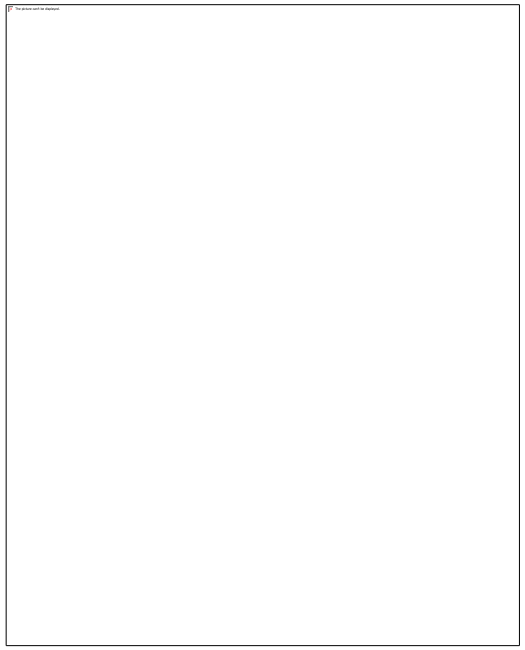




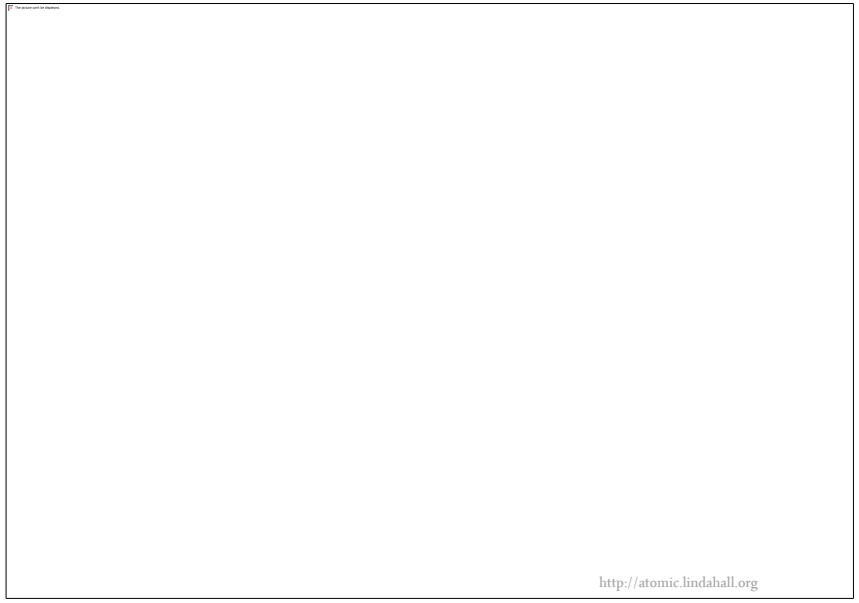
Background Knowledge

Scientists use models to show the relationship of protons, electrons and neutrons within atoms and ions.

Ernest Rutherford was a New Zealand Scientist. In 1911 he announced his new atomic model based on what he observed from his famous 'gold foil' experiment.



Rutherford's model of an atom



extra info

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Background Knowledge

Atomic Theory

extra info

Rutherford – New Zealand Physicist 1911

Results from Rutherford's gold foil experiment could not be explained by the 'plum pudding' model of Thompson so Instead, in 1911, Rutherford proposed a new model of the atom in which all of the positive charge is condensed into a tiny, massive **nucleus** about ten thousand times smaller than the entire atom. Rutherford explained the much lighter electrons circulated outside the nucleus.

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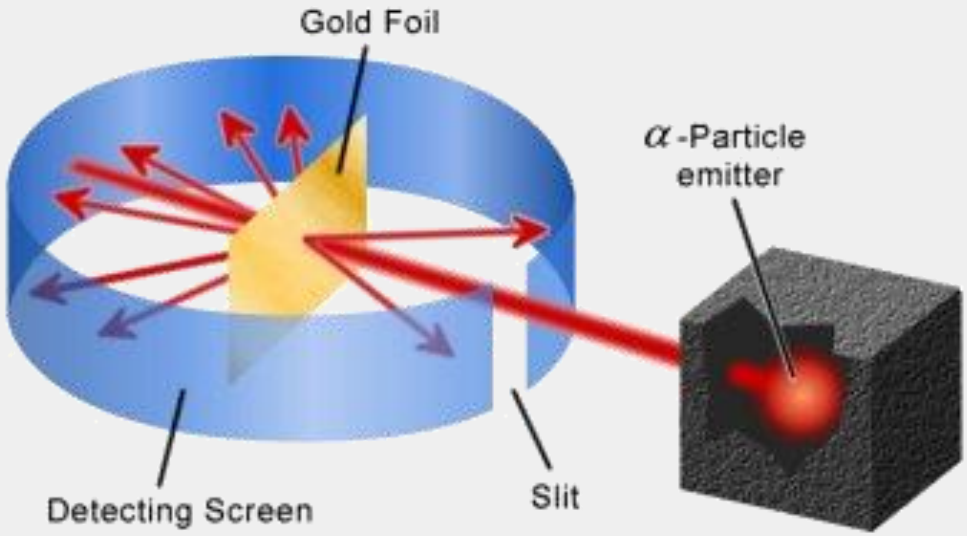
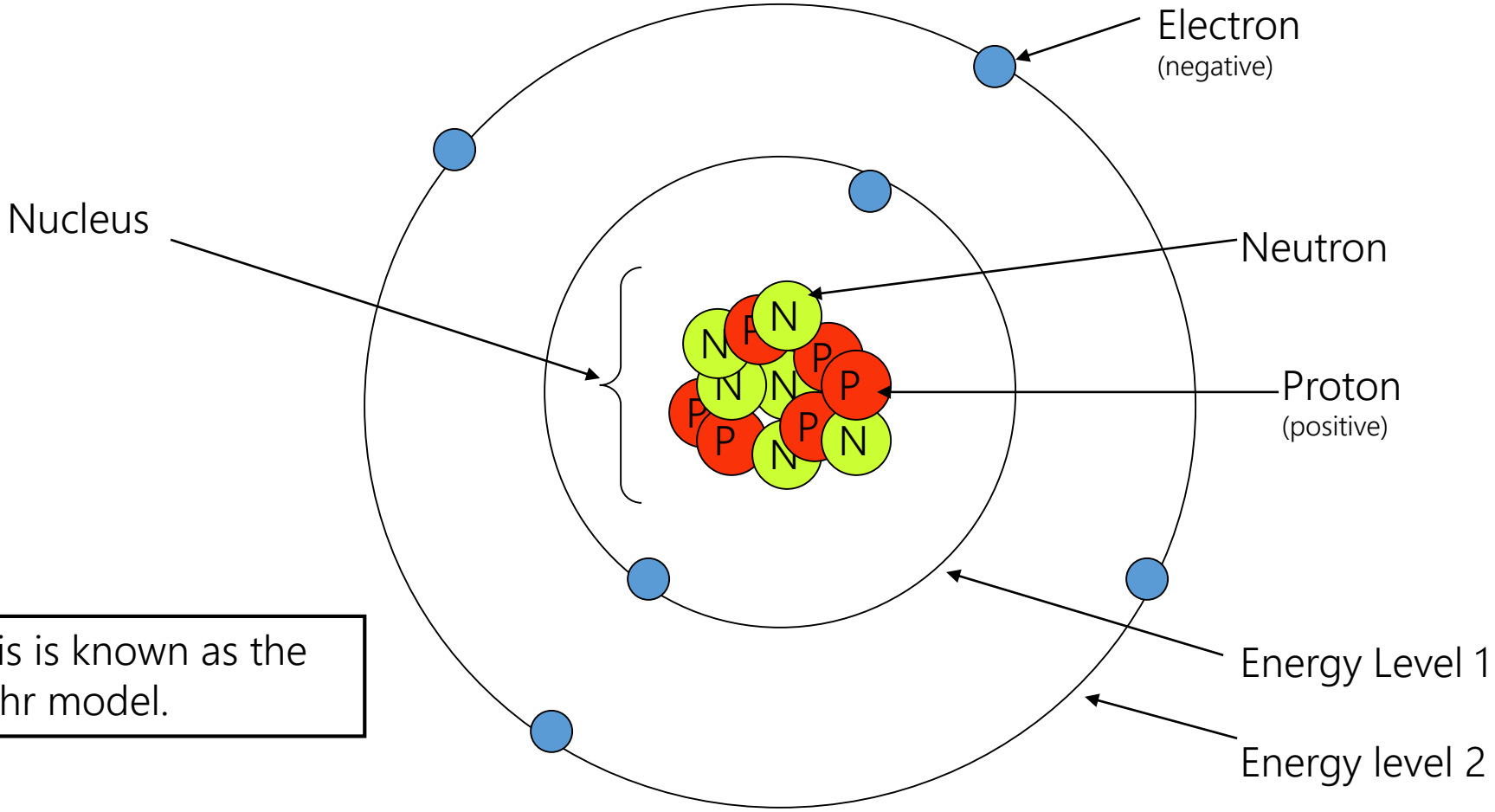
This was a revolution in the ideas of atoms as Rutherford's model implied that matter consisted almost entirely of empty space.



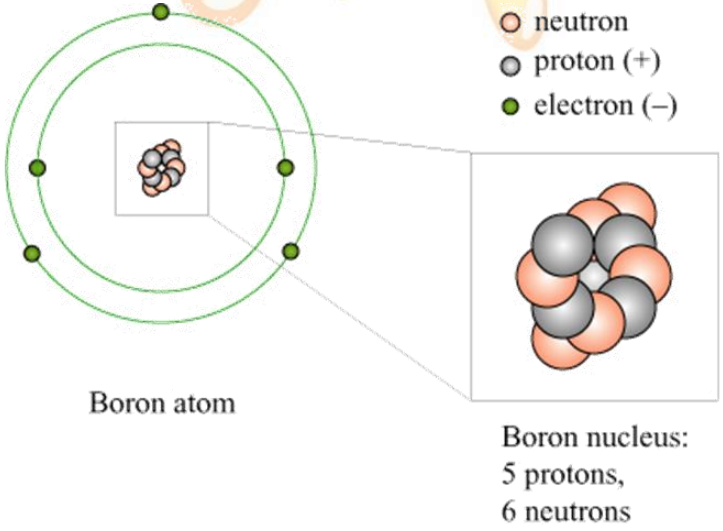
Atoms contain protons, electrons and neutrons

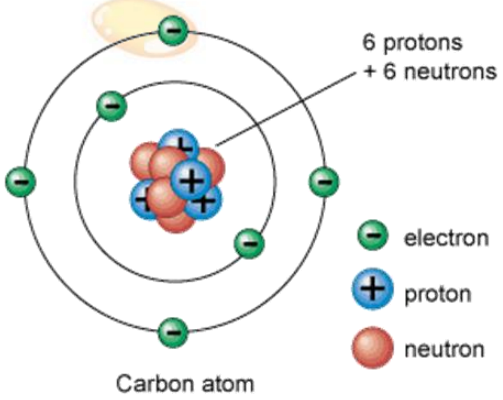
Atoms are made up of smaller particles, the number of these determine the type of atom. Atoms have a central nucleus, which contains protons (p) and neutrons (n). Electrons (e) orbit outside the nucleus, arranged in energy levels.



This is known as the Bohr model.

Each different type of element has a different number of protons in its atoms





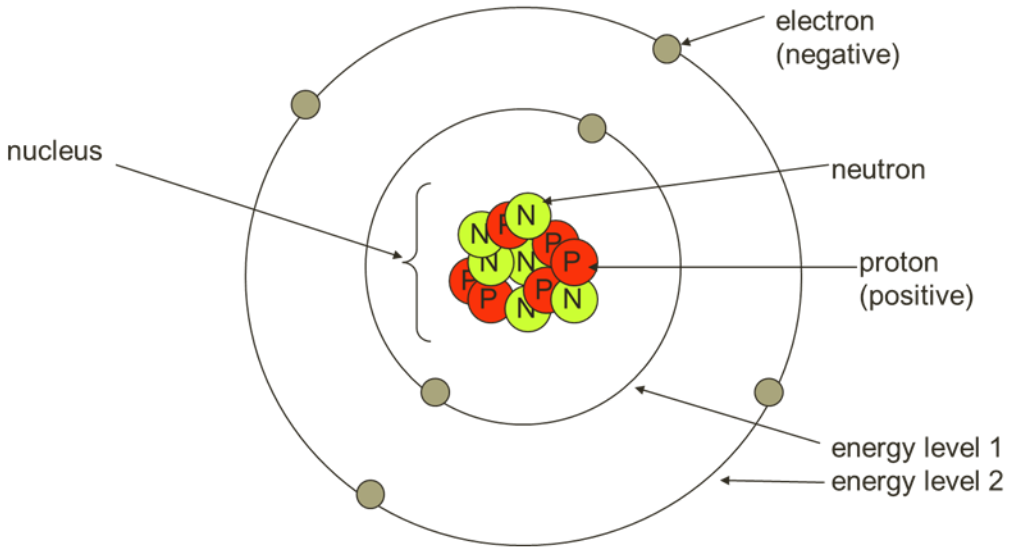
All Boron atoms have 5 protons in their nucleus.

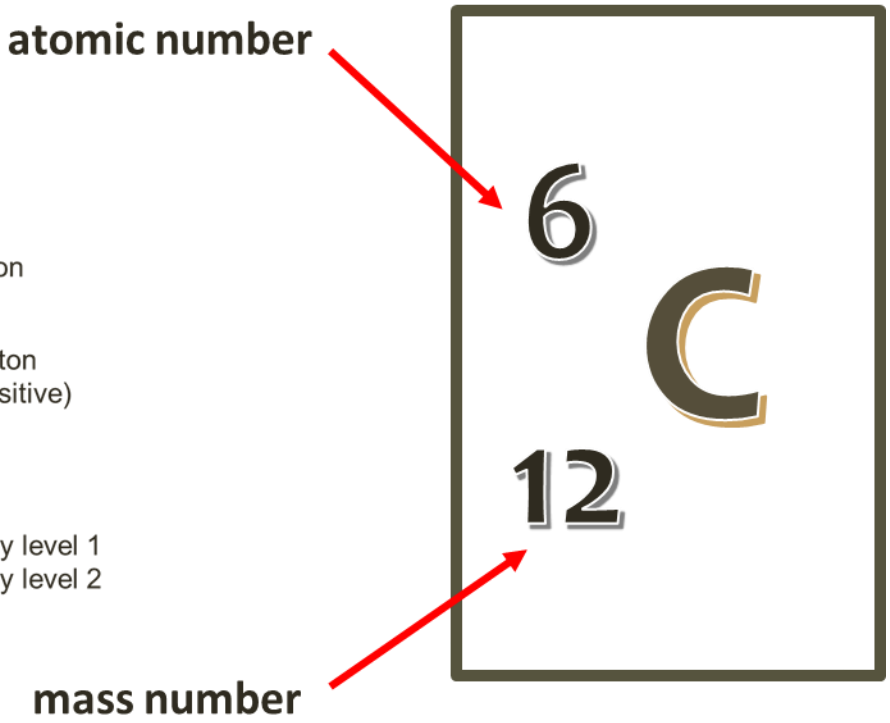
All Carbon atoms have 6 protons in their nucleus.

Positive protons bond to each other with a special type of force in the centre of an atom, called the nucleus. **Each type of atom has a specific number of protons**. Neutral neutrons in approximately the same number as protons, also join together with the protons to form the nucleus. The positive charge of the nucleus holds the same number of negative electrons in position around it.

Atomic and Mass number

The atomic number is unique for each element. An atom has the same number of electrons as protons.
The atomic number of an atom is equal to the number of **protons.** (and also **electrons**)
The mass number of an atom is equal to the number of **protons and neutrons.** Both numbers are normally found in the periodic table.





Background Knowledge

Calculating protons, neutrons and electrons

Number of protons:
For an atom or ion = atomic number

Number of electrons:
For an atom = atomic number
For a negative ion = atomic number + charge (- =1, -2 =2 etc.)
For a positive ion = atomic number – charge (+ =1, +2 = 2 etc.)

