*

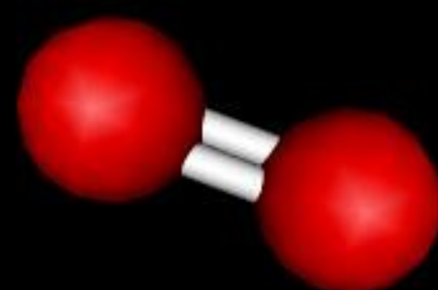
EdExcel Unit C2 – Discovering Chemistry

N Smith
St. Aidan's

Topic 1 – Atomic Structure and the Periodic Table

Periodic Table Introduction

How would you arrange these elements into groups?



Development of the Periodic Table

1817: Johann Dobereiner developed the law of "triads" – he put elements together in groups of 3 according to their properties.

1864: John Newlands arranged the known elements in order of atomic mass and found out that every 8th element had similar properties:

Li	Be	B	C	N	O	F	Na	Mg	Al

1869: Dimitri Mendeleev arranged the known elements in order of mass but he also left in gaps and was able to predict the properties of unknown elements:

Li	Be	B	C	N	O	F		Na	Mg	Al

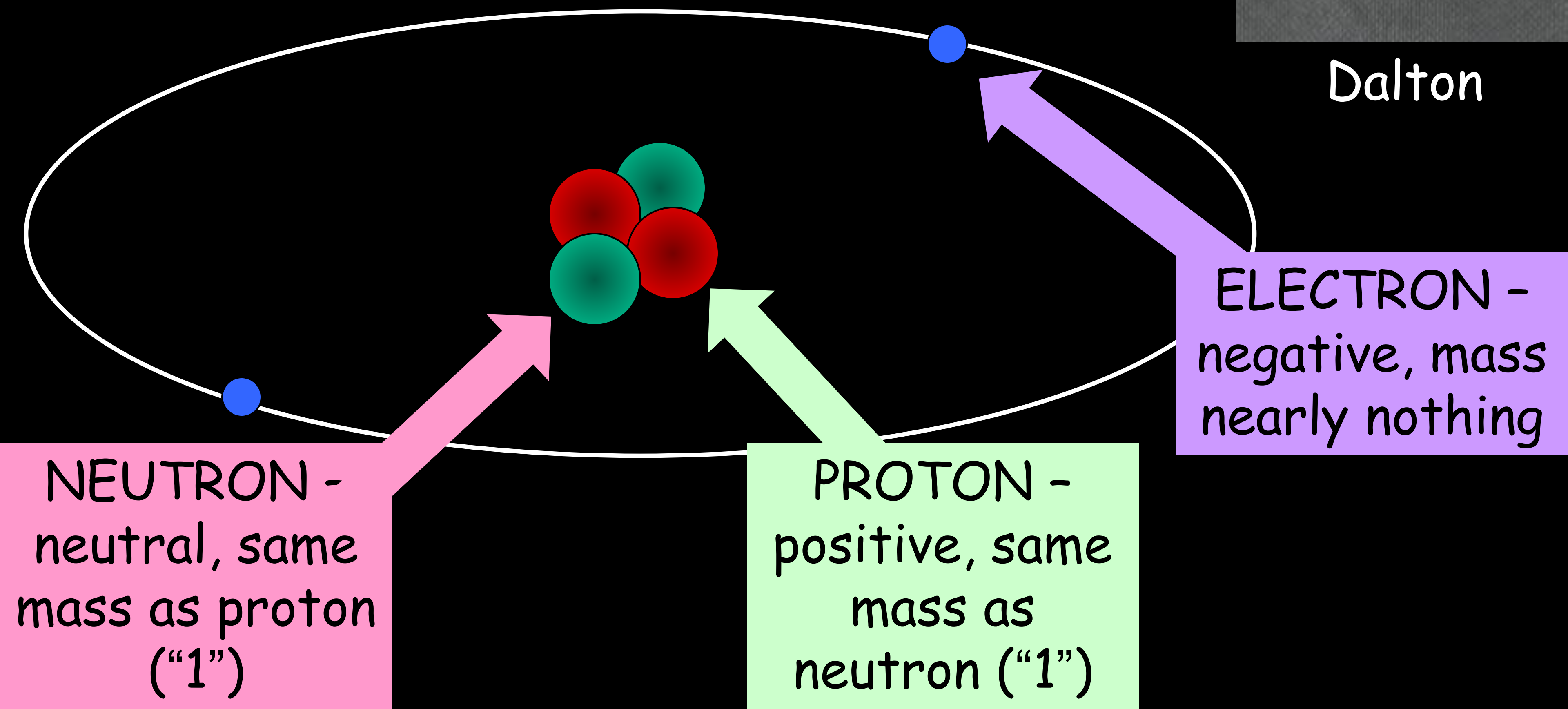
1913: Henry Moseley proposed the use of atomic number rather than atomic mass.

The structure of the atom

*

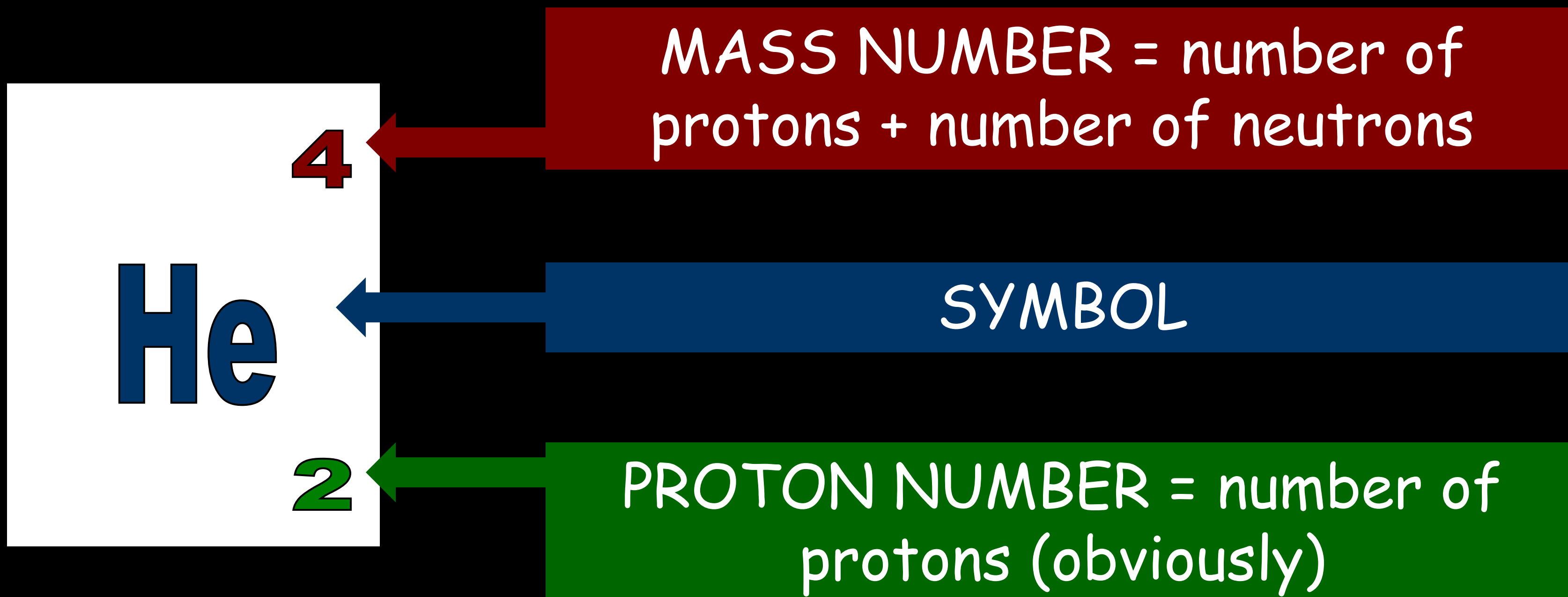
I did some experiments in 1808 that proved this and called these particles ATOMS. Most of an atom is empty space and the nucleus is actually very small so this diagram is wrong:

Dalton

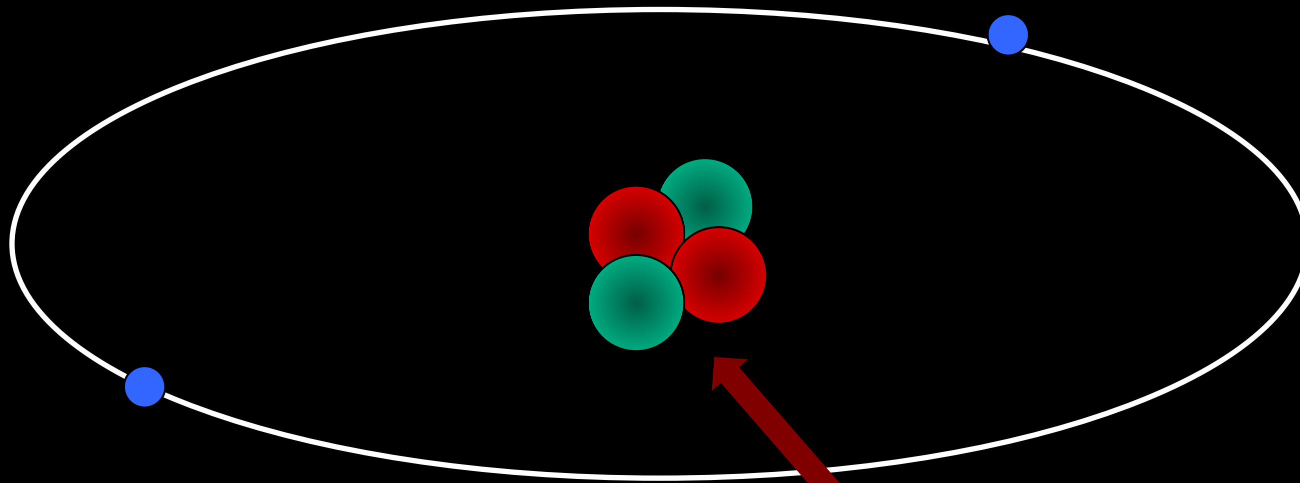


Mass and atomic number

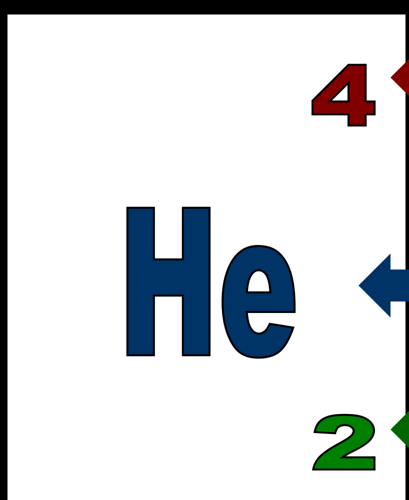
Particle	Relative Mass	Relative Charge
Proton	1	+1
Neutron	1	0
Electron	Very small	-1



Atomic mass in more detail



RELATIVE ATOMIC MASS, A_r ("Mass number") = number of protons + number of neutrons



SYMBOL

PROTON NUMBER = number of protons (obviously) – this number is always the same for an element

*

Mass and atomic number

How many protons, neutrons and electrons?

$^{1}_{1}\mathrm{H}$

$^{11}_{5}\mathrm{B}$

$^{16}_{8}\mathrm{O}$

$^{23}_{11}\mathrm{Na}$

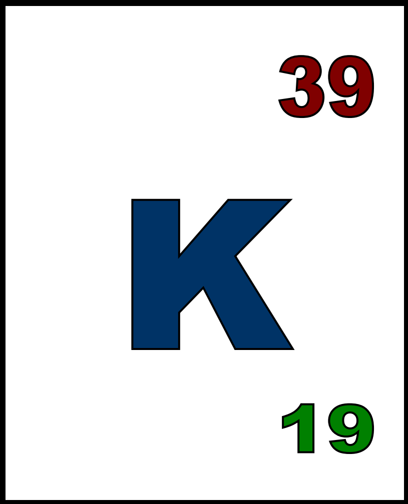
$^{35}_{17}\mathrm{Cl}$

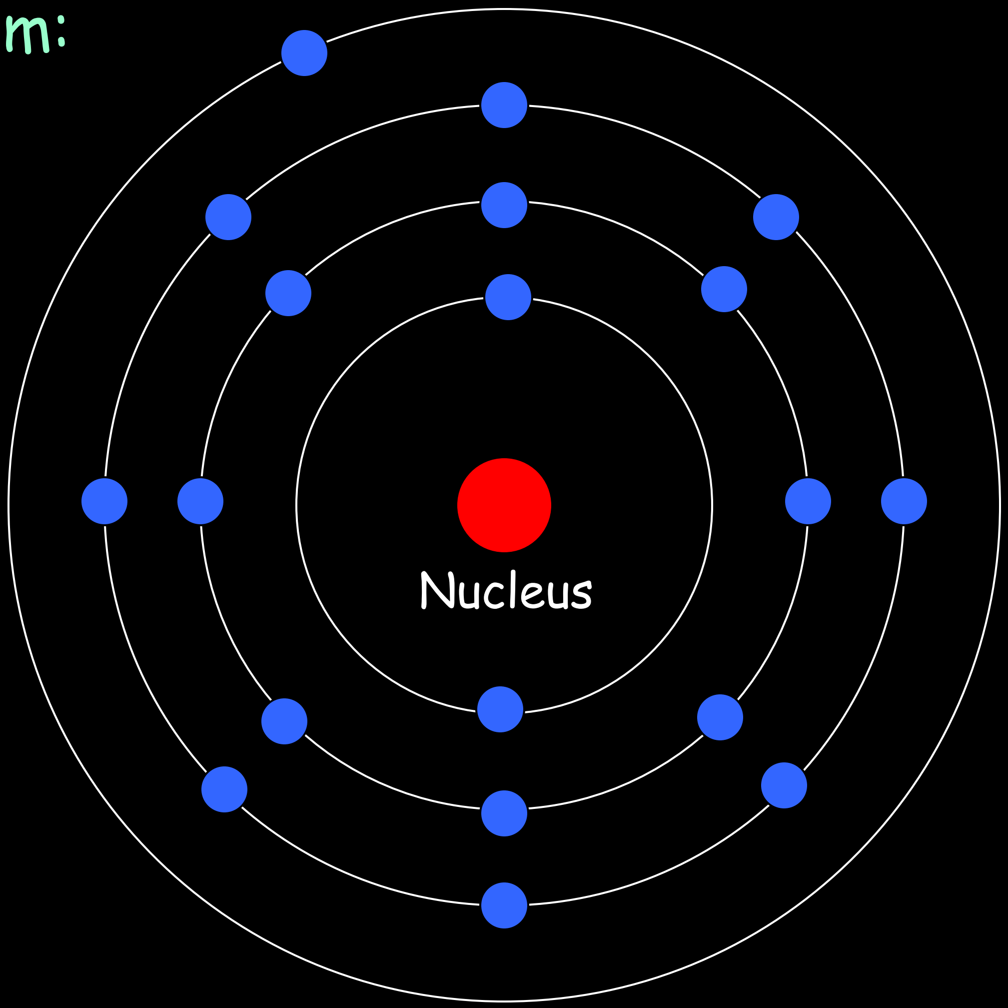
$^{238}_{92}\mathrm{U}$

Electron structure

*

Consider an atom of Potassium:





Potassium has 19 electrons. These electrons occupy specific energy levels "shells"…

The inner shell has __ electrons

The next shell has __ electrons

The next shell has __ electrons

The next shell has the remaining __ electron

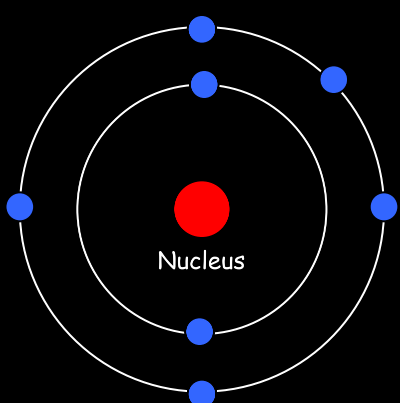
Electron structure

= 2,8,8,1

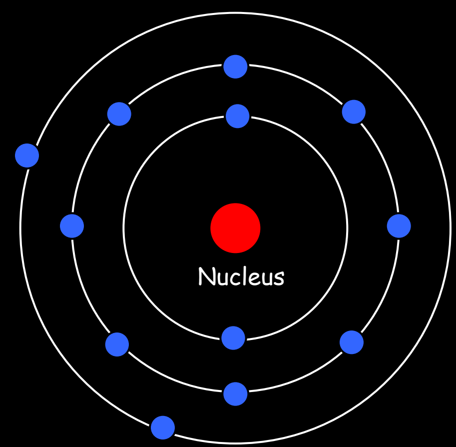
Electron structure

Draw the electronic structure of the following atoms:

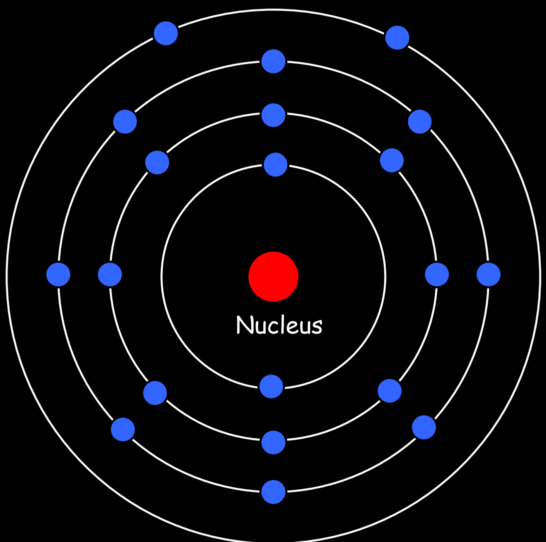
14 N 7	24 Mg 12	40 Ca 20



Electron structure = 2,5



Electron structure = 2,8,2

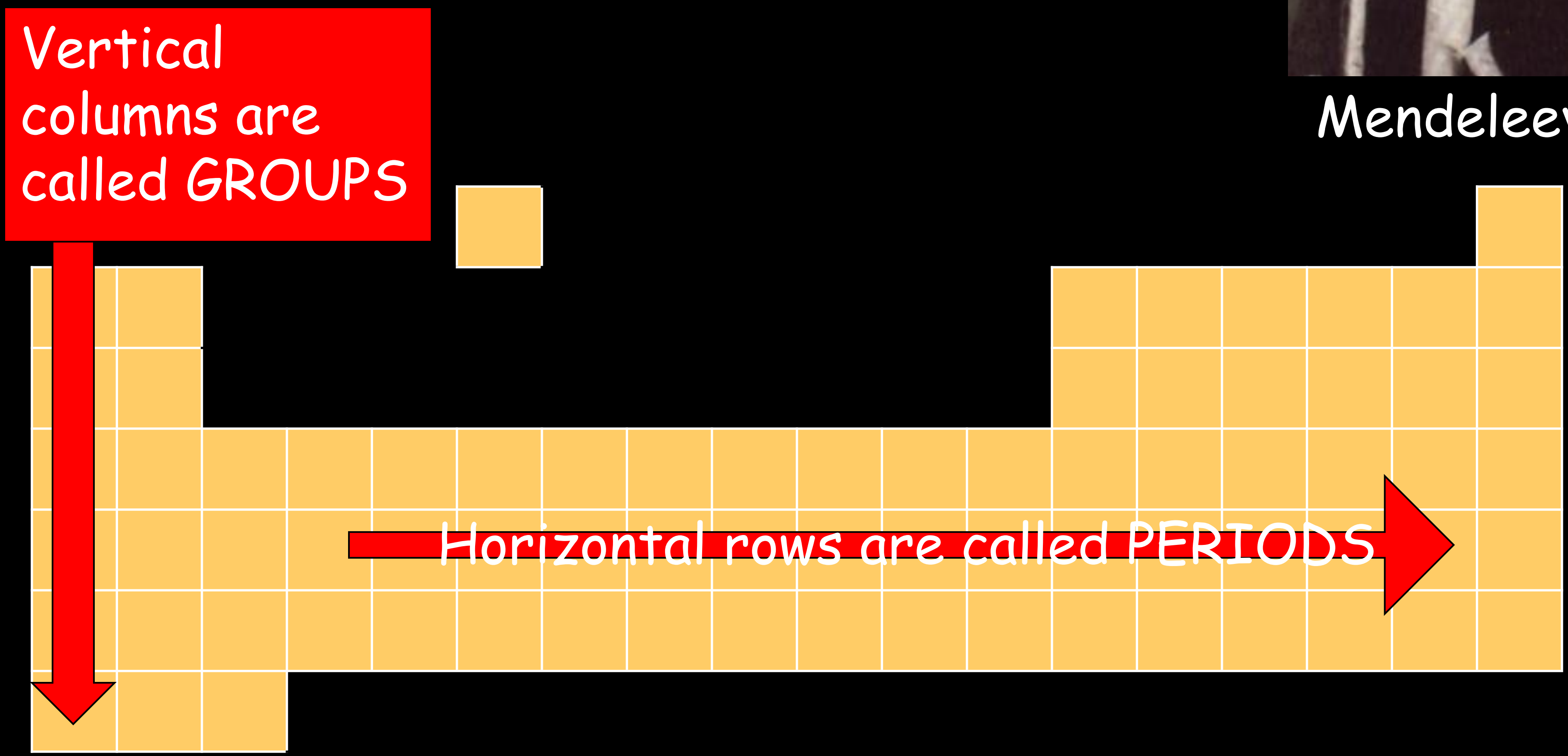


Electron structure = 2,8,8,2

Periodic table

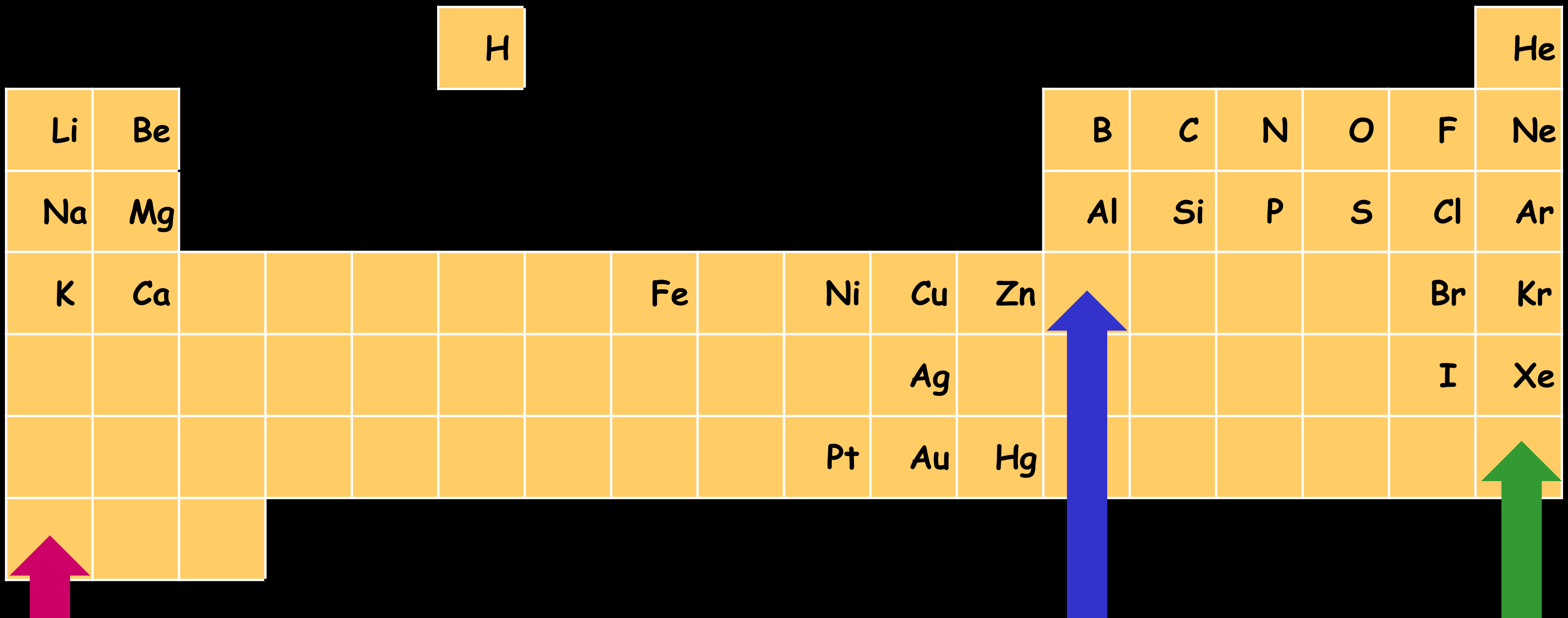
The periodic table arranges all the elements in groups according to their properties.

Mendeleev



The Periodic Table

Fact 1: Elements in the same group have the same number of electrons in the outer shell (this corresponds to their group number)



E.g. all group 1 metals have __ electron in their outer shell

These elements have __ electrons in their outer shells

These elements have __ electrons in their outer shell

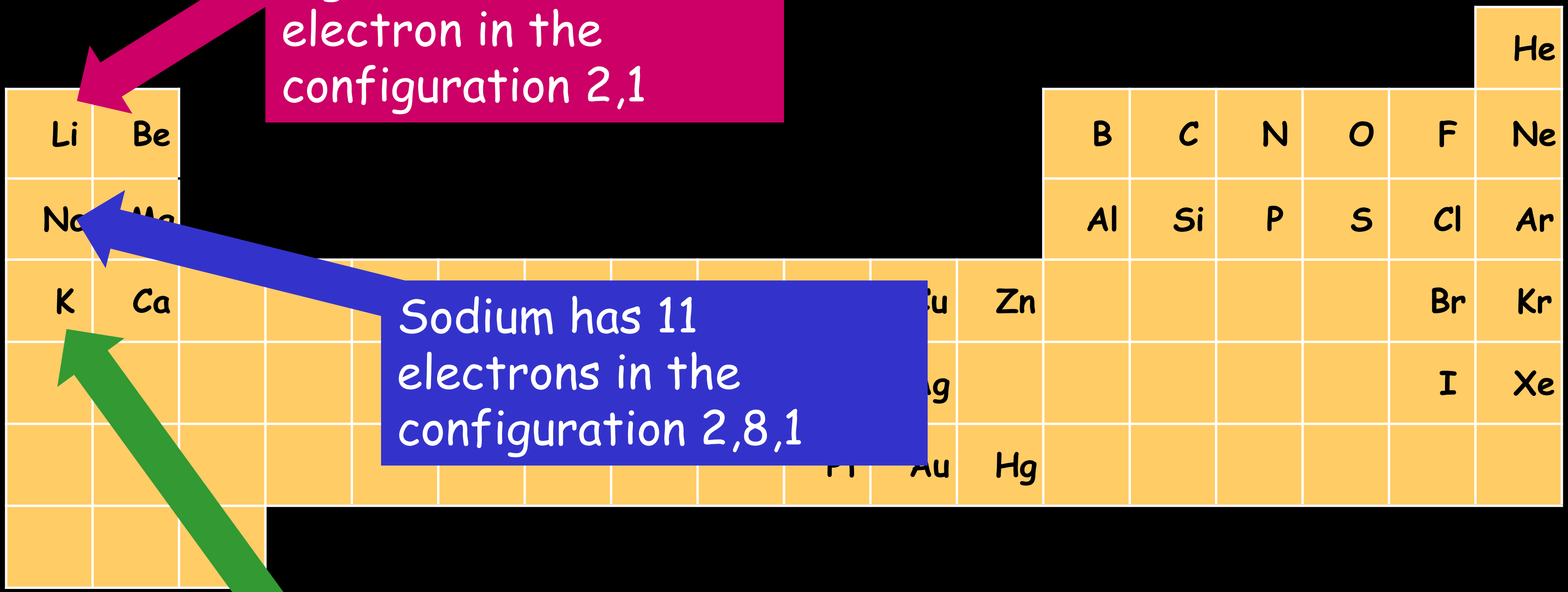
The Periodic Table

Fact 2: As you move down through the periods an extra electron shell is added:

E.g. Lithium has 3 electron in the configuration 2,1

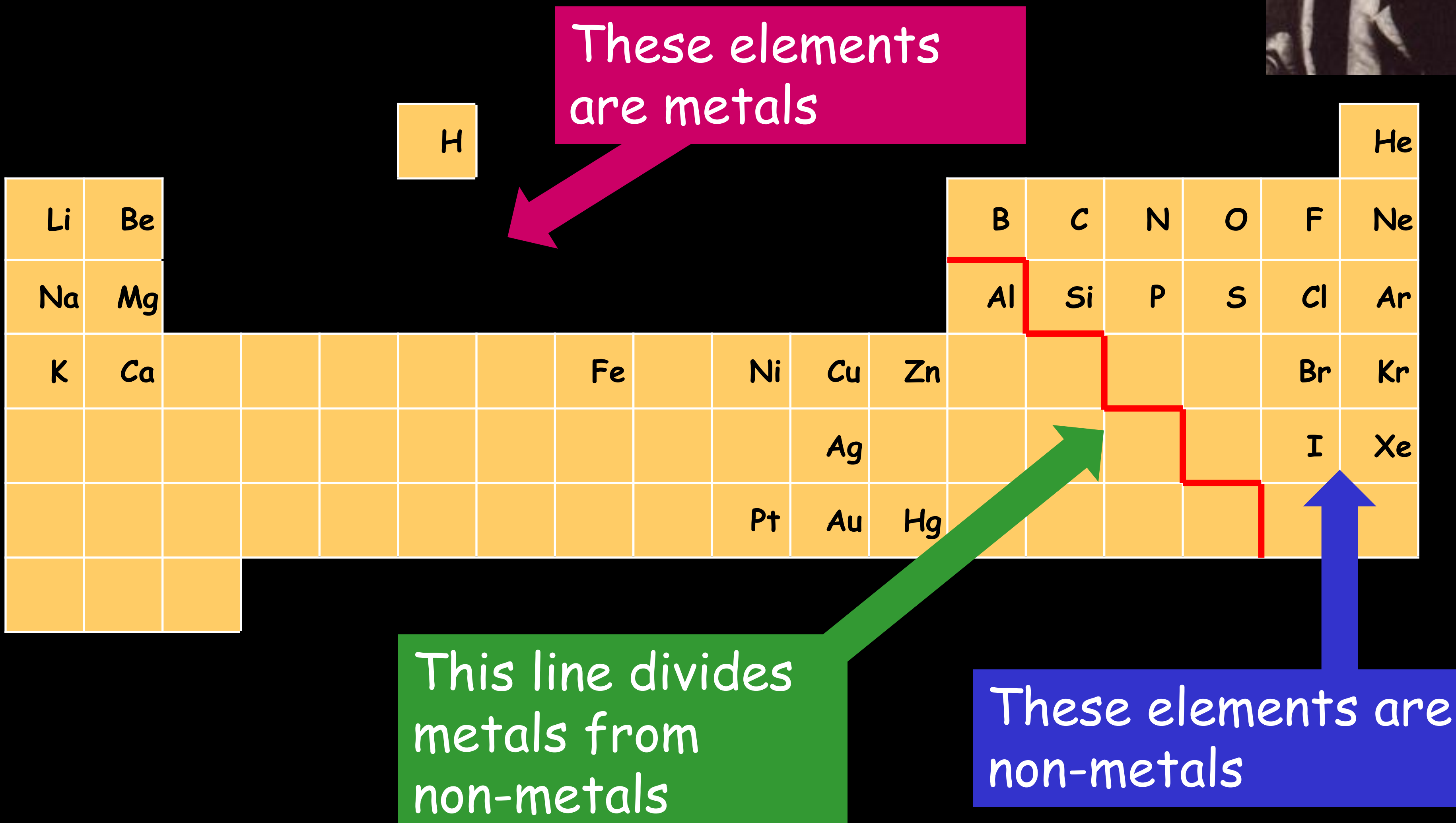
Sodium has 11 electrons in the configuration 2,8,1

Potassium has 19 electrons in the configuration __,__,__,__



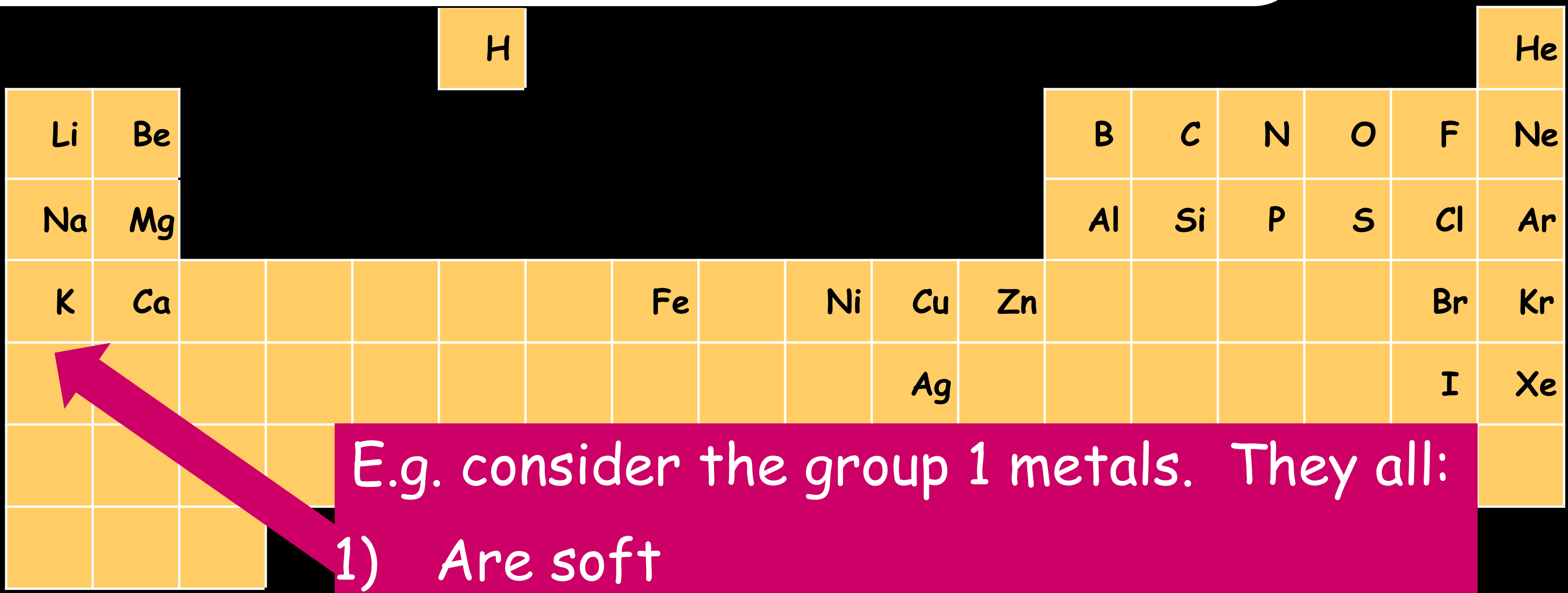
The Periodic Table

Fact 3: Most of the elements are metals:



The Periodic Table

Fact 4: (Most important) All of the elements in the same group have similar PROPERTIES. This is how I thought of the periodic table in the place. This is called PERIODICITY.



E.g. consider the group 1 metals. They all:

1) Are soft
2) Can be easily cut with a knife
3) React with water

Isotopes

An isotope is an atom with a different number of neutrons:

Notice that the mass number is different. How many neutrons does each isotope have?

16	17	18
O	O	O
8	8	8

Each isotope has 8 protons – *if it didn't then it just wouldn't be oxygen any more.*

*

Strange atomic masses

When you look at a periodic table sometimes the atomic mass is not a whole number. Consider chlorine, for example:

35.5

Cl

17

How can an atom have a decimal for its mass?