Number of neutrons:
For an atom or ion = mass number - atomic number

atom or ion	number of protons	number of electrons	number of neutrons
Mg	12	12	12
Mg^{2+}	12	10	12
F	9	9	10
F-	9	10	10

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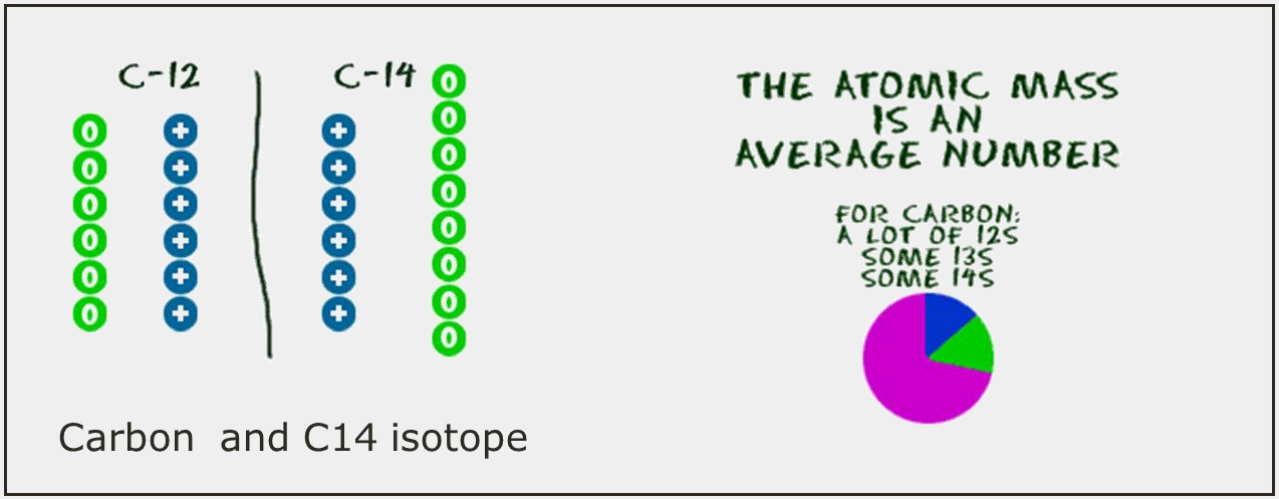
Background Knowledge

The Mass Number of an atom is equal to the average number of protons and neutrons in an atom.

extra info

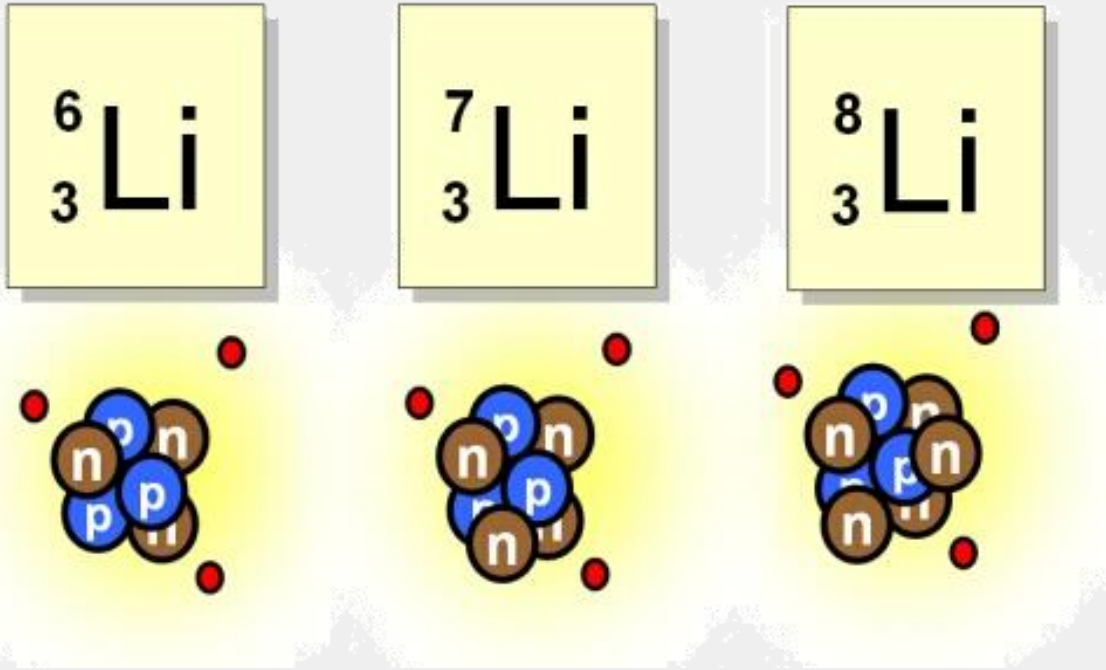


Carbon and C14 isotope

Why is the Mass Number not always a whole number?
Most elements have a proportion of their atoms that exist as isotopes – Atoms that have less or more neutrons. The Mass number is worked out by finding the Mass number of all the isotopes and averaging them by their proportions.

Background Knowledge

Isotopes have the same Atomic number but a different Mass number



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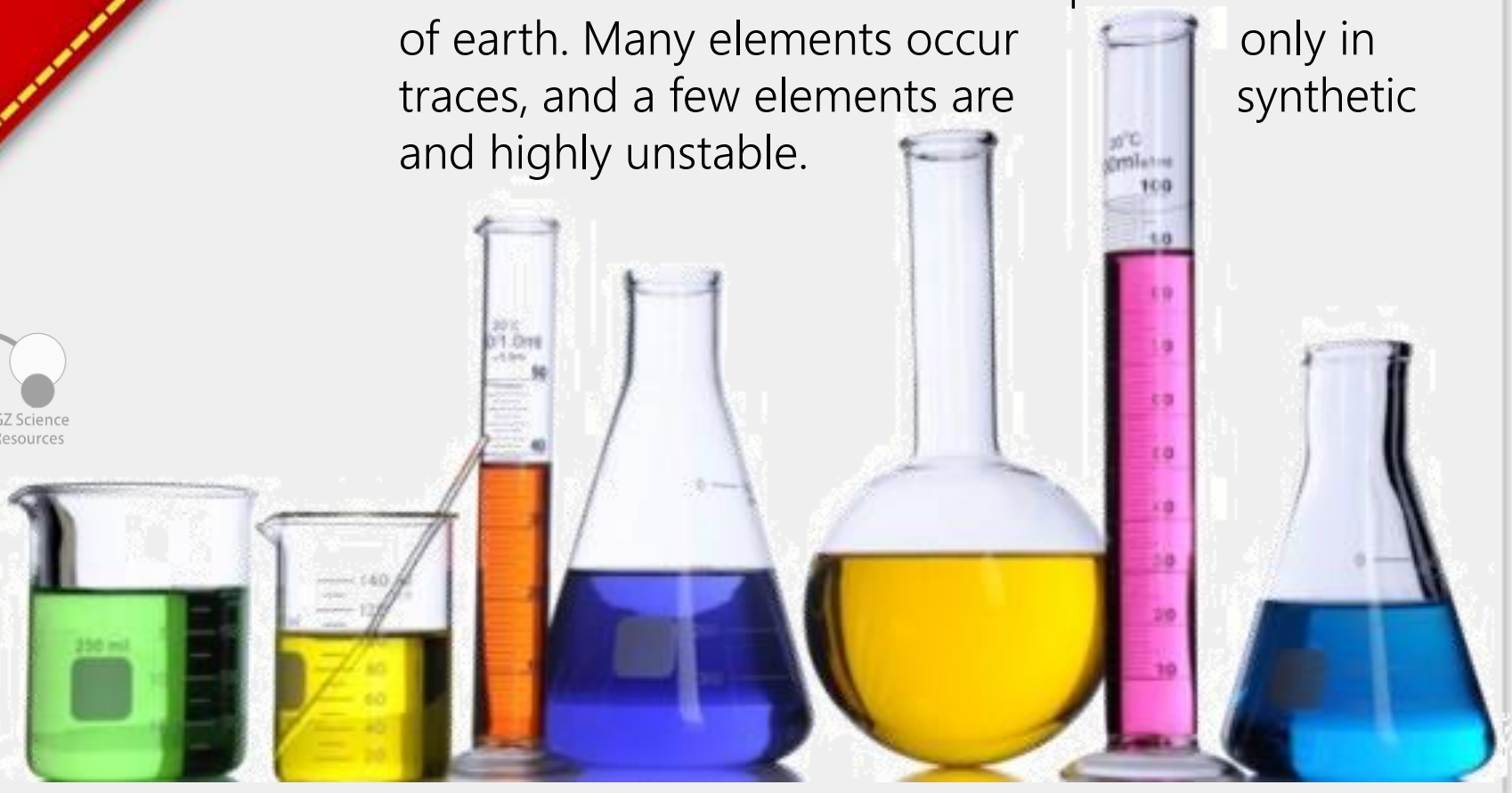
extra info

Isotopes of elements occur when atoms have the same atomic number (Z) but different numbers of neutrons in the nucleus. The numbers of neutrons in an atom does not affect the way an element behaves chemically, but it does affect the way it behaves physically.
Isotopes found in nature are generally stable, however radioactive isotopes do exist such as 238Uranium

Background Knowledge

The elements and Periodic table

A large amount of energy is required to break an atom down into smaller particles. The elements occur in widely varying quantities on earth. The ten most abundant elements make up 98% of the mass of earth. Many elements occur only in traces, and a few elements are synthetic and highly unstable.



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Background Knowledge

Periodic table Development

extra info

Mendeleev – Russian professor of Chemistry 1834 - 1907

Dimitri Mendeleev was a Chemist who created a periodic table based on elements relative atomic mass and placed the elements in groups based on the elements similar properties. Not all of the elements had been discovered at the time he created the table so he left gaps that has subsequently been filled.

Table of the Periodic Law. (Mendeléef, 1904.)

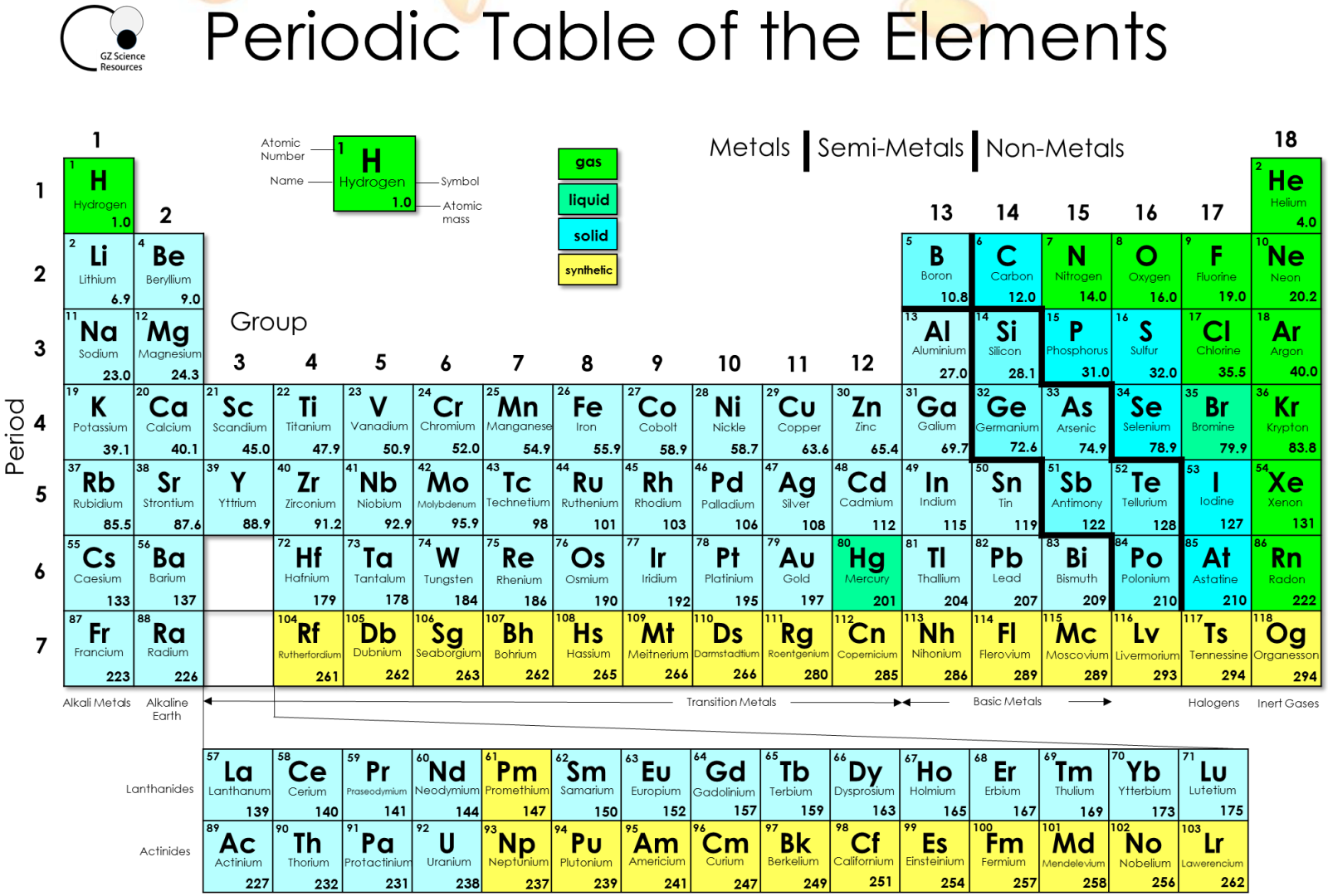
Series	Zero Group	Group I	Group II	Group III	Group IV	Group V	Group VI	Group VII	Group VIII
0	x								
1		Hydrogen H—1·008							
2	Helium He—4·0	Lithium Li—7·03	Beryllium Be—9·1	Boron B—11·0	Carbon C—12·0	Nitrogen N—14·04	Oxygen O—16·00	Fluorine F—19·0	
3	Neon Ne—19·9	Sodium Na—23·05	Magnesium Mg—24·1	Aluminium Al—27·0	Silicon Si—28·4	Phosphorus P—31·0	Sulphur S—32·06	Chlorine Cl—35·45	
4	Argon Ar—38	Potassium K—39·1	Calcium Ca—40·1	Scandium Sc—44·1	Titanium Ti—48·1	Vanadium V—51·4	Chromium Cr—52·1	Manganese Ma—55·0	Iron Fe—55·9 Cobalt Co—59 Nickel Ni—59 (Cu)
5		Copper Cu—63·6	Zinc Zn—65·4	Gallium Ga—70·0	Germanium G—72·3	Arsenic As—75·0	Selenium Se—79	Bromine Br—79·95	
6	Krypton Kr—81·8	Rubidium Rb—85·4	Strontium Sr—87·6	Yttrium Y—89·0	Zirconium Zr—90·6	Niobium Nb—94·0	Molybdenum Mo—96·0	—	Ruthenium Ru—101·7 Rhodium Rh—103·0 Palladium Pd—106·5 (Ag)
7		Silver Ag—107·9	Cadmium Cd—112·4	Indium In—114·0	Tin Sn—119·0	Antimony Sb—120·0	Tellurium Te—127	Iodine I—127	
8	Xenon Xe—128	Caesium Cs—132·9	Barium Ba—137·4	Lanthanum La—139	Cerium Ce—140	—	—		— — — (—)
9		—	—		—	—	—	—	
10	—	—	—	Ytterbium Yb—173	—	Tantalum Ta—183	Tungsten W—184	—	Osmium Os—191 Iridium Ir—193 Platinum Pt—194·9 (Au)
11		Gold Au—197·2	Mercury Hg—200·0	Thallium Tl—204·1	Lead Pb—206·9	Bismuth Bi—208	—	—	
12	—	—	Radium Rd—224	—	Thorium Th—232	—	Uranium U—239		

Groups 3 to 12 were added after Mendeleev's table – these are called the transition metals

Group 18 – the noble gases, were not discovered at that time and were also added after.

The periodic table organises elements by atomic number

The elements increase in atomic number as you move from left to right and from top to bottom of the periodic table.



Background Knowledge

Groups of elements on the periodic table have common physical and chemical properties

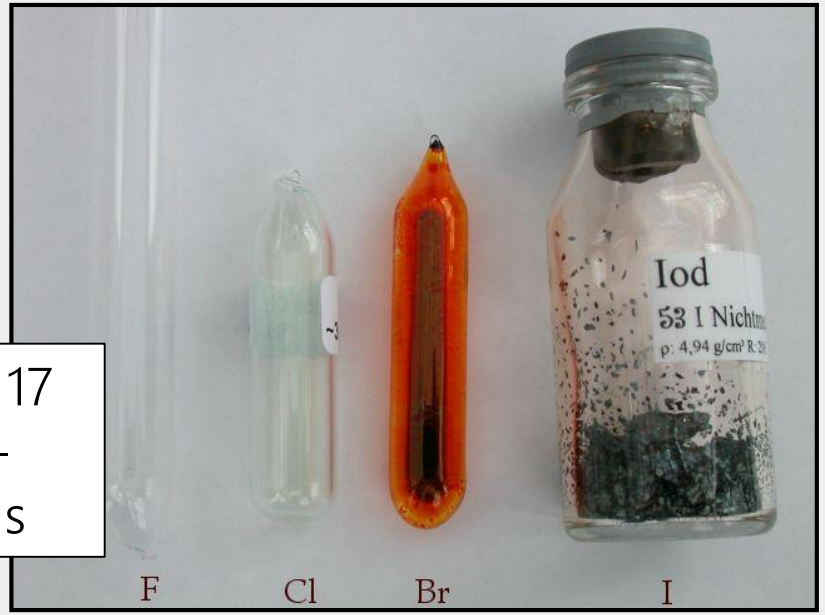
extra info

Elements that are in the same group show similar types of chemical and physical properties. Their atoms chemically react the same way because their electrons in the outside energy level in the atoms are arranged the same way.

Group 1 Metals

The elements in a group also have similar physical properties because of the way the atoms join together and are arranged.

Group 17 Non-Metals

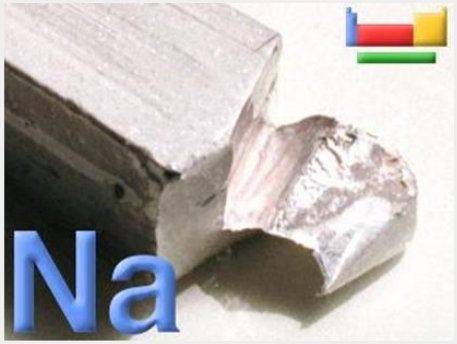


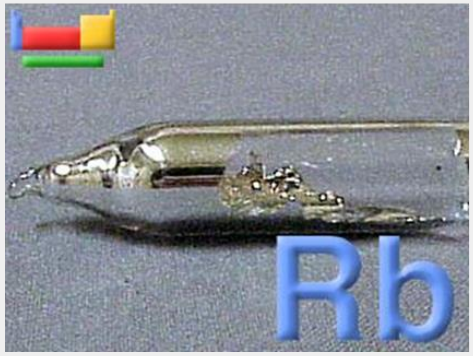
Background Knowledge

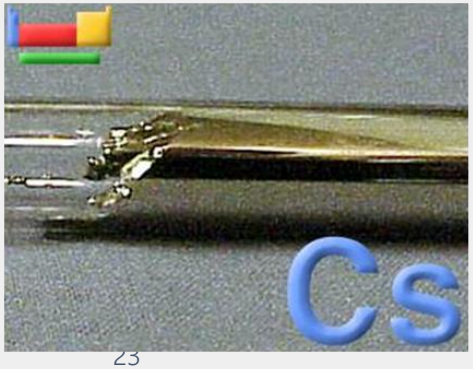
Group One Elements

extra info

These elements are called the **Alkali Metals**. They are all very reactive with air and, especially so, water. The further down the group the more reactive they are. Hydrogen is not included in this as it does not share similar properties with the rest of the elements.







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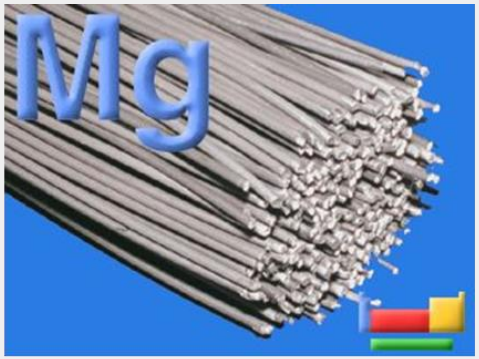
Background Knowledge

Group two elements

These elements are called the **Alkali Earth Metals**. They all react with air, but are less reactive than group 1.



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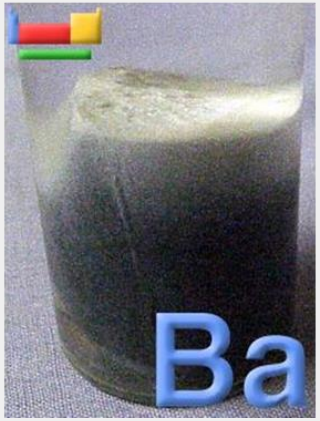

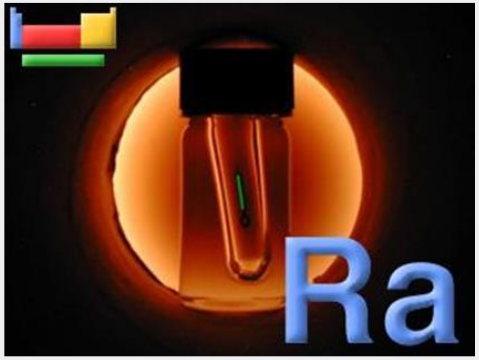

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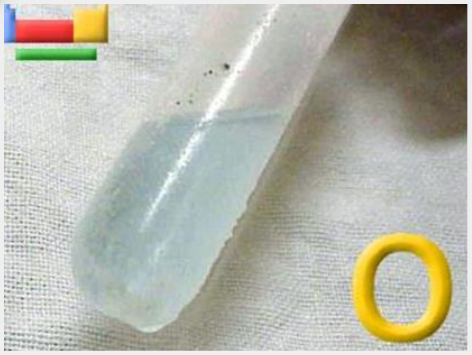
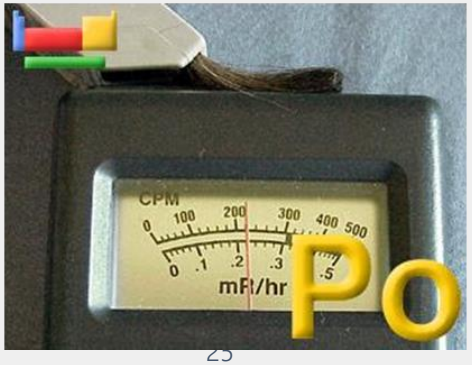
Background Knowledge

Group 16 elements

extra info

These elements are mostly Non-Metals. As we move down the group the elements show some metallic properties.





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Background Knowledge

Group 17 Elements

These elements are called the **Halogens**. They are very reactive an change from gas to liquid to solid as you move down the group.

extra info

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Background Knowledge

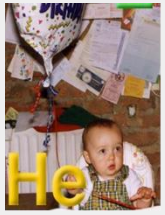
Group 18 Elements

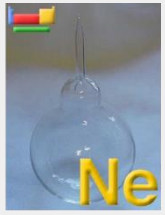
These gases are a family of elements, and all of them are located in the far right column of the periodic table called Group Eighteen (Group XVIII). This family has the most stable elements of all.

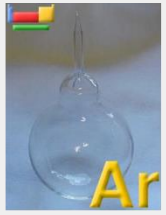
Stable atoms have full energy levels of electrons. All of the inert gases have full outer energy levels with eight electrons (except helium (He) with a energy level that is full with two electrons). The fact that their outer energy levels are full means they do not react with other elements. In fact, they rarely combine with other elements. Their non-reactivity is why they are called inert.

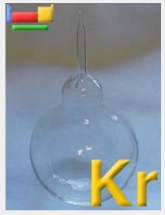
extra info

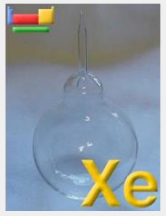
These elements are called the **Inert gases**. They are very non reactive and have only just been discovered relatively recently because of that.











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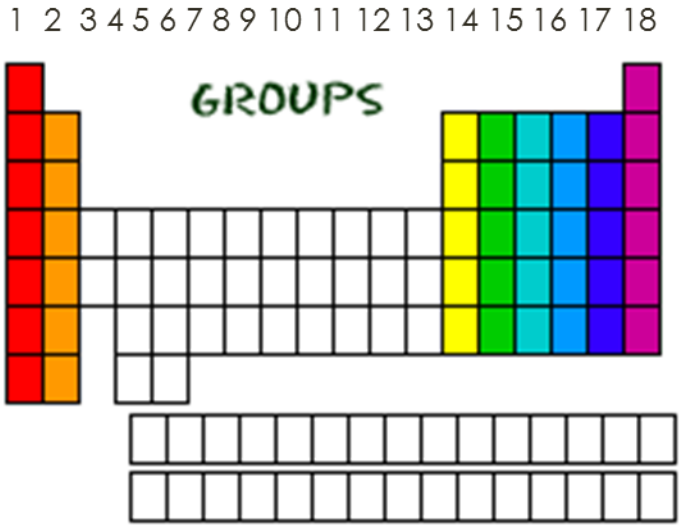
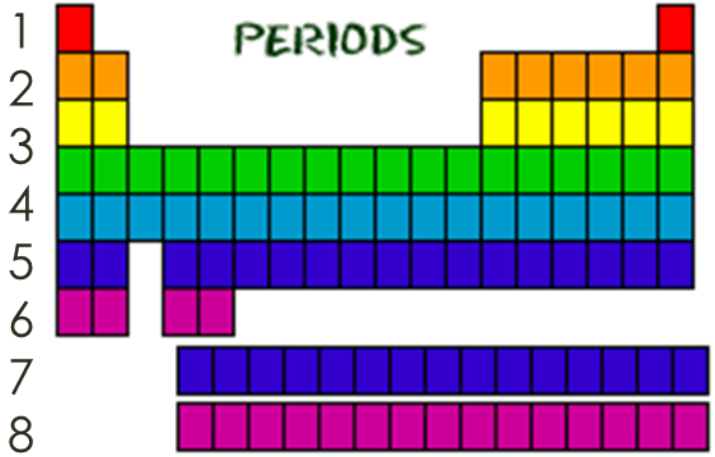
The periodic table organises elements by atomic number

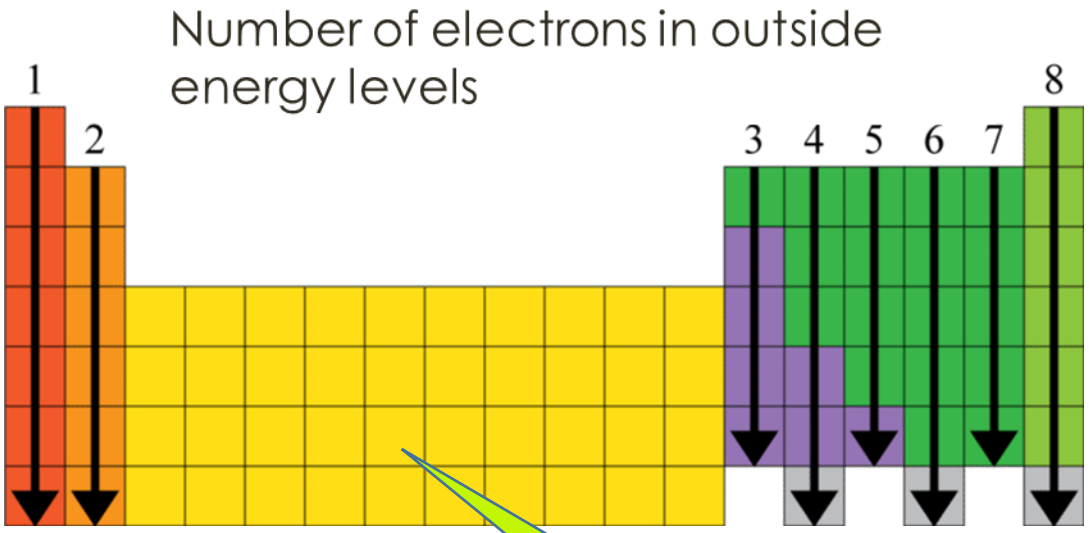
The Periodic Table is also organised into **groups that go down a column** numbered from 1 to 18, from left to right and **Periods that go across a row numbered from 1 to 8,** from top to bottom





The columns (downwards) of a periodic table are called groups.
The rows (across) of a periodic table are called periods.

There is a relationship between the group number and the number of outer electrons.



The elements in a **group** have the **same number of electrons in their outer energy level**. Every element in the first column (group one) has one electron in its outer energy level. Every element on the second column (group two) has two electrons in the outer energy level.

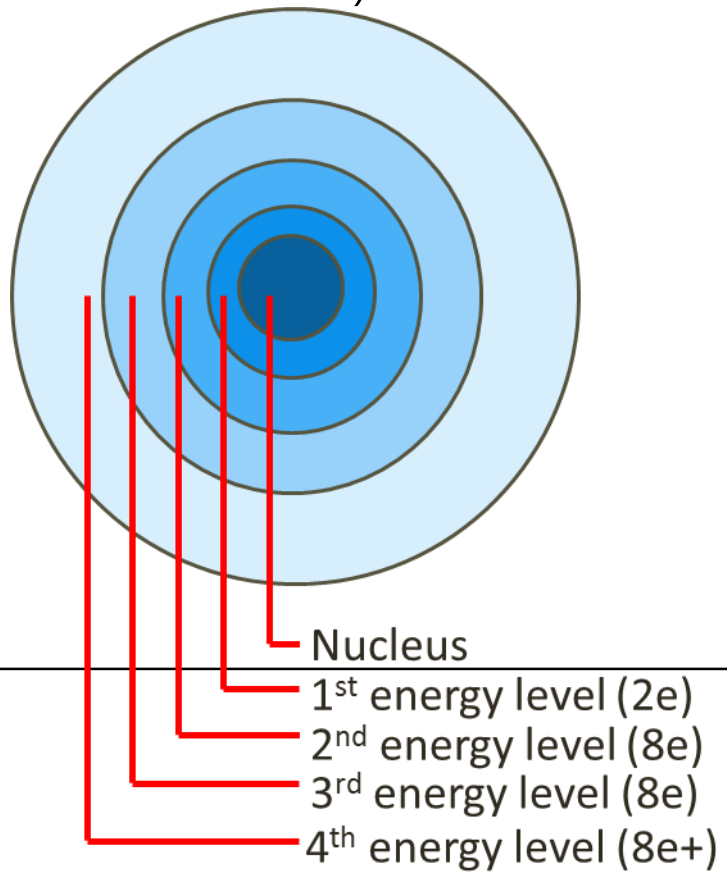
Note: for groups 13 to 18 it is only the last number that relates to number of electrons. i.e. group 13 has 3, group 14 has 4…

In this unit we can **leave out** the central group of elements in the yellow block

The electrons in an atom are arranged in a series of energy levels.

Electrons move or 'orbit' around the nucleus in **energy levels** or shells.
The energy levels further away from the nucleus are able to fit more electrons.
The first energy level is filled first, followed by the second and so on until all the electrons (the same number of protons in an atom) have been used.

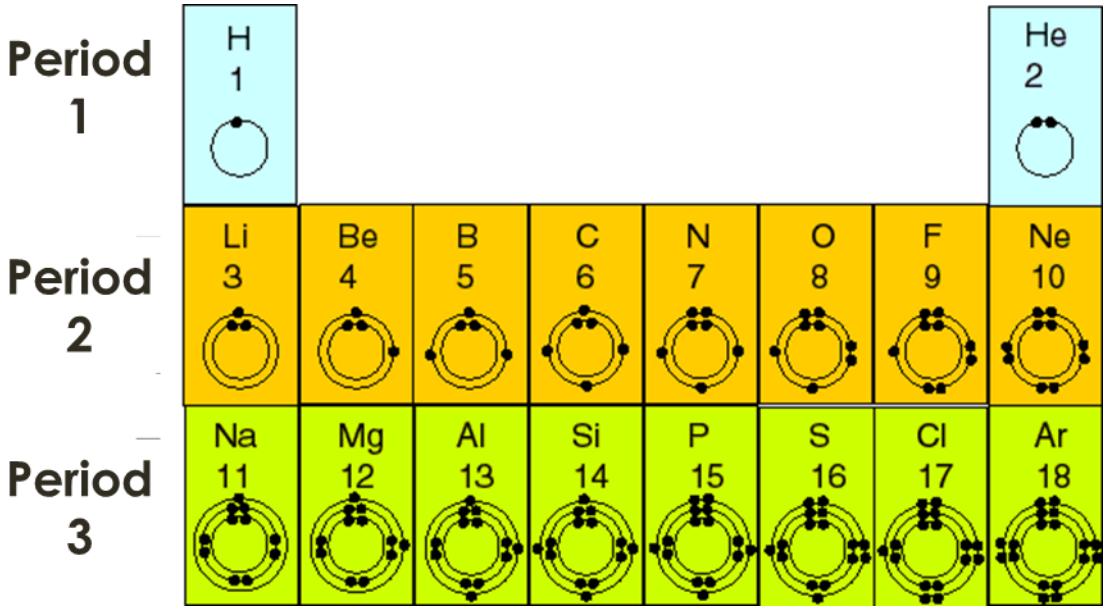
Maximum numbers of electrons in each energy level are:
>2 in the first EL (nearest the nucleus)
>8 in the second EL
>8 in the third EL (before the fourth shell starts to fill)
>8+ in the fourth EL



You need to draw the configurations of the first 20 elements as well as knowing their names and symbols

There is a relationship between the period number and the number of electron shells an atom has.

GZ Science Resources



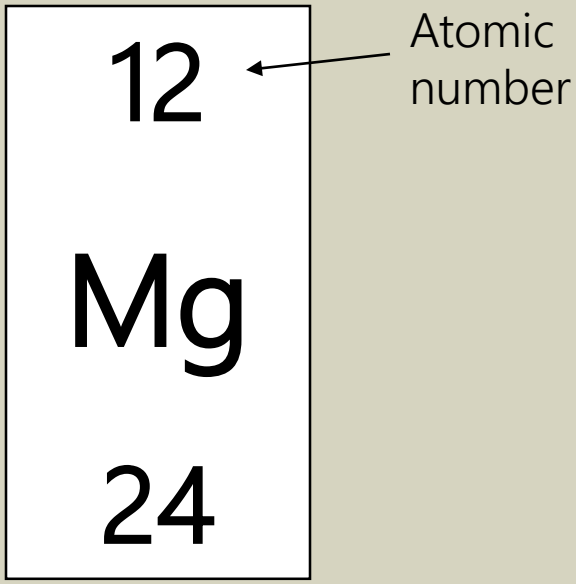
In the periodic table, elements have something in common if they are in the **same period**. All of the elements in a period have the **same number of electron energy levels**. Every element in the top row (the first period) has one energy level for its electrons) All of the elements in the second row (the second period) have two energy levels for their electrons. It continues down the periodic table the same way.

At this time, the maximum number of electron energy levels for an element is seven.

Did you know

Electron configuration

A shorthand way of describing the way electrons are arranged in an atom is called the ***electron configuration***. The information for the number of electrons is found by an elements Atomic Number (number of electrons = number of protons in a neutral atom). Each EL is filled to its maximum capacity, starting with the lowest EL first (EL number 1). A comma separates the EL. The EL are filled until all the electrons are placed.



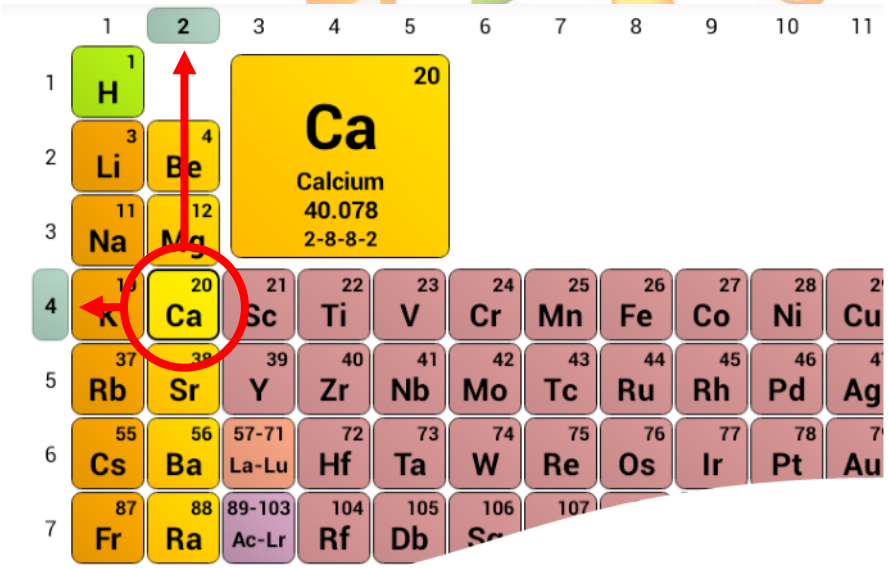
Atomic number

The total of the electron configuration must equal the atomic number in an atom

2, 8, 2

First EL, second EL, third EL

Using the Periodic table to write electron configurations



Period number gives number of energy levels.
The last number of group gives electrons in outer energy level.
i.e. group 17 - 7 electrons in outer energy level.