This is because out of every four naturally occurring chlorine atoms, 3 have a mass of 35 and 1 has a mass of 37 so the average atomic mass is:

$$(3 \times 35 + 1 \times 37) / 4 = 35.5$$

Q. Magnesium is often found as ^{24}Mg or ^{26}Mg. If 79% of magnesium is ^{24}Mg what is the average atomic mass?

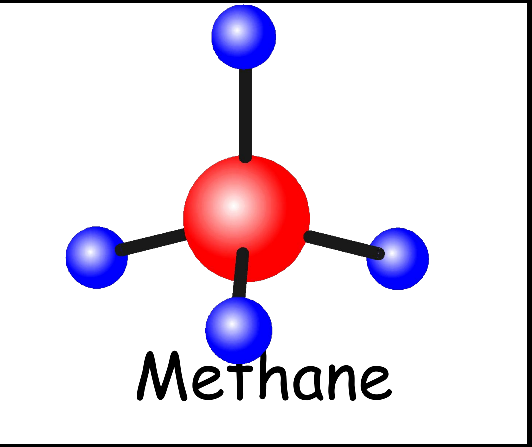
$$(79 \times 24 + 21 \times 26) / 100 = 24.4$$

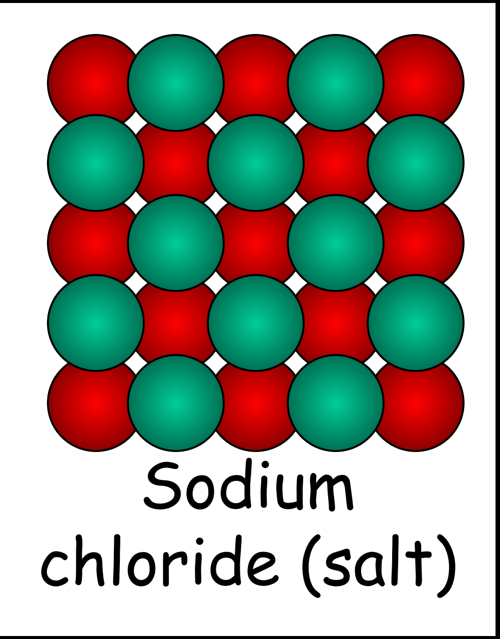
Topic 2 – Ionic Compounds and Analysis

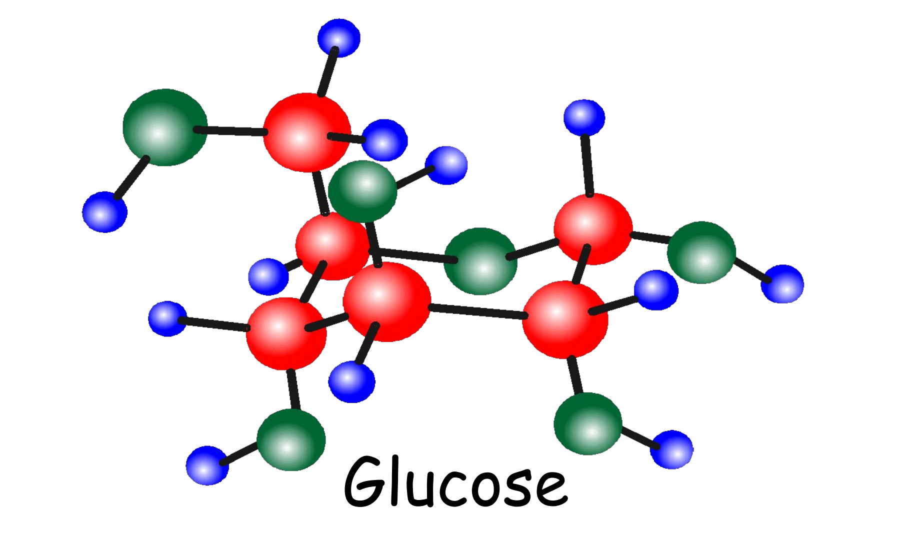
*

Compounds

Compounds are formed when two or more elements are chemically combined. Some examples:

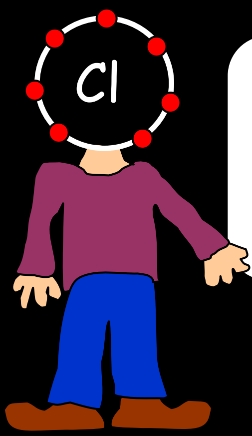




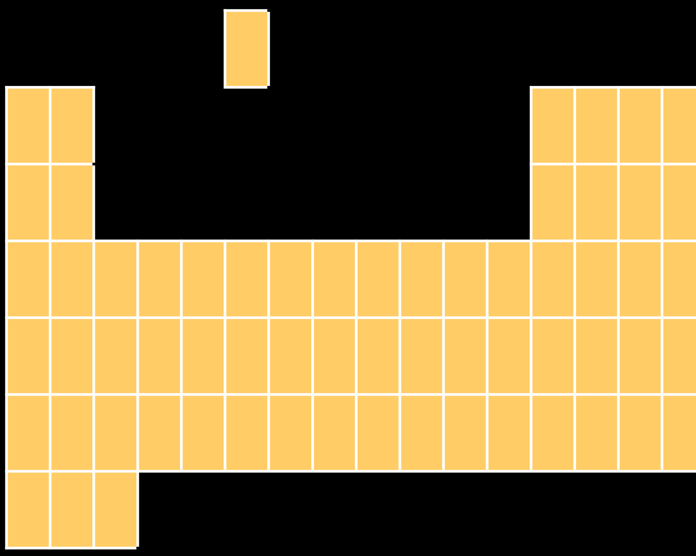


How are these compounds formed? Let's consider two ways – "ionic" and "covalent" bonding.

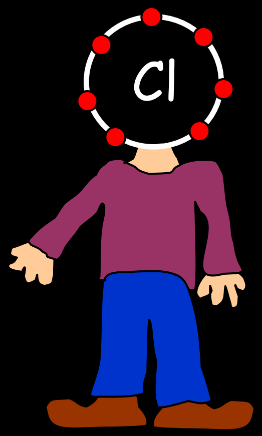
Introduction to Bonding



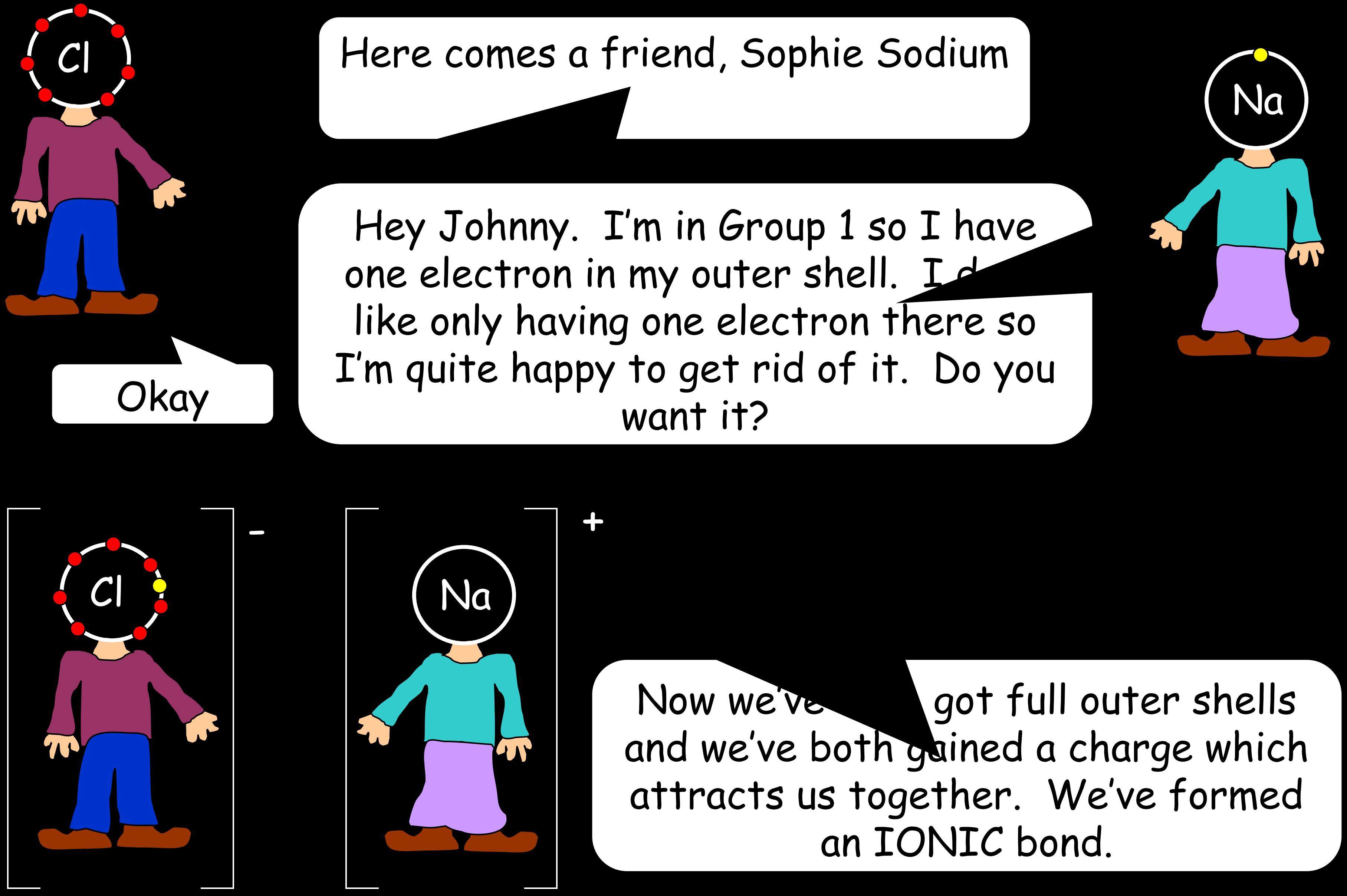
Hi. My name's Johnny Chlorine. I'm in Group 7, so I have 7 electron my outer shell



I'd quite like to have a full outer shell. To do this I need to GAIN an electron. Who can help me?