Ca 2 ,8 ,8 ,2

Step 1. Ca in period (row 4) so has 4 energy levels

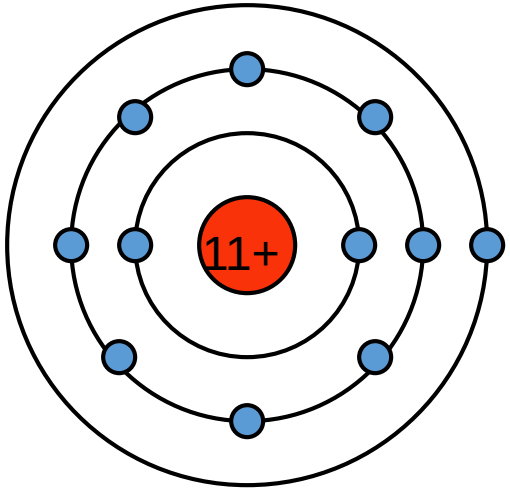
Step 2. Ca in group 2 so has 2 electrons in the outside energy level

Step 3. backfill all energy levels with 8 electrons (2 in first) and add commas between each

Ions are formed by gain or loss of electrons

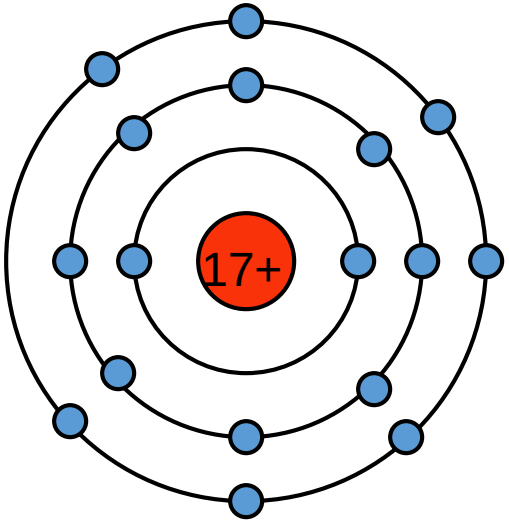
Ions are atoms or groups of atoms with electrical charge.
Elements are most stable when the outer energy level (valence shell) is full.
Elements can lose or gain electrons when they react with other chemicals to form ions.

Cation Sodium (Na)



Sodium now becomes the sodium ion Na^+

Anion Chlorine (Cl)

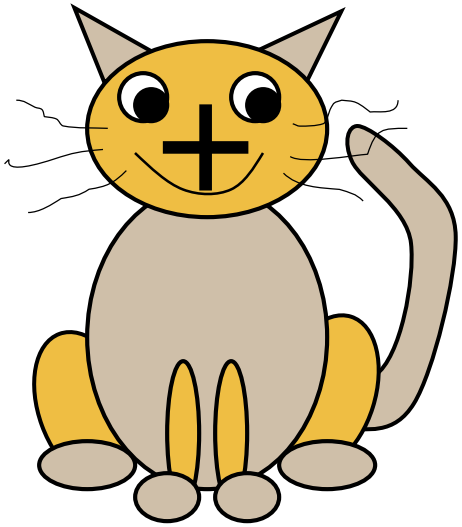


Chlorine now becomes the chloride ion Cl^-

Ions are formed by gain or loss of electrons

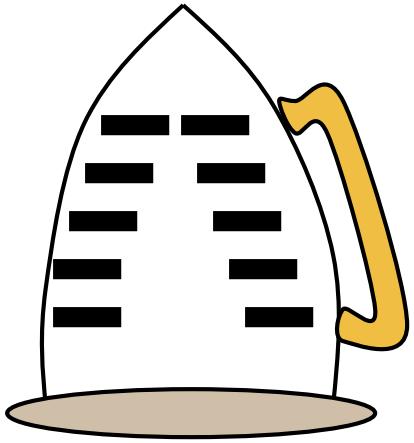
Atoms that lose electrons form positively charged ions, or cations.
Atoms that gain electrons form negatively charged ions, or anions.

Cation (Cat)



Metals lose electrons to form Cations. They have 1-3 electrons in their outside energy level

Anion (an Iron)



Non-Metals gain electrons to form Anions. They have 7-8 electrons in their outside energy level.

GZ Science Resources

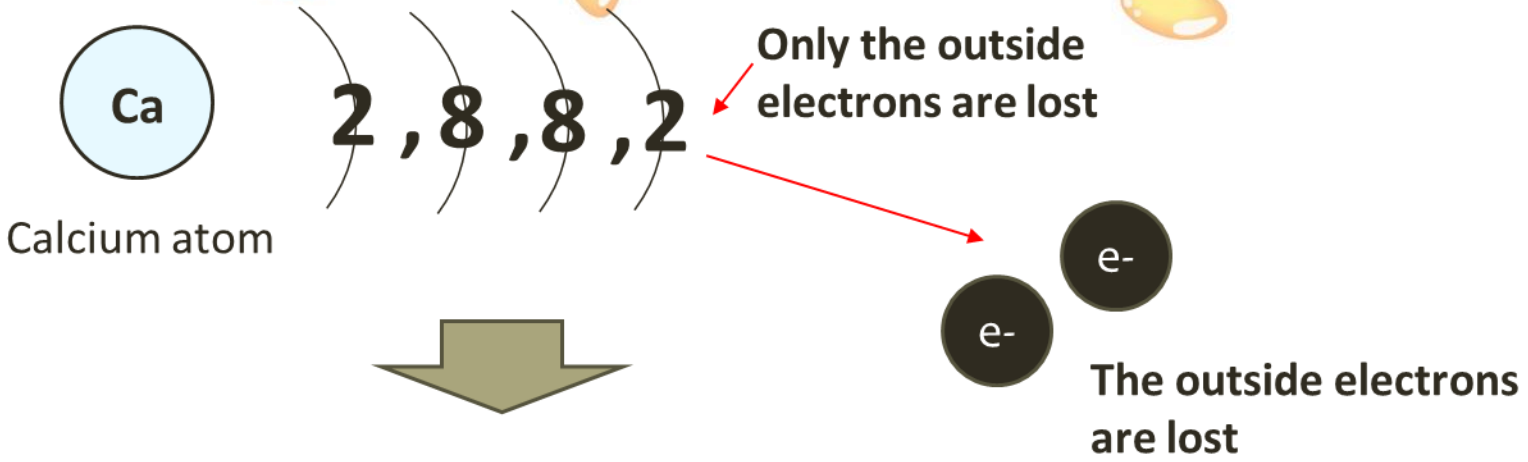
Ion Chart – Positive Ions (metals)

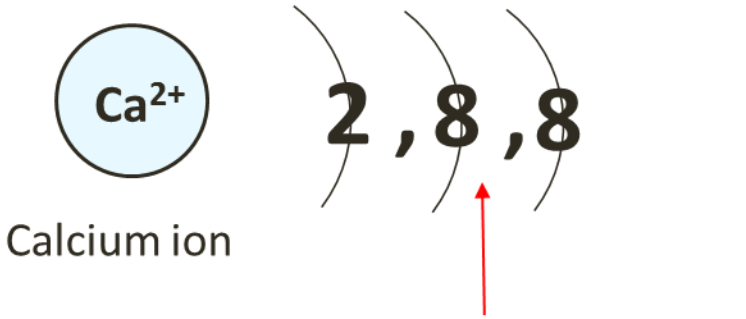
Charge on Ions		
1+	2+	3+
sodium Na^+	magnesium Mg^{2+}	aluminium Al^{3+}
potassium K^+	iron (II) Fe^{2+}	iron (III) Fe^{3+}
silver Ag^+	copper (II) Cu^{2+}	
ammonium NH_4^+	zinc Zn^{2+}	
Hydrogen H^+	barium Ba^{2+}	
Lithium Li^+	lead Pb^{2+}	

Ion chart – negative ions (non-metals)

Charge on ions			
1-		2-	
chloride	Cl^-	carbonate	CO_3^{2-}
iodide	I^-	oxide	O^{2-}
hydroxide	OH^-	sulfide	S^{2-}
hydrogen carbonate	HCO_3^-	sulfate	SO_4^{2-}
fluoride	F^-		
bromide	Br^-		
nitrate	NO_3^-		

Electron configurations of ions – Cations (metals)

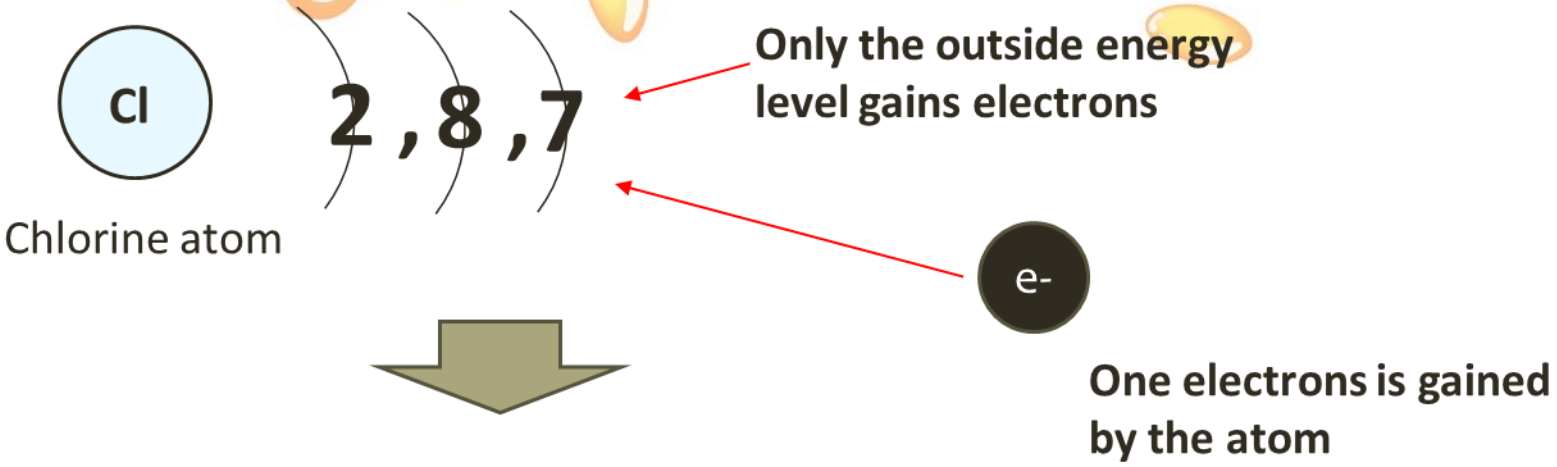


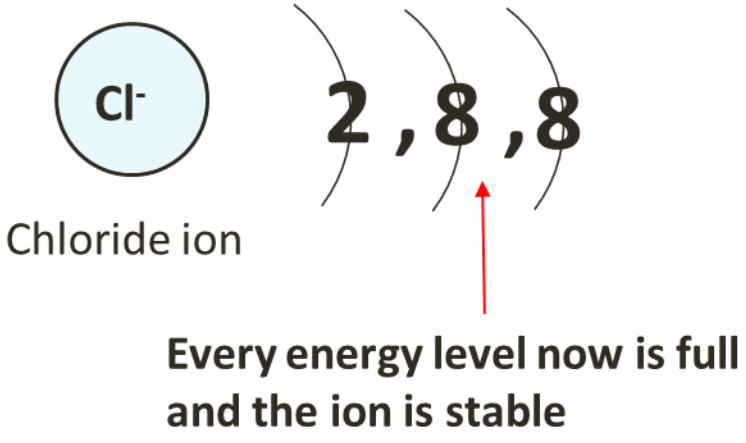


The Ca atom has 20 protons and 20 electrons so has no charge. It is neutral.

The Ca^{2+} ion has 20 protons and 18 electrons so has a 2+ charge.

Electron configurations of ions – Anions (non-metals)





The Cl atom has 17 protons and 17 electrons so has no charge. It is neutral.

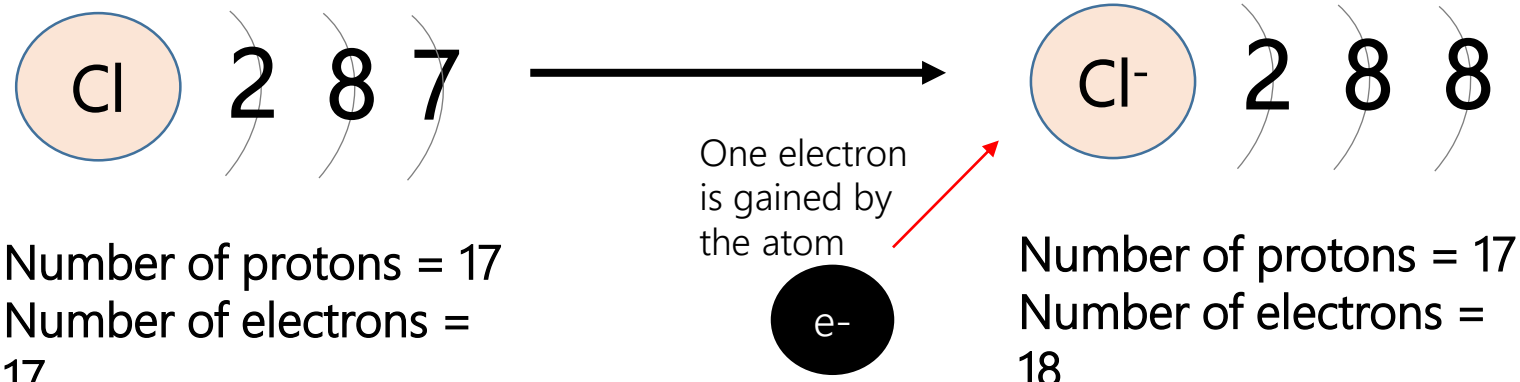
The Cl^- ion has 17 protons and 18 electrons so has a 1- charge.

NCEA 2012 Electron Configuration - (Part ONE)

Achieved Question

Question 1a: Complete the table below for ions formed by Ca, F, and Cl.

	Atomic Number	Electron arrangement of atom	Electron arrangement of ion	Ion symbol
Ca	20	2,8,8,2	2,8,8	Ca^{2+}
F	9	2,7	2,8	F^-
Cl	17	2,8,7	2,8,8	Cl^-



Number of protons = 17
Number of electrons = 17
Charge = 0 (neutral)

Number of protons = 17
Number of electrons = 18
Charge = -1

NCEA 2012 Electron Configuration - (Part TWO)

Excellence Question

Question 1b: Explain the charges on ALL three ions, in terms of electron arrangement and number of protons. Use their positions on the periodic table to explain why two of the atoms form ions with the **same charge**, AND two of the atoms form ions with the **same electron arrangement**.

	Atomic Number	Electron arrangement of atom	Electron arrangement of ion	Ion symbol
Ca	20	2,8,8,2	2,8,8	Ca^{2+}
F	9	2,7	2,8	F^-
Cl	17	2,8,7	2,8,8	Cl^-

F has 9 protons and electron arrangement of 2,7. Cl has 17 protons and an electron arrangement of 2,8,7. Both atoms are in group 17 of the periodic table as they both have 7 electrons in the valence shell. Both atoms gain one electron to have a full outer shell. For F ion the electron arrangement is 2,8, and for Cl ion it is 2,8,8.
F has a charge of –1 as it now has 10 electrons (–) and 9 protons (+). Cl has a charge of –1 as it now has 18 electrons (–) and 17 protons (+).
Ca has 20 protons and electron arrangement of 2,8,8,2. Ca has two electrons in its outer shell, which it loses, so its new outer shell is full (2,8,8) and it has a charge of +2, as it still has 20 protons (+) and now has only 18 electrons (–). Therefore Ca and Cl ions now both have the same electron configuration of 2,8,8.

NCEA 2013 Electron Configuration - (Part ONE)

Achieved Question

Question 1a: F^-, Ne, and Mg^{2+} have the **same** electron arrangement.
(a) Complete the table below.

	Atomic Number	Number of protons	Number of electrons	Electron arrangement
F^-	9	9	10	2,8
Ne	10	10	10	2,8
Mg^{2+}	12	12	10	2,8

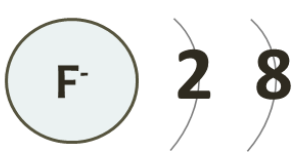
Number of proton = 9
Number of electrons = 9
Charge = 0 (neutral)

Number of proton = 9
Number of electrons = 10
Charge = -1

NCEA 2013 Electron Configuration - (Part TWO)

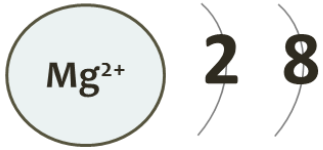
Excellence Question

Question 1b: Compare the atomic structure of F^-, Ne, and Mg^{2+}.
In your answer you should:
- describe the difference between an atom and an ion
- explain the charges on F^-, Ne, and Mg^{2+} in terms of electron arrangement and number of protons
- relate the position of F^-, Ne, and Mg^{2+} on the periodic table to the charges and electron arrangement
- explain why all three have the same electron arrangement.



Number of proton = 9
Number of electrons = 10
Charge = -1

Number of proton = 10
Number of electrons = 10
Charge = 0 (neutral)

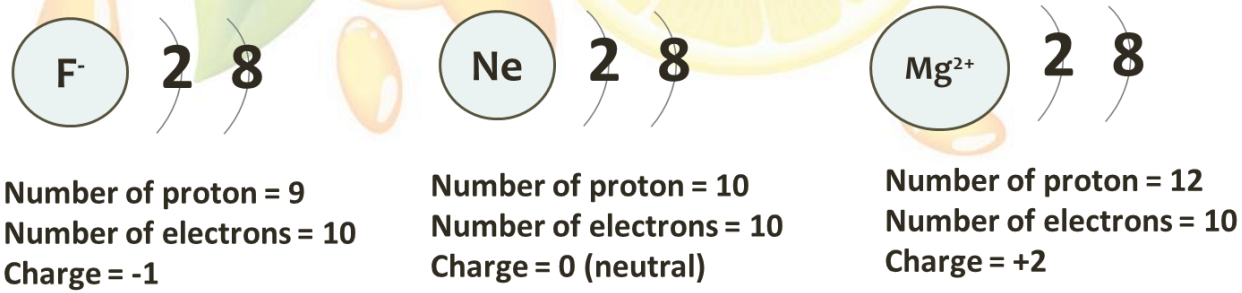


Number of proton = 12
Number of electrons = 10
Charge = +2

The difference between an ion and an atom is that an atom has a neutral charge as it has not gained or lost electrons and therefore has the same number of protons (+) and electrons (–) whereas an ion has a charge as the atom it was formed from has either gained or lost electrons to form a full outer shell and therefore has a different number of protons (+) from the number of electrons (–).

NCEA 2013 Electron Configuration - (Part TWO)

Excellence Question



Explanation of charges

Fluorine has 9 protons and electron arrangement of 2,7. Neon has 10 protons and an electron arrangement of 2,8. Magnesium has 12 protons and an electron arrangement of 2,8,2.

Fluorine gains one electron to have a full outer shell. This is because it is in group 17 and has 7 valence electrons. For fluorine ion, the electron arrangement is 2,8.

Fluorine has a charge of –1 as it now has 10 electrons (negative charges) and nine protons (positive charges).

Neon has no charge as it has the same number of protons and electrons, as it has not gained or lost electrons, as it has an electron arrangement of 2,8 because it is in group 18 of the periodic table and its valence shell is complete.

Magnesium has 12 protons and electron arrangement of 2,8,2.

Magnesium has two electrons in its outer shell as it is in group 2 of the periodic table, which it loses, so its outer shell is full (2,8) and it has a charge of +2, as it still has 12 protons (positive charges) and now has only 10 electrons (negative charges).

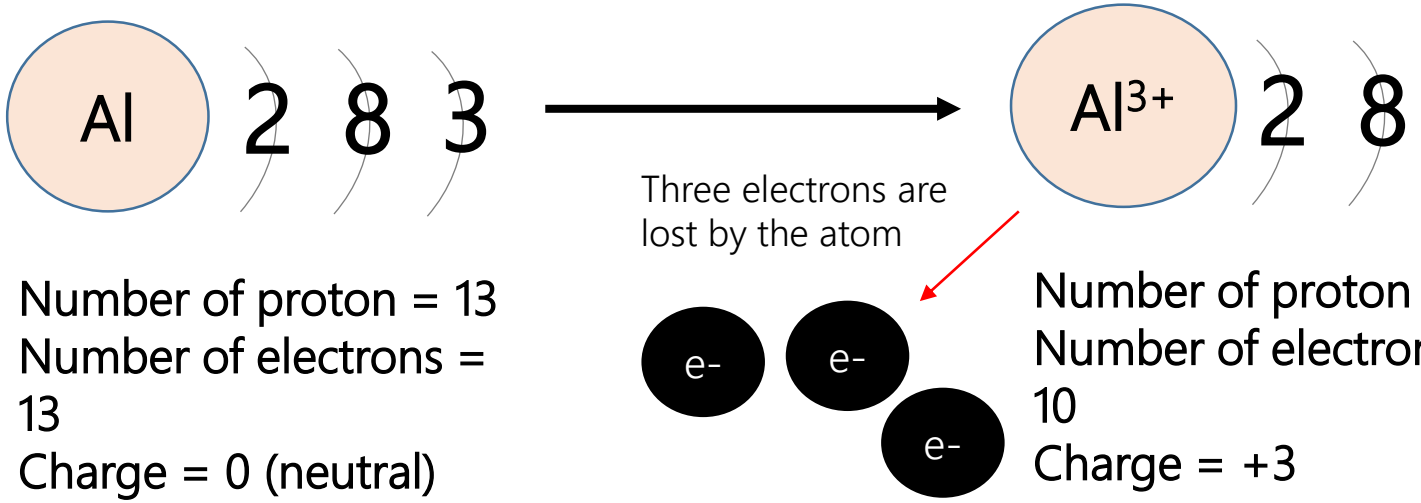
All three have the same electron arrangement as they have gained one electron, lost two electrons or have neither gained or lost electrons. The electron arrangement is 2,8 as this is the nearest possible stable electron arrangement for all three.

NCEA 2014 Electron Configuration - (Part ONE)

Achieved Question

Question 1b: Complete the table below for the ions formed by magnesium, aluminium, and oxygen.

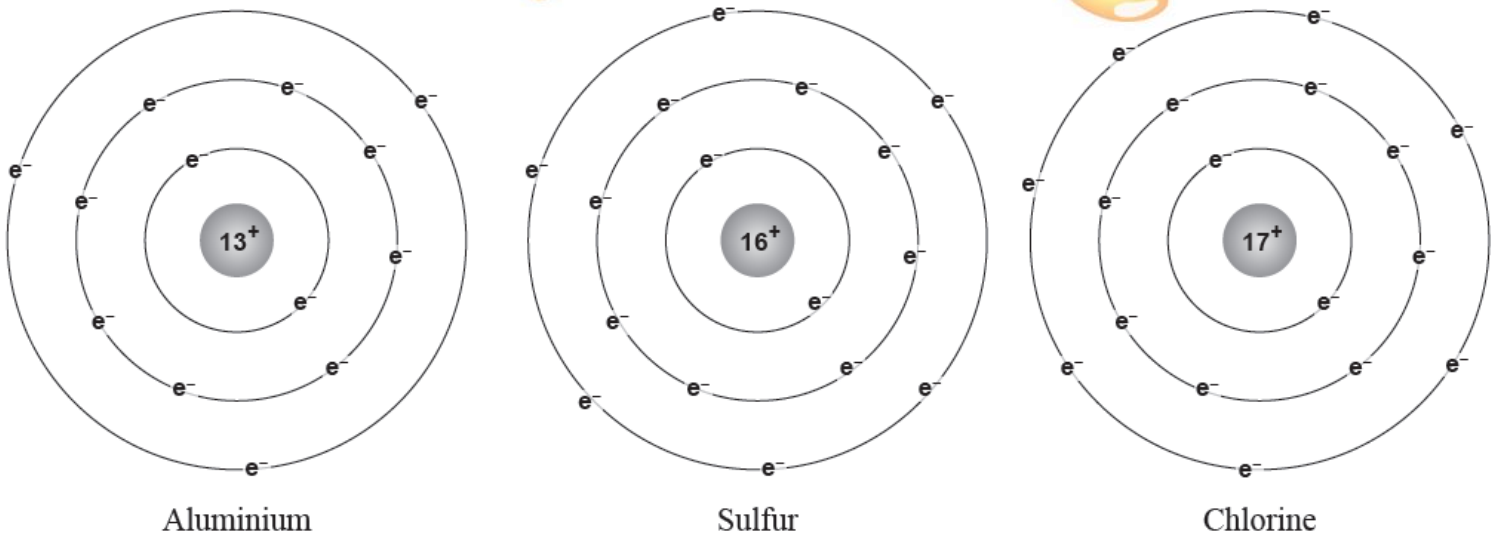
	Atomic Number	Electron arrangement of atom	Electron arrangement of ion	Charge on ion
Mg	12	2,8,2	2,8	+2
Al	13	2,8,3	2,8	+3
O	8	2,6	2,8	-2



NCEA 2015 Electron Configuration

Excellence Question

The diagrams below show models of three different atoms



Aluminium Sulfur Chlorine

Question 2a: Each of these atoms can form ions, as listed below.

- Explain why each of the **ions** has the charge it does, in terms of electron arrangement and number of protons.
- Ions are charged atoms. Explain how each of the ions below reached the charge shown.

You should discuss particles gained or lost by the atoms involved, and the reasons for this. Aluminium ion, Al^{3+}: Sulfide ion, S^{2-} : Chloride ion, Cl^{-} :

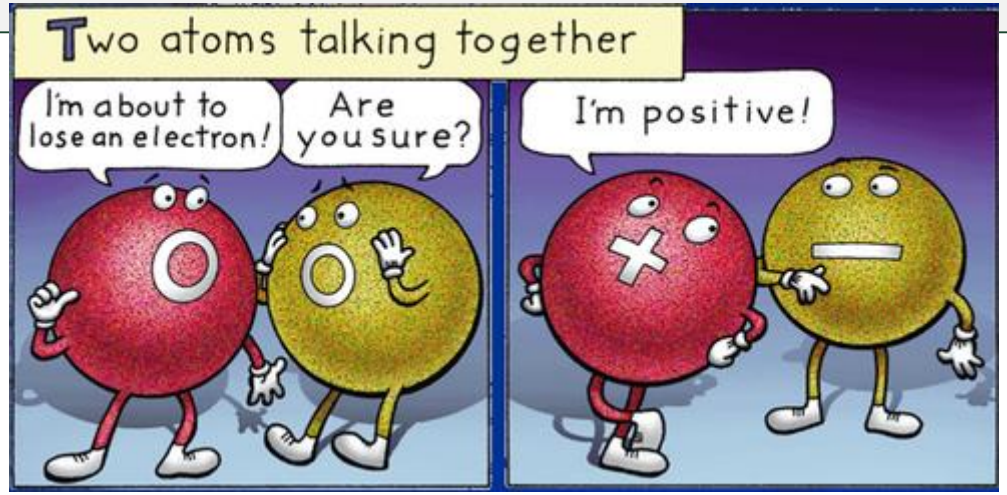
NCEA 2015 Electron Configuration

Excellence Question

Answer 2a: Al^{3+} because it has 13 protons (+ charges) and only 10 electrons (– charges). It has only 10 electrons, as its electron arrangement as an atom was 2,8,3, and when it forms an ion, it loses three electrons to form an arrangement of 2,8 to have a full outer shell, which is more stable.

S^{2-} because it has 16 protons (+ charges) and 18 electrons (– charges). It has 18 electrons, as its electron arrangement as an atom was 2,8,6, and when it forms an ion, it gains two electrons to form an arrangement of 2,8,8 to have a full outer shell, which is more stable.

Cl^{-} because it has 17 protons (+ charges) and 18 electrons (– charges). It has 18 electrons, as its electron arrangement as an atom was 2,8,7, and when it forms an ion it gains one electron to form an arrangement of 2,8,8 to have a full outer shell, which is more stable.

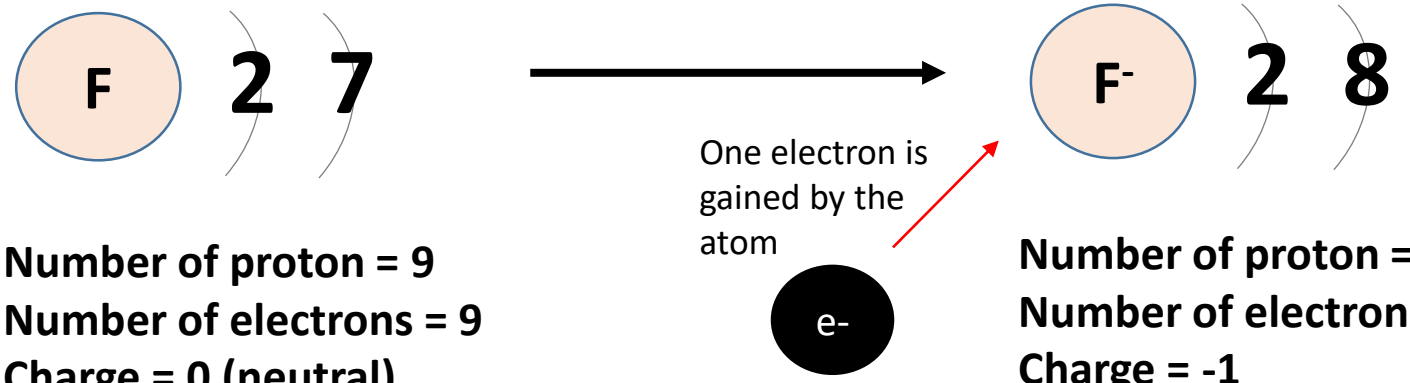


NCEA 2016 Electron Configuration

Achieved Question

Question 1a: Complete the table below.

Element	Atomic Number	Electron arrangement of atom	Electron arrangement of ion
F	9	2,7	2,8
S	16	2,8,6	2,8,8
Ca	20	2,8,8,2	2,8,8



Number of proton = 9
Number of electrons = 9
Charge = 0 (neutral)

Number of proton = 9
Number of electrons = 10
Charge = -1

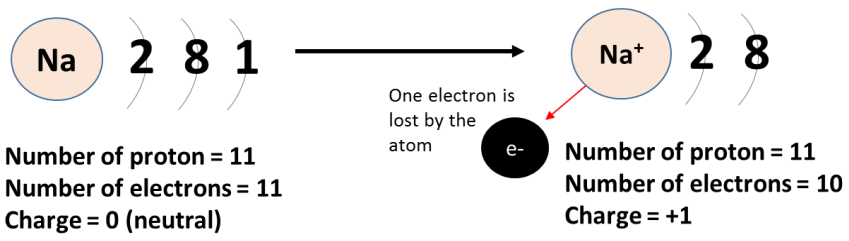
NCEA 2016 Electron Configuration

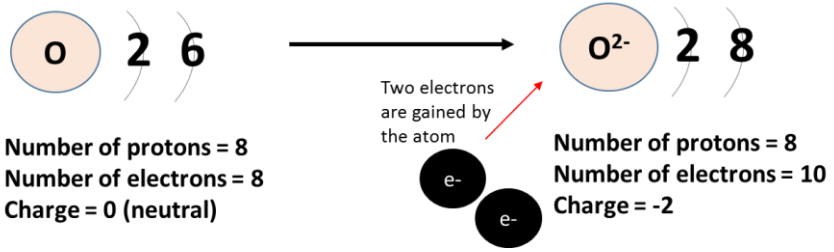
Excellence Question

Question 1c (i) : Sodium burns in oxygen gas, O_2, to form sodium oxide, Na_2O.
(i) Explain how the Na and O atoms form Na^+ and O^{2-} ions, in terms of their groups in the periodic table, electron arrangement, AND number of protons.

Answer 1c (i) : Na is a group one element, so the Na atom has one valence electron and an electron configuration of 2, 8, 1. The Na atom loses its one valence electron to gain a full outer shell – it now has 1 more proton (11) than electrons; the Na^+ ion is formed.

O is a group sixteen element, so the O atom has six valence electrons and an electron configuration of 2, 6. The O atom gains two electrons to gain a full outer shell – it now has 2 less protons (8) than electrons; the O^{2-} ion is formed.





Excellence Question

NCEA 2017 Electron Configuration (Part ONE)

Question 2a: Sodium and potassium are both highly reactive metals that react with oxygen gas. However, sodium and potassium do not react with each other.
(a) Why do sodium and potassium each react with oxygen, but not with each other?
In your answer you should:
• refer to the electron arrangements of each of the three atoms and three ions involved
• explain how the electron arrangement of each of the three atoms relates to its position in the periodic table
• explain how an ionic bond forms when sodium or potassium reacts with oxygen.

Sodium and potassium are both in Group 1 of the periodic table. This means they each have one valence electron. Their atom electron arrangements are shown below:
Na atom: 2, 8, 1
K atom: 2, 8, 8, 1
The Na and K atoms will each lose their one valence electron to gain a stable full outer shell, as shown by the ion electron arrangements below:
Na+: 2, 8
K+: 2, 8, 8

Excellence Question

NCEA 2017 Electron Configuration (Part TWO)

Question 2a: Sodium and potassium are both highly reactive metals that react with oxygen gas. However, sodium and potassium do not react with each other.
(a) Why do sodium and potassium each react with oxygen, but not with each other?

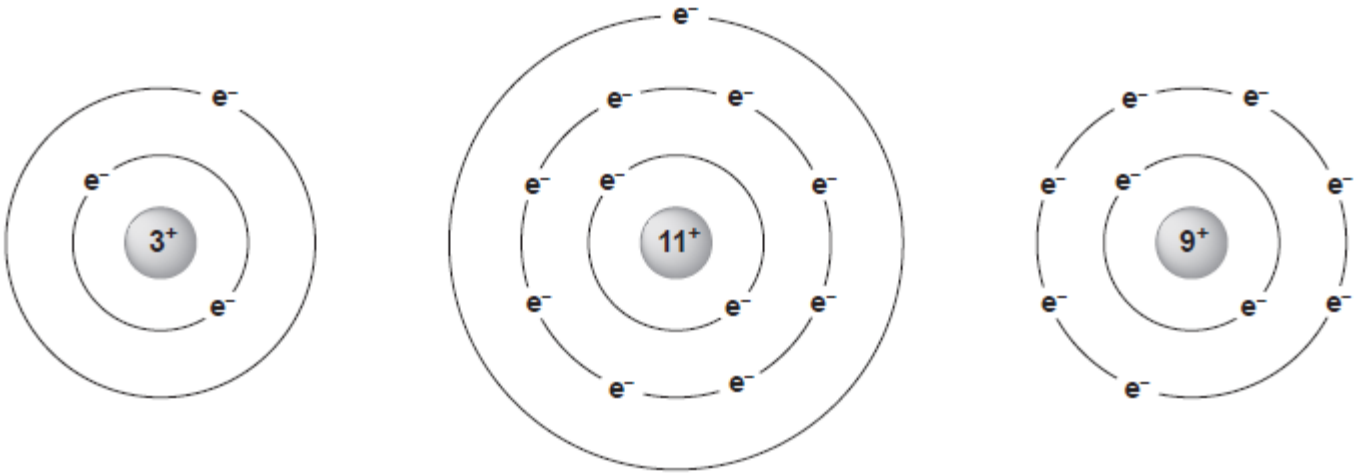
Oxygen is in Group 16 of the Periodic Table. This means it has six valence electrons. Its atom electron arrangement is:
O atom: 2, 6
The O atom will gain two electrons to gain a stable full outer shell, as shown by the ion electron arrangement below:
O^{2-}: 2, 8

Since Na and K each lose one valence electron whereas O gains two electrons, Na and K can transfer electrons to the O atom. This transfer of electrons causes ions to form; the electrostatic attraction between the oppositely charged ions (Na^+ and O^{2-}, and K^+ and O^{2-}) is called an ionic bond. Each O atom will need to react with two K / Na atoms to get the
two electrons it needs.
The Na and K atoms cannot react with each other because they each react by losing one electron. Therefore, electron transfer cannot occur between the Na and K atoms.

Merit Question

NCEA 2018 Electron Configuration (Part ONE)

Question 1a: The diagrams show models of three different atoms:
(a) Why are lithium and sodium in the same group (column) of the Periodic Table, but in different periods (rows)?