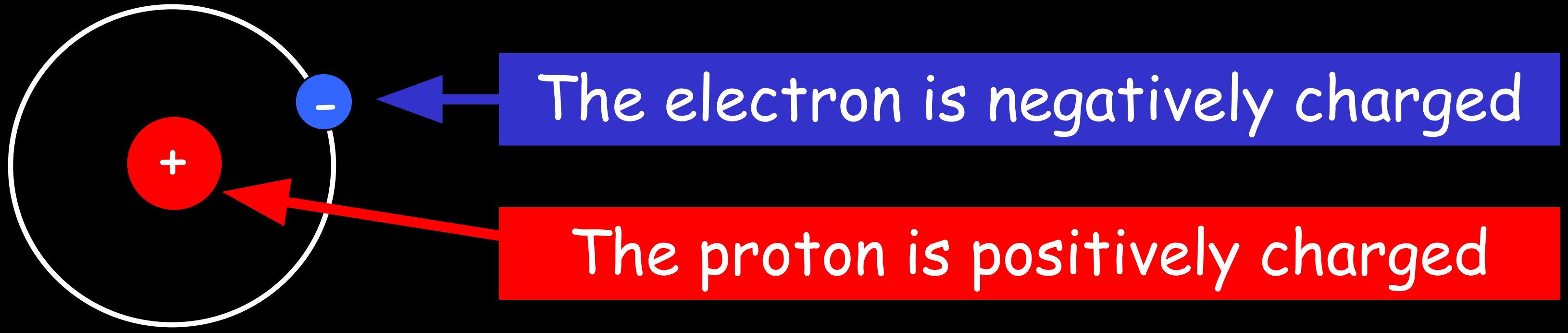


Ionic Bonding

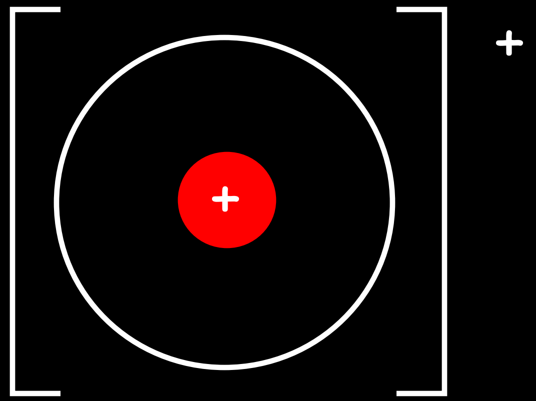


Ions

An ion is formed when an atom gains or loses electrons and becomes charged:



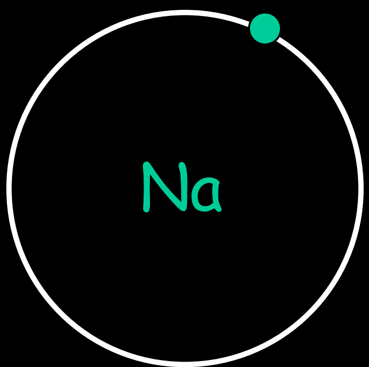
If we "take away" the electron we're left with just a positive charge:



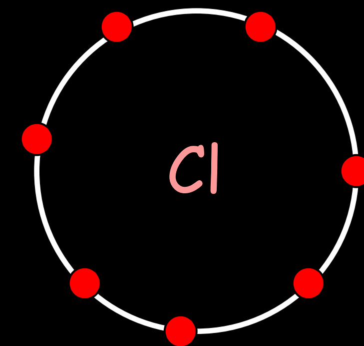
This is called an ion (in this case, a positive hydrogen ion, also called a cation).

Ionic bonding

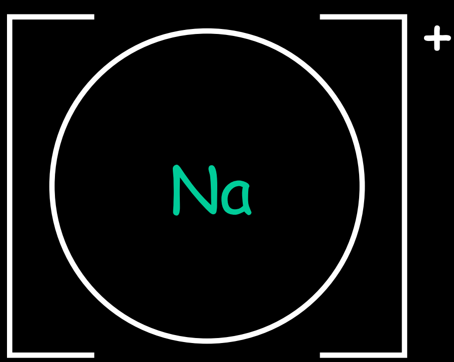
This is where a metal bonds with a non-metal (usually). Instead of sharing the electrons one of the atoms "______" one or more electrons to the other. For example, consider sodium and chlorine:

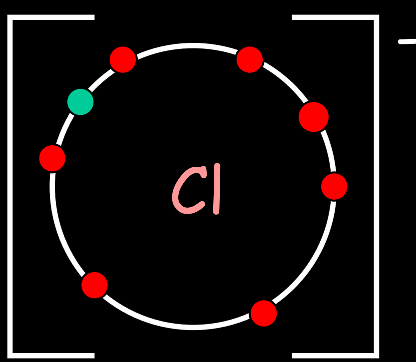


Sodium has 1 electron on its outer shell and chlorine has 7, so if sodium gives its electron to chlorine they both have a ___ outer shell and are _______.



A ________ charged sodium ion (cation)





A __________ charged chloride ion (_______)

Group 1 ________ will always form ions with a charge of +1 when they react with group 7 elements. The group 7 element will always form a negative ion with charge -1.

Words – full, transfers, positively, negatively, metals, anion, stable

Naming compounds

Rule 1 – When two elements join and one is a halogen, oxygen or sulphur the name ends with _____ide

e.g. Magnesium + oxygen → magnesium oxide

1) Sodium + chlorine
2) Magnesium + fluorine
3) Lithium + iodine
4) Chlorine + copper
5) Oxygen + iron
6) KBr
7) LiCl
8) CaO
9) MgS
10) KF

Naming compounds

Rule 2 – When three or more elements combine and one of them is oxygen the ending is ______ate

e.g. Copper + sulphur + oxygen → Copper sulphate

1) Calcium + carbon + oxygen
2) Potassium + carbon + oxygen
3) Calcium + sulphur + oxygen
4) Magnesium + chlorine + oxygen
5) Calcium + oxygen + nitrogen
6) $AgNO_3$
7) H_2SO_4
8) K_2CO_3

*

The Periodic Table

Looking at their position in the Periodic Table and understanding their electron structure, we can predict the charge of different ions.

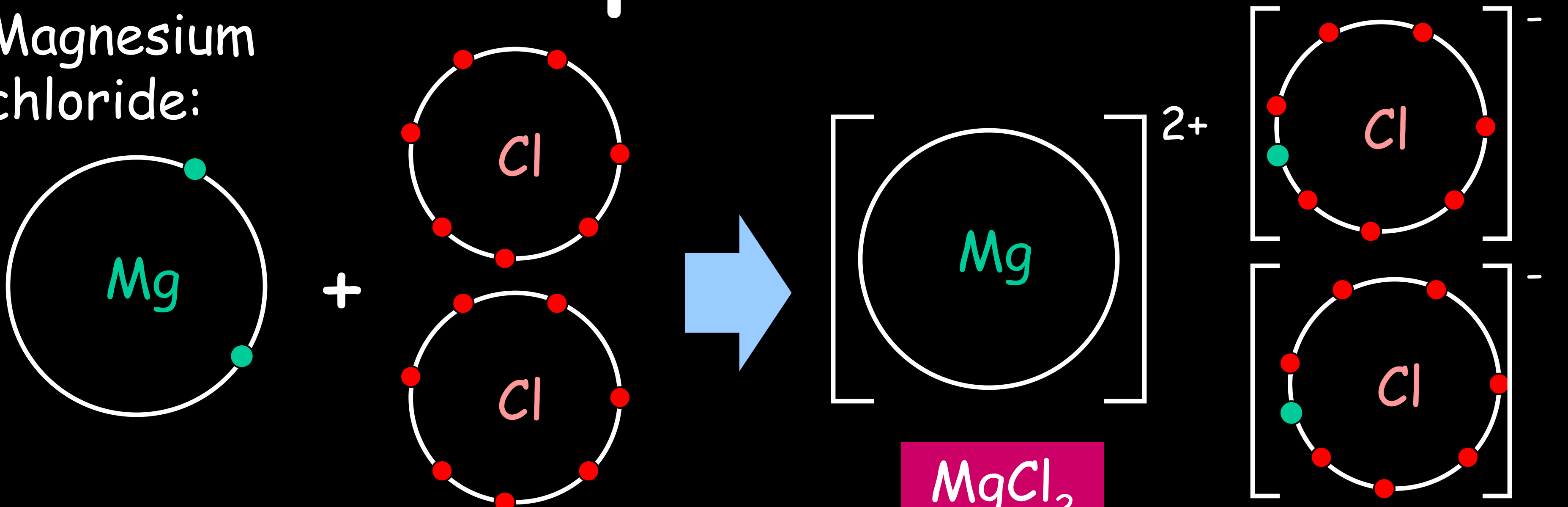
For example, group 1 elements all want to lose one electron so they will all form cations with a charge of +1

What type of ion (and its charge) will elements from groups 2, 6 and 7 form?