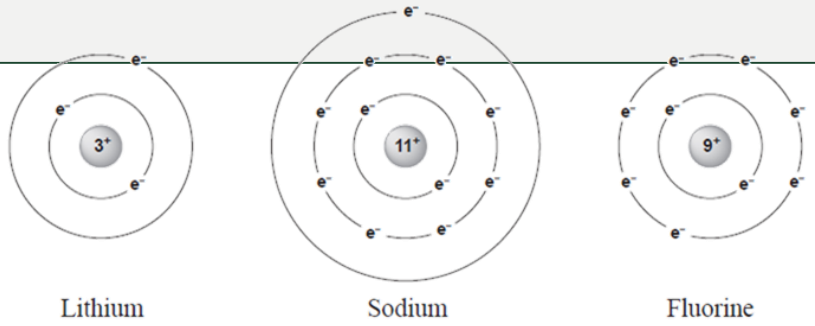
Lithium Sodium Fluorine

Both atoms have the same number of valence electrons, which determines the group (1).
The period is determined by the number of electron shells. Li has 2 electron shells so is found in Period 2; Na has 3 electron shells so is found in Period 3.

Excellence Question

NCEA 2018 Electron Configuration (Part TWO)

Question 1a: The diagrams show models of three different atoms:
(b) Sodium and fluorine form ions that both have the same electron arrangement.
How can sodium and fluoride ions have the same electron arrangement but different charges?
In your answer you should refer to the number of protons, charge, and electron arrangement of the two atoms and ions.



Na has 11 protons and electron arrangement of 2,8,1. F has 9 protons and electron arrangement of 2,7.
Both atoms need to gain or lose electrons to have a full outer shell and become stable.
Na loses one electron to form Na+ ion which has a charge of +1 as it now has 10 negative
electrons and 11 positive protons. F gains 1 electron to form F– ion which has a charge of –1 as it now has 10 negative electrons and 9 positive protons. Therefore, Na and F ions now both have the same electron arrangement of 2,8.

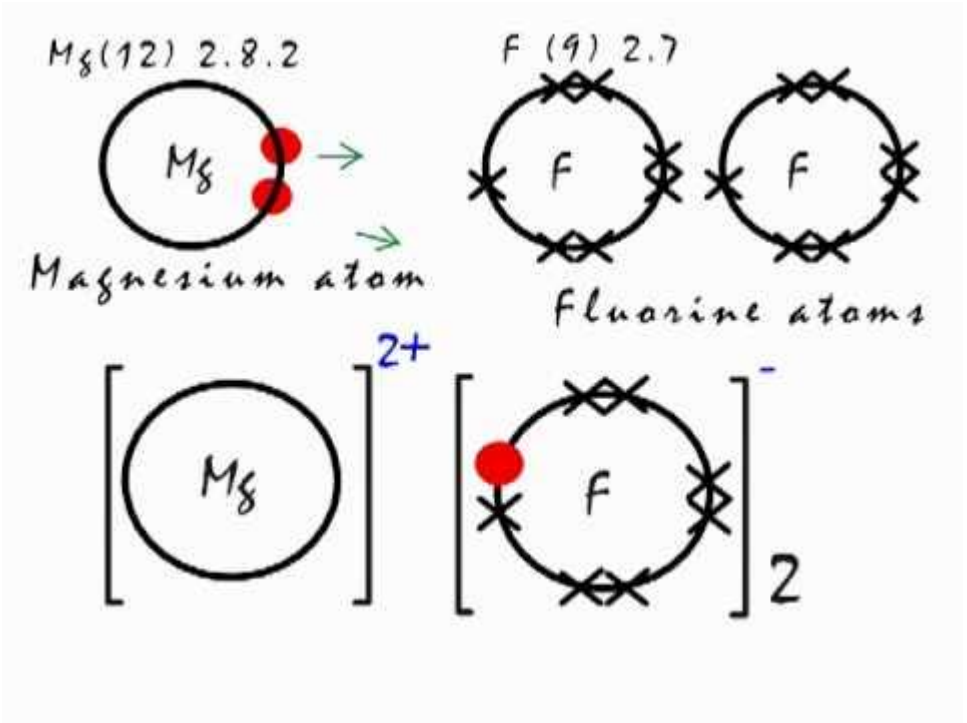
Excellence Question

NCEA 2018 Electron Configuration (Part THREE)

Question 1a: The diagrams show models of three different atoms:
(c) Magnesium fluoride has the formula MgF_2.
Explain how the ratio of ions in the formula is linked to the charge on the ions.
In your answer you should include the number of electrons gained or lost by each atom as it forms the ionic compound.
A diagram may assist your answer.

http://www.nzqa.govt.nz

Magnesium loses 2 electrons to end up with a charge of +2. Fluorine will gain only one
electron to have a charge of –1.
As Mg reacts, it loses the 2 electrons in its outer shell; one to each F atom to fill their outer shells.
In order to have a neutral compound, one magnesium ion is needed to cancel out the
charge on two fluoride ions with a combined charge of –2.



Excellence Question

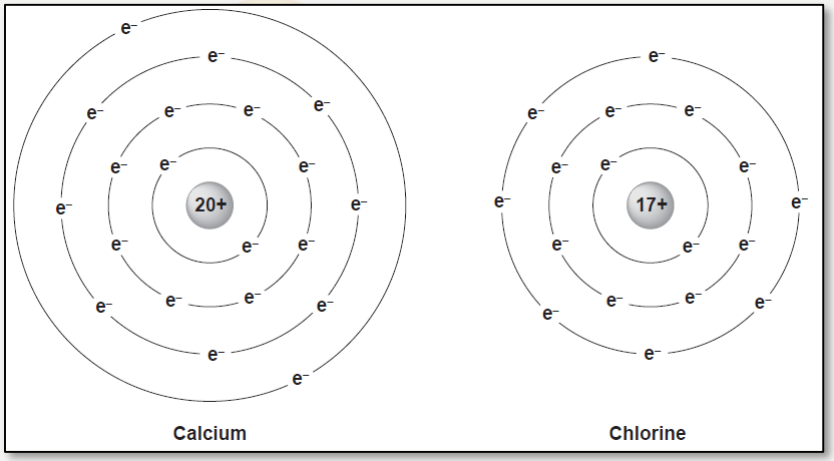
NCEA 2019 Electron Configuration (Part ONE)

http://www.nzqa.govt.nz

Question 1a: The diagram shows models of two atoms. (a) Write the electronic arrangement of the two atoms. (b(i)) and ions (ii) Explain how each ion, Ca^{2+} and Cl^{-}, is formed.

In your answer you should:

- explain why these elements form ions
- explain the charges on both **ions** in terms of electron arrangement of atoms and ions, number of protons and number of electrons, and charge.



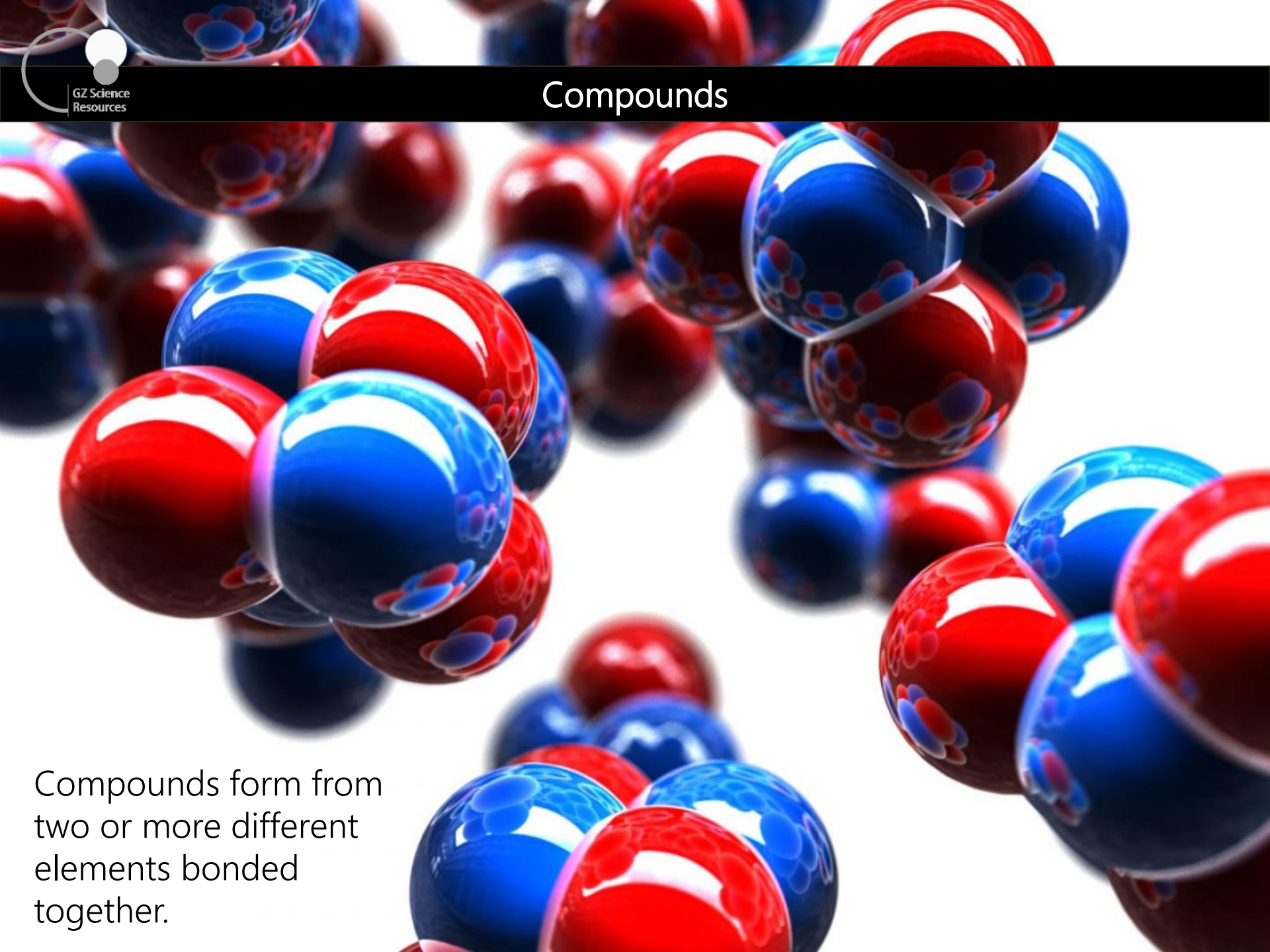
Atoms: Ca: 2,8,8,2 Cl: 2,8,7 Both **ions** have the electron arrangement 2,8,8

Cl^- because it has 17+ protons (+ charges) and 18- electrons (– charges). It has 18 electrons, as its electron arrangement as an atom was 2,8,7 and when it forms an ion, it gains one electron to form an arrangement of 2,8,8 to have a full outer shell, which is more stable.

Ca^{2+} because it has 20+ protons (+ charges) and only 18- electrons (– charges). It has only 18 electrons, as its electron arrangement as an atom was 2,8,8,2, and when it forms an ion, it loses two electrons to form an arrangement of 2,8,8 to have a full outer shell, which is more stable.

GZ Science Resources

Compounds



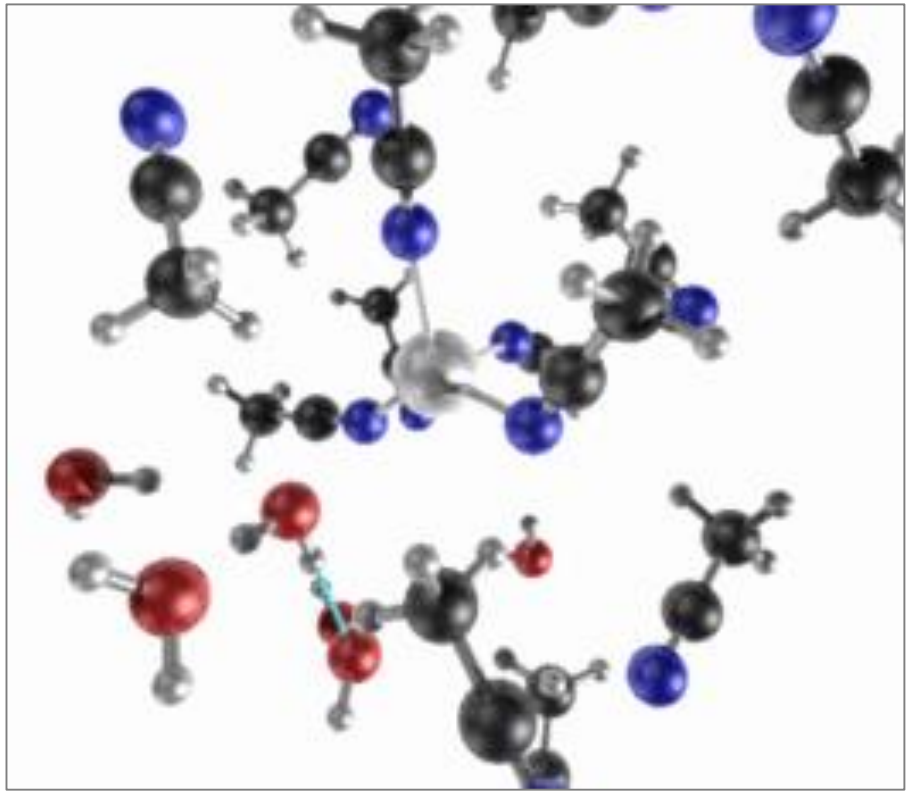
Compounds form from two or more different elements bonded together.

GZ Science Resources

Compounds

The compounds are often more stable than the elements they originated from and may release this extra energy in the form of heat and/or light when bonding together.

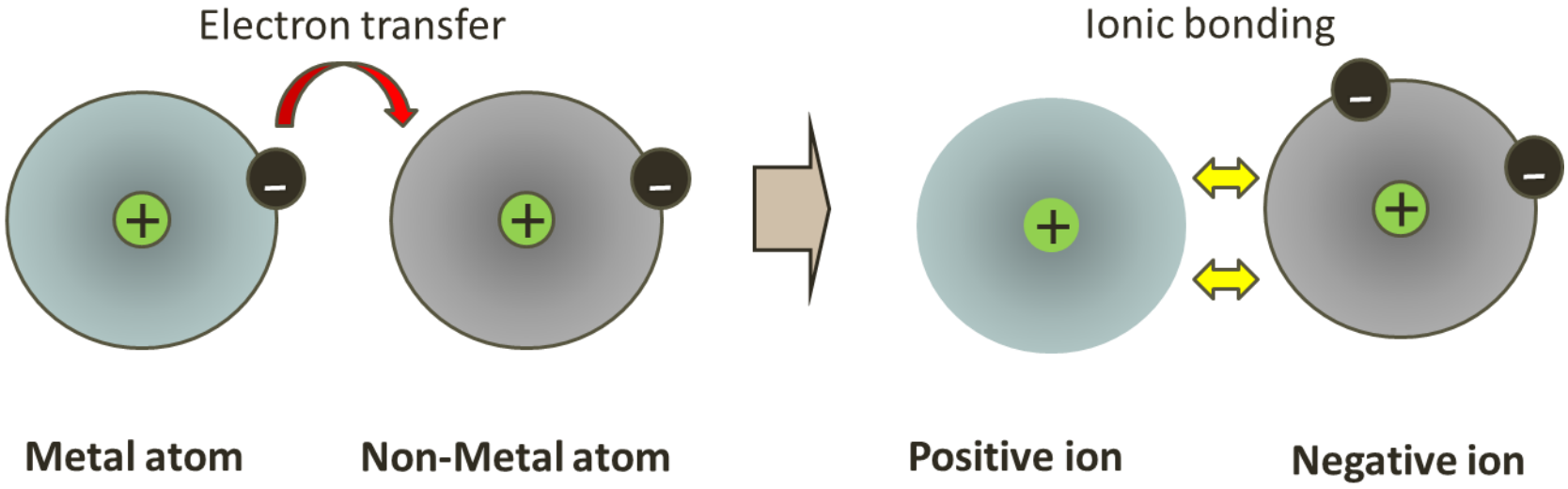
There are two main types of bonding holding atoms together in a compound; **Ionic** and **Covalent**.



Ionic Bonding

Ionic Bonding is where one atom takes valence (outside energy level) electrons from another to form ions and the resulting negative and positive ions hold together with **electrostatic attraction**. This type of bonding occurs when a **metal** and **non-metal** react and there is a **transfer of electrons** to form ions.

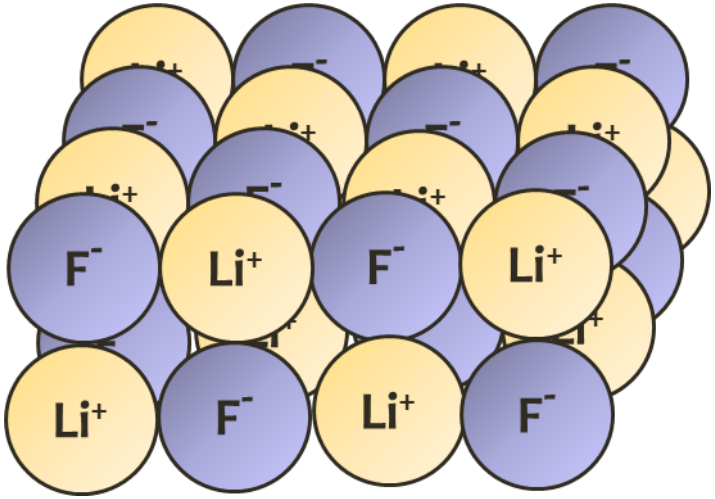
The ions then combine in a set ratio to form a neutral compound with negative and positive charges balanced out.



Ionic compounds are the product of chemical reactions between metal and non-metal ions

GZ Science Resources

Some compounds are ionic compounds, since they are made up of cations and anions.



The Anion (F) takes the electrons off the Cation (Li) so their outer energy levels have a stable 8 electrons each.
Anions and Cations have a strong electrostatic attraction for each other so they bond together as a compound.

Compounds are neutral substances. For ionic compounds, the charges of the positive ions are balanced by the charges of the negative ions.

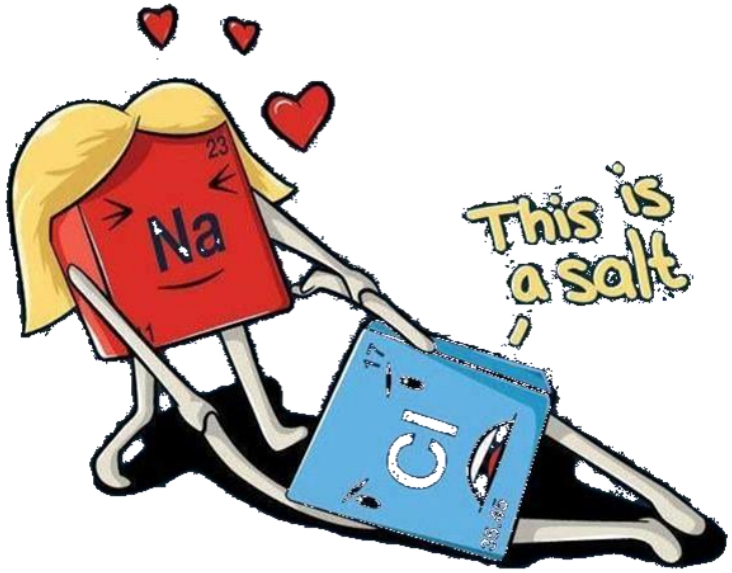
NCEA 2015 Ionic Bonding

Question 2b: Explain why an ionic bond would **not** form between a sulfide ion and a chloride ion.
In your answer you should:
- describe an ionic bond
- refer to charges and electron arrangements of the ions involved.

Excellence Question

Answer 2b: An ionic bond is the attraction between a positive ion and a negative ion. It is formed because opposite charges will attract one another.

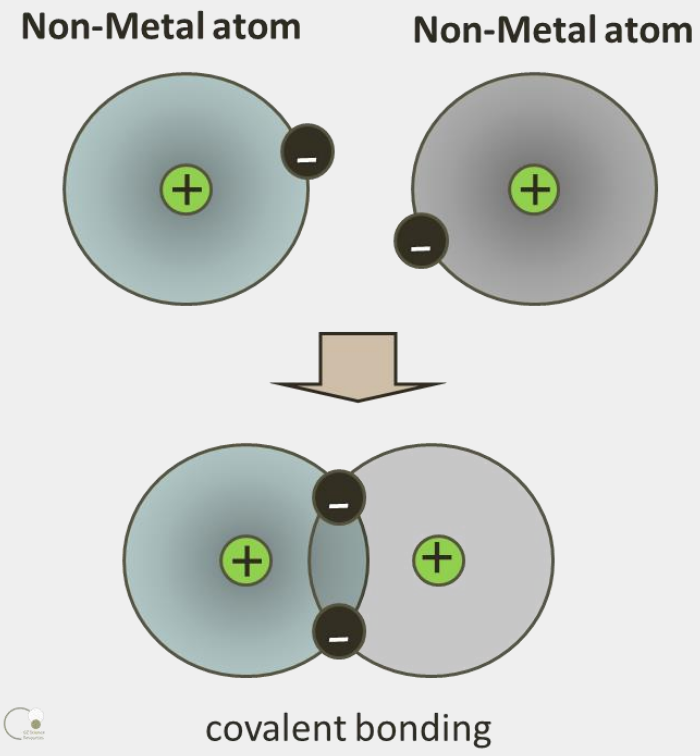
An ionic bond would not form between chloride ions and sulphide ions, as they **both have negative charges** because they have both gained negative electrons in order to form a full valence shell, and the ions with the **same charge will repel** each other.



Background Knowledge

Covalent Bonding

Covalent Bonding is where electrons are shared between neighbouring atoms. This often occurs when two or more **non-metals** react. No ions are formed and there is no transfer of electrons. The compound formed is neutral with no charge.



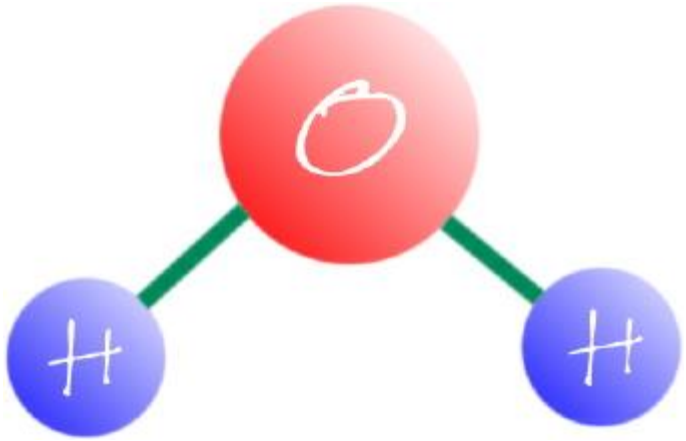
The valance electrons (electrons in outside energy level) are involved in bonding. These electrons orbit in pairs. The negative charge of the electron pair will attract the positively positive nucleus of other atoms, and this holds the atoms together in a molecule.

extra info

GZ Science Resources

Chemical compound formula

Elements in a compound combine in fixed amounts. It is possible to write a **formula** for a compound.



H_2O

This formula for water (H_2O) tells us that there are 2 Hydrogen atoms and 1 Oxygen atom in a molecule of water

Chemical compound formula

A formula tells you the type of atoms that are in a compound and the number of each atom.

2 Mg atoms 4 N atoms 12 O atoms

$$2\,Mg(NO_3)_2$$

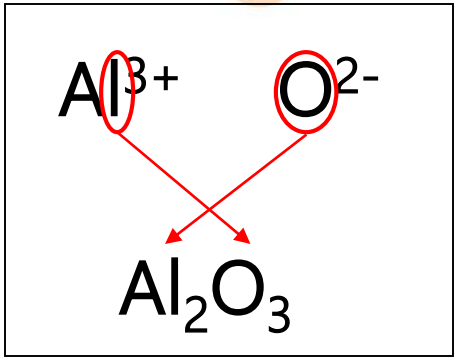
A number in front of the compound tells you how many molecules there are.

A number after an atom tells you how many atoms of that type are in the molecule.

A number after brackets tells you how many times to multiply every atom inside the brackets.

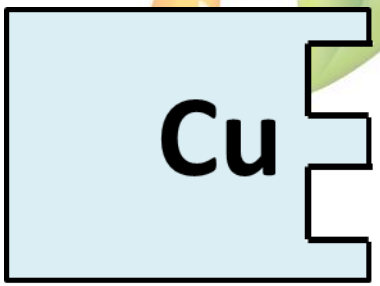
Writing Chemical compound formula

1. Write down the ions (with charges) that react to form the compound. Cation comes before Anion.



2. Cross and drop the charge numbers.
3. Place brackets around a compound ion.
4. If the numbers are both the same remove.
5. If any of the numbers are a 1 they are removed
6. Remove any brackets if not followed by a number

The visual method for balancing compounds



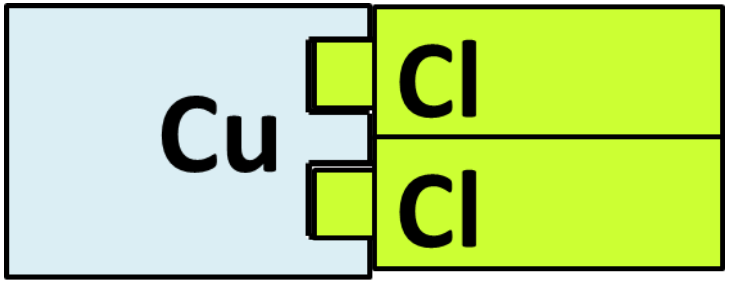
Copper

Chloride

Copper forms a positive copper ion of Cu^{2+}. It loses 2 electrons – shown by the 2 "missing spaces" in the shape

Chlorine forms a negative chloride ion of Cl^- . It gains 1 electron – shown by the 1 "extra tab" in the shape

If we want to form a balanced ionic compound then each space in the positive ion must be filled by a tab from the negative ion. In this case 2 chloride ions are needed for each copper ion to form copper chloride.



Copper Chloride

GZ Science Resources

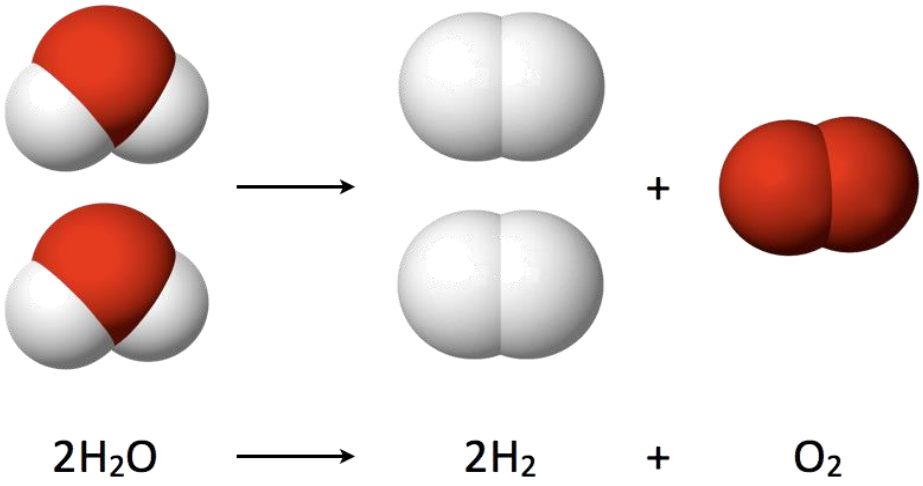
The visual ion chart

Cation			Anion	
1+	2+	3+	2-	1-
H Hydrogen	Mg Magnesium	Fe Iron (III)	O Oxide	Cl Chloride
Na Sodium	Ca Calcium		SO_4 Sulfate	OH Hydroxide
K Potassium	Cu Copper	Al Aluminium	CO_3 Carbonate	NO_3 Nitrate
NH_4 Ammonium	Pb Lead		S Sulfide	HCO_3 Hydrogen Carbonate
Ag Silver	Zn Zinc	Fe Iron (III)		F fluoride
Li Lithium	Fe Iron (II)			

Chemical Reactions - reactants & products

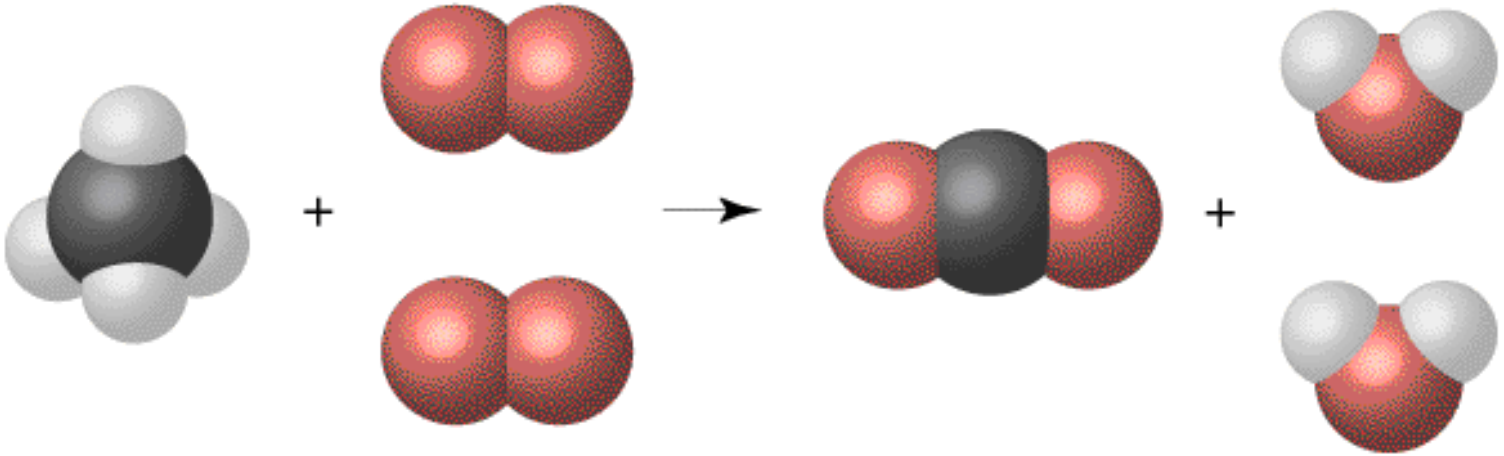
A **chemical reaction** is a process that produces a chemical change to one or more substances.
A chemical reaction will produce a **new substance.** Other observations may include a temperature change, a colour change or production of gas.
Chemicals that are used in a chemical reaction are known as **reactants**. Those that are formed are known as **products**.
Chemical reactions between particles involve breaking bonds and forming new bonds.

Reactants → Products



Chemical equations

Compounds and elements can react together to form new substances in a **chemical reaction**. We use a **chemical equation** to show the substances we start with, called **reactants**, and the substances that are formed called **products**.



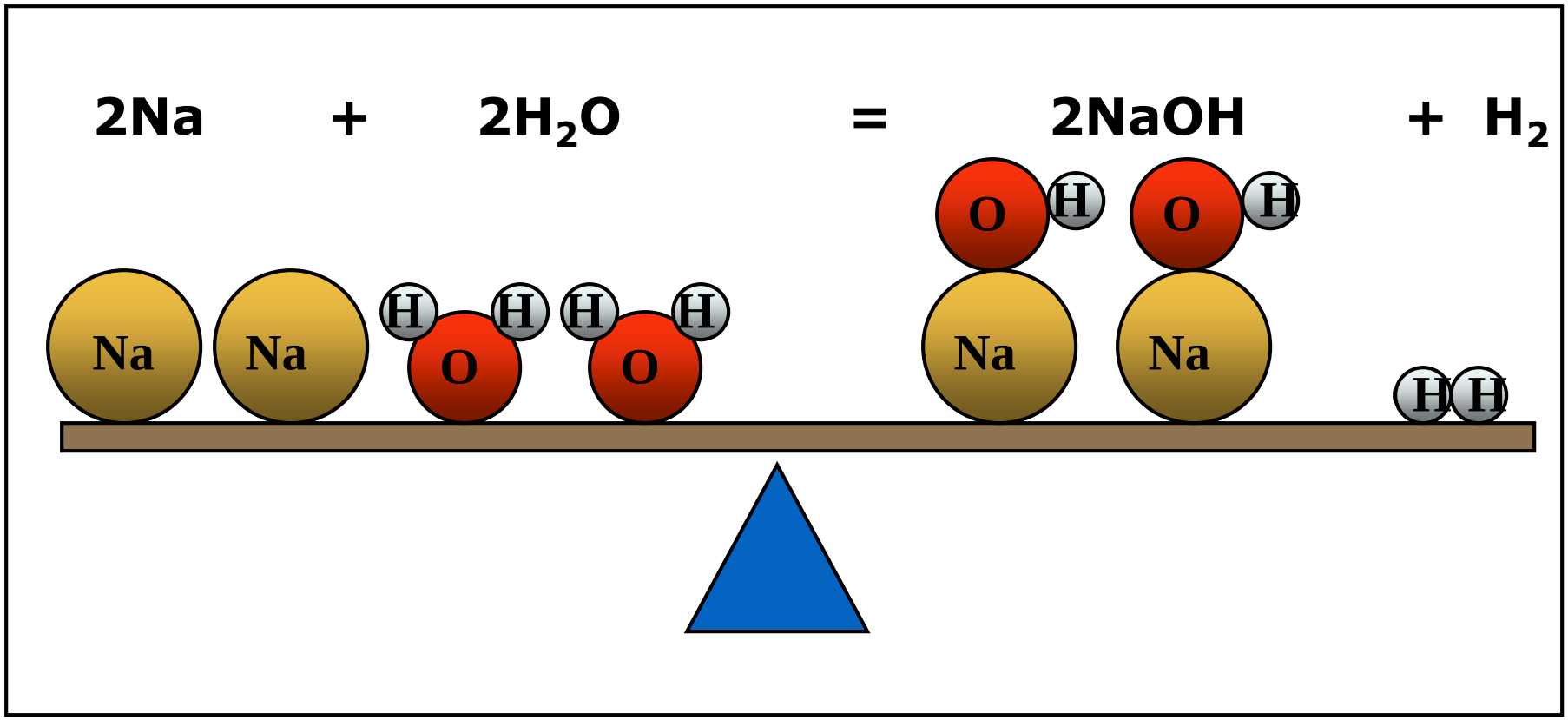
One methane molecule + Two oxygen molecules → One carbon dioxide molecule + Two water molecules

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

(1 C, 4 H) (4 O) (1 C, 2 O) (2 O, 4 H)

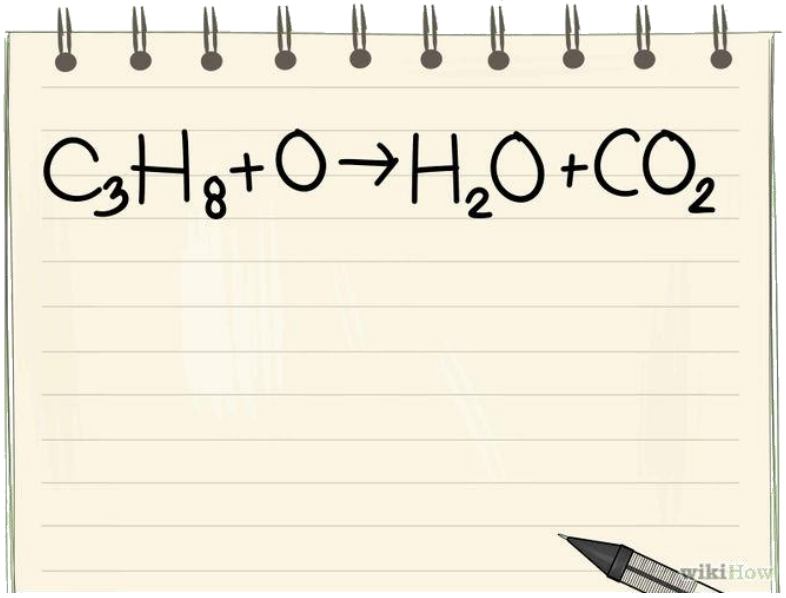
Balancing chemical equations

Balanced equations must have the same number of atoms on each side of the equation i.e. reactants and products.