					H												He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca						Fe		Ni	Cu	Zn					Br	Kr
										Ag						I	Xe
									Pt	Au	Hg						

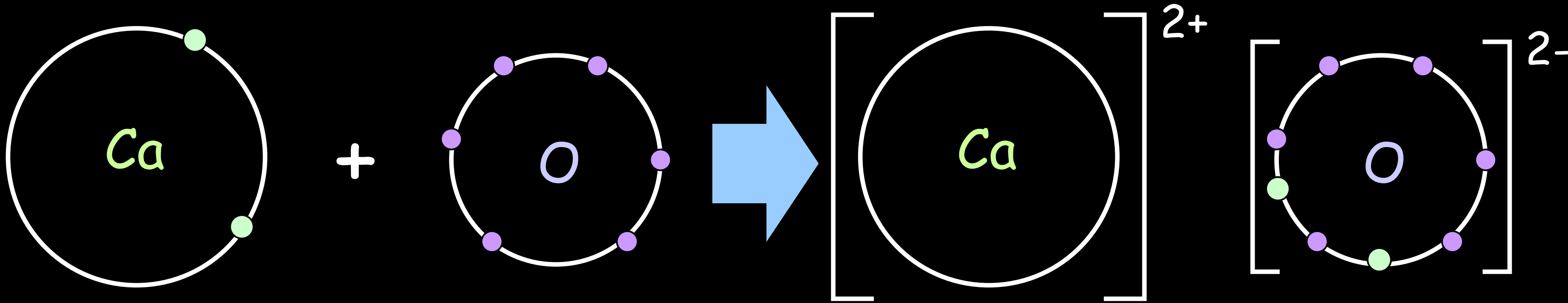
Some examples of ionic bonds

Magnesium chloride:



$MgCl_2$

Calcium oxide:



CaO

Balancing ions

*

Some common ions:

Sodium – Na^+

Potassium – K^+

Magnesium – Mg^{2+}

Ammonium – NH_4^+

Chloride – Cl^-

Bromide – Br^-

Oxide – O^{2-}

Sulphate – SO_4^{2-}

Determine the formula of these compounds:

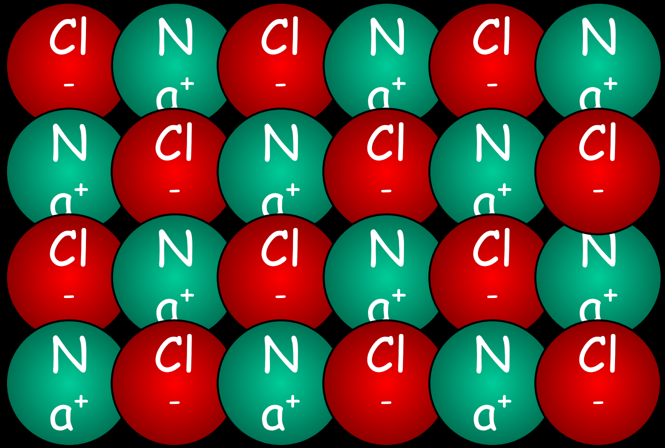
1) Sodium chloride
2) Magnesium oxide
3) Magnesium chloride
4) Ammonium chloride
5) Sodium sulphate
6) Sodium oxide

Answers:

1) $NaCl$
2) MgO
3) $MgCl_2$
4) NH_4Cl
5) Na_2SO_4
6) NaO

Giant Ionic Structures

When many positive and negative ions are joined they form a "giant ionic lattice" where each ion is held to the other by strong electrostatic forces of attraction (ionic bonds).

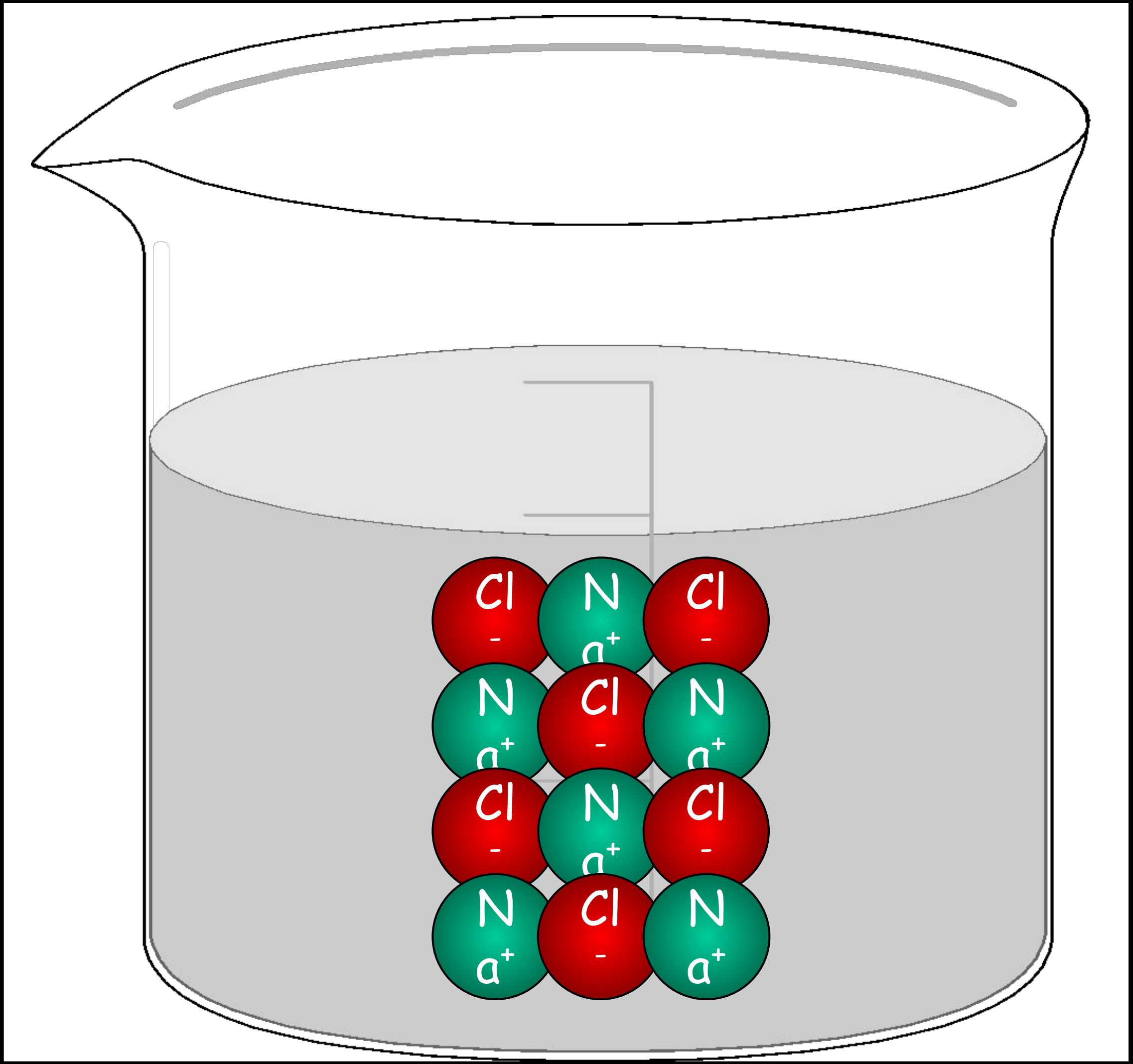


If these ions are strongly held together what affect would this have on the substance's:

1) Melting point?
2) Boiling point?
3) State (solid, liquid or gas) at room temperature?

Dissolving Ionic Structures

When an ionic structure like sodium chloride is dissolved it enables the water to conduct electricity as charge is carried by the ions:



Solubility rules

The following guidelines are useful in working out if a substance will dissolve:

- All common sodium, potassium and ammonium salts are soluble
- All nitrates are soluble
- Common chlorides are soluble but not silver and lead
- Common sulfates are soluble but not those of lead, barium and calcium
- Common carbonates and hydroxides are insoluble except those of sodium, potassium and ammonium

Precipitation Reactions

A precipitation reaction occurs when an insoluble solid is made by mixing two ionic solutions together.

Method:

1) Mix the reactants together

2) Filter off the precipitate

3) Wash the residue

4) Dry the residue in an oven at 50°C

Precipitates

*

Some metal compounds form precipitates, i.e. an insoluble solid that is formed when sodium hydroxide is added to them. Consider calcium chloride:

$$CaCl_2 \quad + \quad 2NaOH \longrightarrow Ca(OH)_2 + 2NaCl$$

What precipitates are formed with the following metal compounds when they react with sodium hydroxide?

Metal compound	Precipitate formed	Soluble or insoluble?	Colour
Calcium chloride	Calcium hydroxide		White
Aluminium chloride			
Magnesium chloride			
Ammonium chloride			

Barium Sulfate

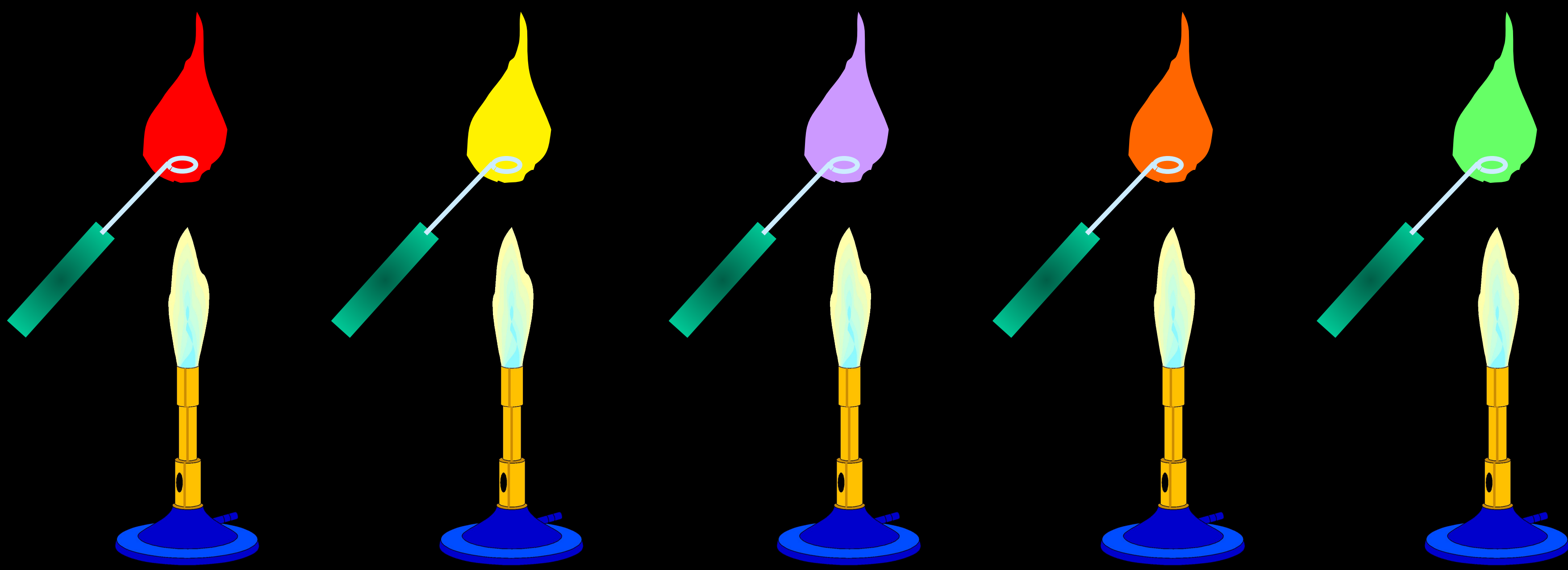
Barium sulfate can be used as part of a "barium meal" to X-ray patients. Why?