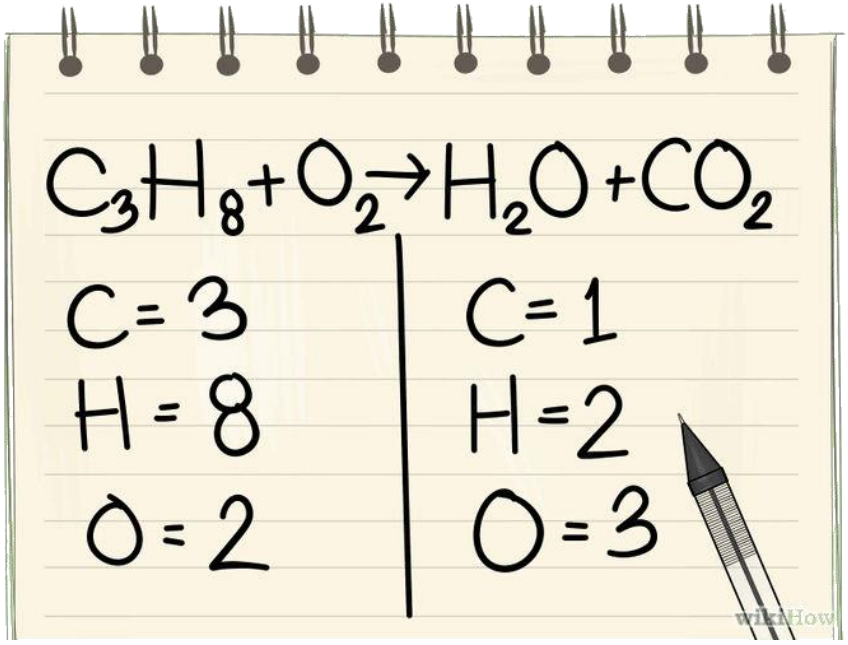


Balancing Chemical equations

1. To balance an equation first write down the equation



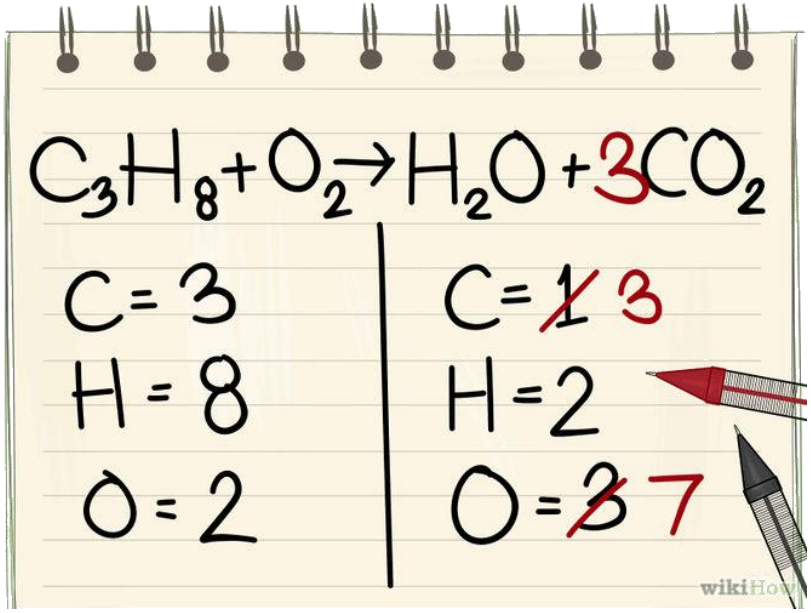
2. Count the total number of each atom for reactants and products



The total number of each type of atom must be the same for reactants and products if they equation is balanced

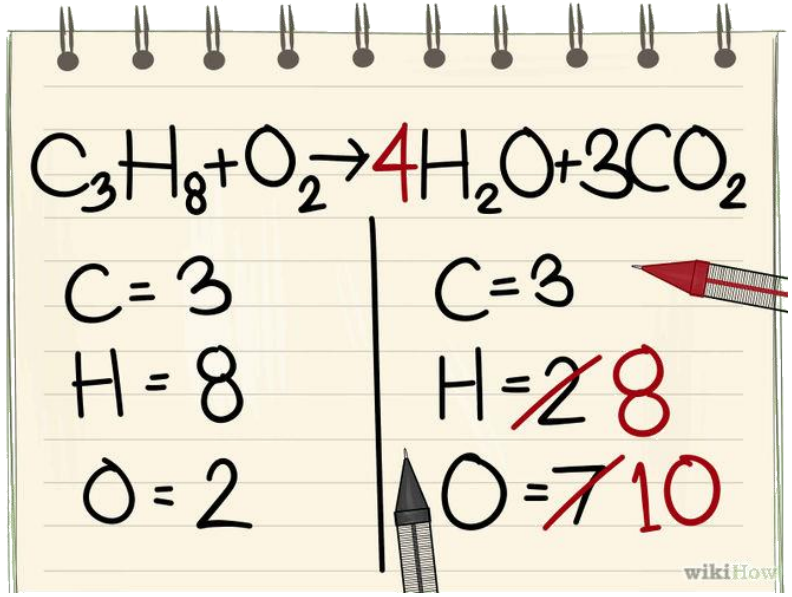
Balancing Chemical equations

3. Starting with the first atom (C) **multiply until it is the same on both sides** – and place this number in front of the compound. You may change the number of another atom but you can sort this as you move down the list



Only put numbers in front of compounds **NOT** after an atom as this changes the formula

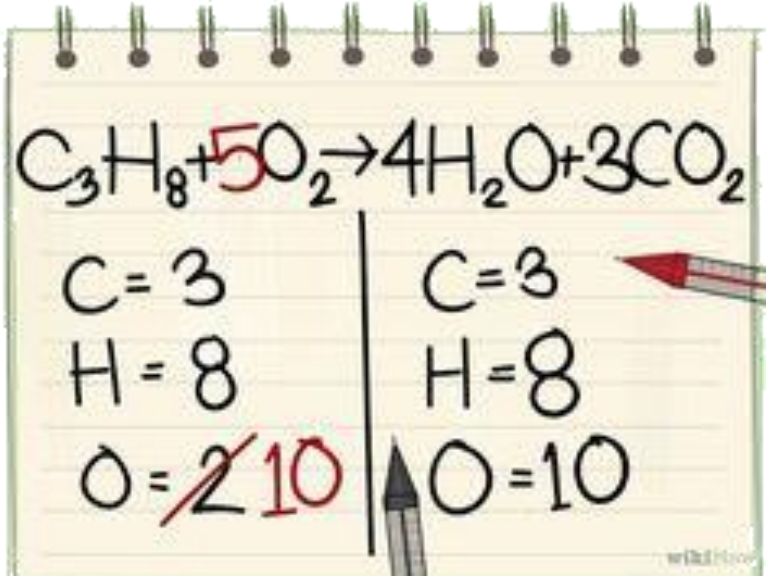
4. Moving down the list to the next atom (H) multiply until both sides are the same – again you may also increase another atom but sort that out after



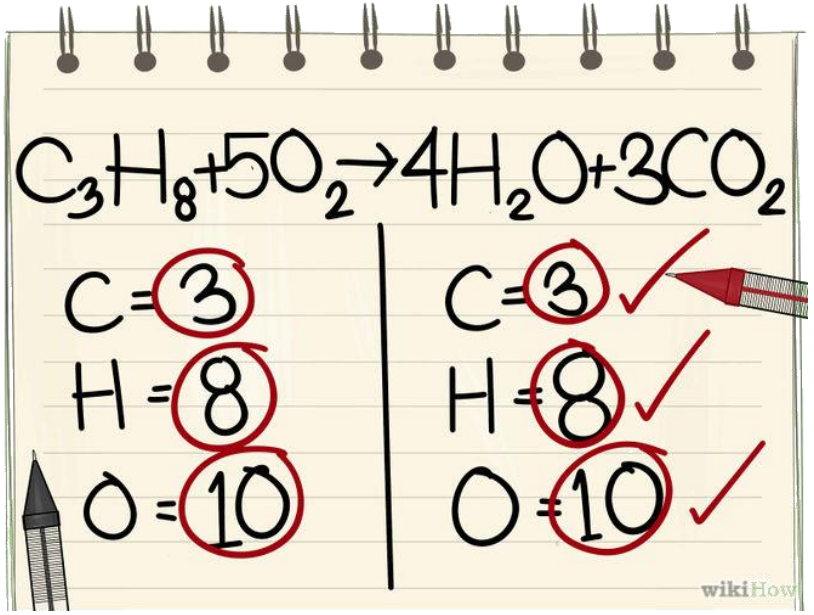
Balancing Chemical equations

Sometimes you may have to go back and rebalance another atom again for the second time

5. Moving to the last atom on this list (O) multiply until it is the same number on both sides



6. If all atoms are **the same number on both sides** then the equation is **balanced**!



NCEA 2014 Ionic Compounds - (part one)

Excellence Question

Q: The formula for magnesium oxide is MgO. The formula for aluminium oxide is Al_2O_3.Explain why the two formulae are different.
In your answer:
- consider the ratio of ions in each formula and explain how the ratio is related to the charge on the ions
- relate the ratio of ions in the formula to the number of electrons lost or gained by each atom..

<u>Fully explains the ratio of ions in magnesium oxide</u>

Step one: charge of ions - Magnesium ion has a charge of +2 and oxide ion has a charge of –2.
Step two: neutral compounds - A compound overall has to have no charge. Therefore the +2 charge of magnesium ion cancels out the –2 charge of oxide ion and so therefore the ratio of ions is one to one.
Step three: movement of electrons - The charge on the ions arises as magnesium has to lose two electrons in order to have a full outer shell and gets a charge of +2, and oxygen has to gain two electrons in order to have a full outer shell and gets a charge of –2.

NCEA 2014 Ionic Compounds - (part two)

Excellence Question

Q: The formula for magnesium oxide is MgO. The formula for aluminium oxide is Al_2O_3.Explain why the two formulae are different.
In your answer:
- consider the ratio of ions in each formula and explain how the ratio is related to the charge on the ions
- relate the ratio of ions in the formula to the number of electrons lost or gained by each atom..

<u>Fully explains the ratio of ions in aluminium oxide</u>

Step one: charge of ions - Aluminium ion has a charge of +3, and oxide ion has a charge of -2.
Step two: neutral compounds - A compound overall has to have no charge. two aluminium ions with a combined charge of +6 are required to cancel out the charge on three oxide ions with a combined charge of –6.
Step three: movement of electrons - The charge on the ions arises as aluminium has to lose three electrons in order to have a full outer shell and gets a charge of +3, and oxygen has to gain two
electrons in order to have a full outer shell and gets a charge of –2.

NCEA 2014 Ionic Compounds

Achieved Question

Question 1a: Write the formulae for the following ionic compounds.
(i) Calcium chloride
(ii) Sodium nitrate
(iii) Zinc nitrate

Answer 1a:
Calcium chloride- $CaCl_2$
Sodium nitrate - $NaNO_3$
Zinc nitrate - $Zn(NO_3)_2$

NCEA 2015 Ionic Compounds - (Part ONE)

Excellence Question

Question 2c: Determine the ionic formulae of the compound that forms when aluminium combines with chlorine, AND when aluminium combines with sulfur.
In your answer you should:
• consider the ratio of ions in each formula, and explain how the ratio is related to the charge on the ions
• relate the ratio of ions in each formula to the number of electrons lost or gained by each atom when forming ions.
Aluminium and chlorine: Aluminium and sulfur:

Answer 2c: Elements 1 and 3: $AlCl_3$

Aluminium has a charge of +3. In order to have a neutral compound overall, one aluminium ion is required to cancel out the charge on three chloride ions with a combined charge of –3. The charge on the aluminium ion arises as it gives away three electrons in order to have a full outer shell. Because it has to give 3 electrons away and each chlorine has to accept one electron, in order to have a full shell, the ratio of ions required is one to three.

NCEA 2015 Ionic Compounds - (Part TWO)

Excellence Question

Question 2c: Determine the ionic formulae of the compound that forms when aluminium combines with chlorine, AND when aluminium combines with sulfur.
In your answer you should:
• consider the ratio of ions in each formula, and explain how the ratio is related to the charge on the ions
• relate the ratio of ions in each formula to the number of electrons lost or gained by each atom when forming ions.
Aluminium and chlorine: Aluminium and sulfur:

Answer 2c: Element 1 and 2: Al_2S_3
The aluminium ion has a charge of +3. In order to have a neutral compound overall, two aluminium ions with a combined charge of +6 are required to cancel out the charge on three 2^- sulfide ions with a combined charge of –6.
The charge on the aluminium ion arises as aluminium gives away three electrons in order to have a full outer shell. Because it has to give 3 electrons away and sulfur has to accept two electrons in order to have a full shell, the ratio of ions required is two to three.

NCEA 2016 Ionic Compounds

Achieved Question

Question 1b: Write the formulae for the following ionic compounds.
(i) Silver fluoride
(ii) Potassium sulfate
(iii) Calcium nitrate

Answer 1b:
Silver fluoride - AgF
Potassium sulfate - K_2SO_4
Calcium nitrate - $Ca(NO_3)_2$

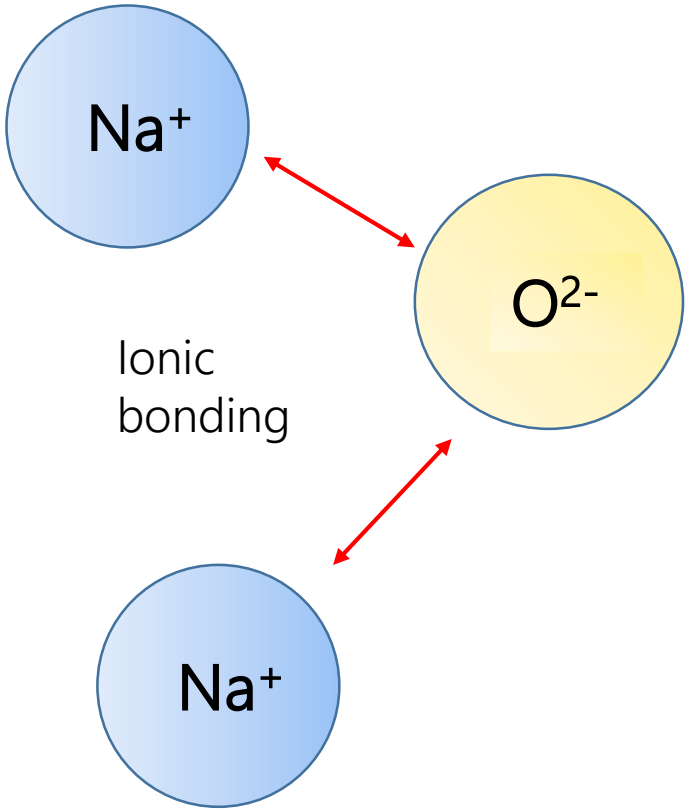
NCEA 2016 Ionic Compounds

Excellence Question

Question 1c (ii): Justify the ratio of Na^+ and O^{2-} ions in the formula Na_2O, in terms of the **electrons** lost or gained, and the **charge** on each ion.
Include an explanation of the **type of bonding** between the Na^+ and O^{2-} ions.

Answer 1c (ii):

- The Na atom **loses one electron** to form the Na^+ ion; however, the O atom requires two electrons to fill its outer shell. Therefore, **two Na atoms react for every one O atom**.
- The two Na^+ ions have a total charge of +2 to balance the –2 charge of the O^{2-} ion, i.e. an ionic compound has no overall charge.
- The bonding / attraction between the Na^+ ions and the O^{2-} ions is an **ionic bond**, formed when the electrons lost by the Na are gained by the O.



Excellence Question

NCEA 2017 Ionic Compounds

Question 3a: (i) Explain why silver oxide, Ag_2O, has a 2:1 ratio of ions.

http://www.nzqa.govt.nz

In your answer you should:

- relate the ratio of ions to the number of electrons lost or gained by each atom when forming ions
- explain how the ratio of the ions in the compound is related to the charge on the ions.

https://dir.indiamart.com/ahmedabad/silver-oxide.html

Answer 3a:

Each silver (Ag) atom loses one electron to form the Ag^+ ion;
however, each oxygen atom requires two electrons to fill its outer shell. Therefore, two Ag atoms react for every O atom,
i.e. two Ag atoms lose 2 electrons and one O atom gains 2 electrons.
The two Ag^+ ions have a total charge of +2 to balance the –2 total charge of the O^{2-} ion, i.e. an ionic compound has no overall charge.

Excellence Question

NCEA 2018 Ionic Compounds

http://www.nzqa.govt.nz

Question 1c: Magnesium fluoride has the formula MgF_2.
Explain how the ratio of ions in the formula is linked to the charge on the ions.
In your answer you should include the number of electrons gained or lost by each atom as it forms the ionic compound.
A diagram may assist your answer.

Magnesium loses 2 electrons to end up with a charge of +2. Fluorine will gain only one electron to have a charge of –1.
As Mg reacts, it loses the 2 electrons in its outer shell; one to each F atom to fill their outer shells.
In order to have a neutral compound, one magnesium ion is needed to cancel out the charge on two fluoride ions with a combined charge of –2.

Must fully explain the ratio of ions in magnesium fluoride, including electrons gained by 2 fluorine atoms equals the electrons lost by 1 magnesium AND the charge on Mg balances the charge on the 2 Fs.

Excellence Question

NCEA 2019 Ionic Compounds

http://www.nzqa.govt.nz

Question 2c: Calcium reacts with chlorine, forming the ionic compound calcium chloride, $CaCl_2$.
Explain the ratio of calcium ions to chloride ions in $CaCl_2$.
In your answer you should explain:
- how the ratio is related to the charge on the ions
- the number of electrons gained or lost by each atom as it forms the ionic compound.

Calcium loses 2 electrons to form Ca^{2+} ending up with a charge of +2. Chlorine will gain only one electron to become Cl– and have a charge of –1. As Ca reacts, it loses the 2 electrons in its outer shell; one to each Cl atom to fill their outer shells. In order to have a neutral compound, one Calcium ion is needed to cancel out the charge on two chloride ions with a combined charge of –2.

The Ca atom needs to lose 2 electrons but Cl only need to gain one so that each will have a full outer shell and be stable. Ca ion has a charge of +2 while Cl has –1 so there needs to be two Cl's so that they can accept one electron each from Ca / Ca needs two Cl's so it can give one electron to each.
The charges then cancel each other out to make a compound with a neutral / no / zero charge.