1) Barium sulfate is opaque to X rays so they will show up in an X ray
2) It's insoluble so it won't pass into the bloodstream

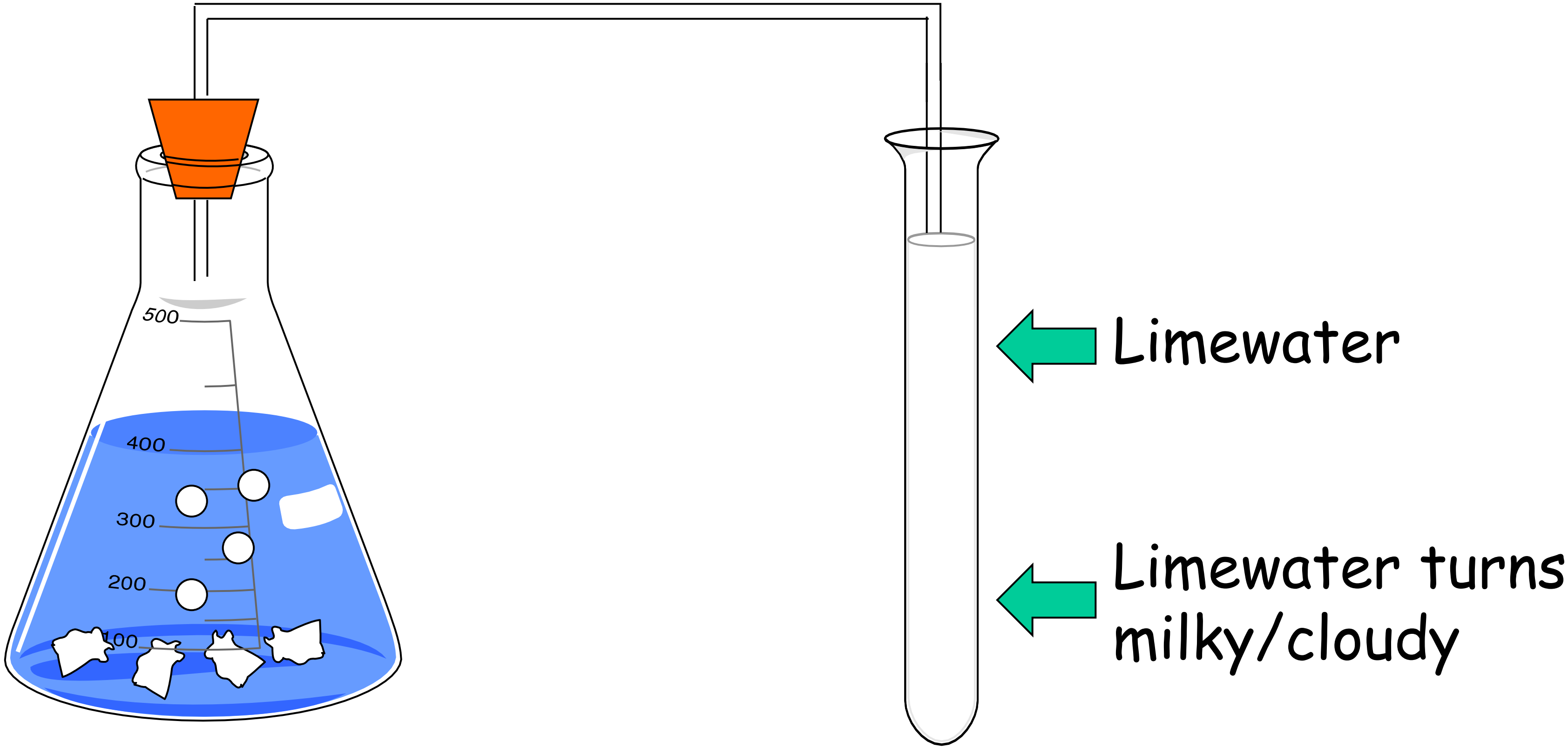
Flame tests

Compounds containing lithium, sodium, potassium, calcium and barium ions can be recognised by burning the compound and observing the colours produced:

Lithium	Sodium	Potassium	Calcium	Barium
Red	*Yellow*	*Lilac*	*Brick red*	*Green*



Testing for carbonate ions



Calcium carbonate + hydrochloric acid → calcium chloride + carbon dioxide + water

Testing for chloride and sulfate ions

For each test state: 1) The colour of the precipitate

2) What compound it is

Test 1: Chloride ions

Add a few drops of dilute nitric acid to the chloride ion solution followed by a few drops of silver nitrate.

Precipitate formed = silver chloride (white)

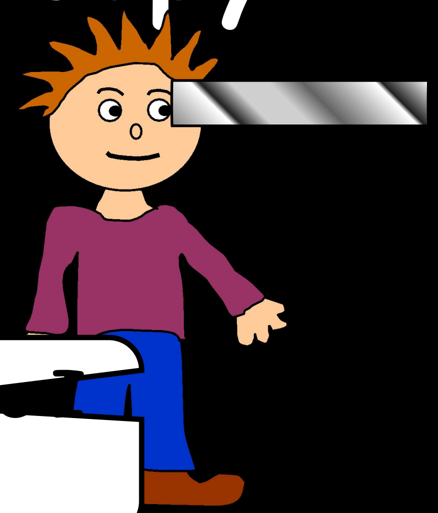
Test 2: Sulphate ions

Add a few drops of dilute hydrochloric acid to the sulphate ion solution followed by a few drops of barium chloride.

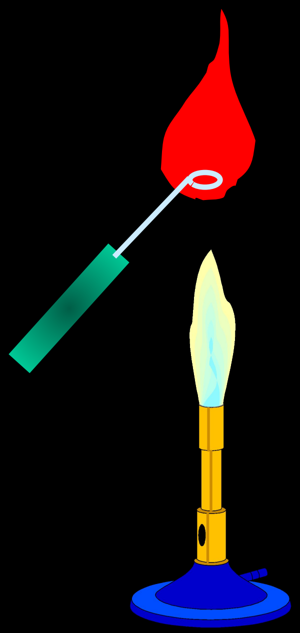
Precipitate formed = barium sulphate (white again)

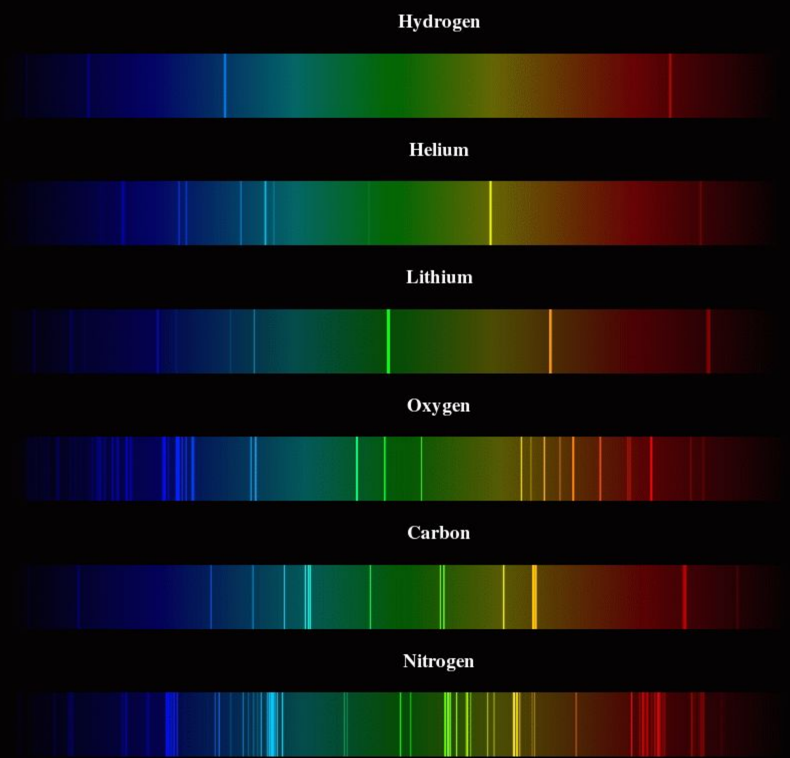
Spectroscopy

Spectroscopy is kind of like a flame test but using a "spectroscope" to see the results:



Using this spectroscope I can see this:



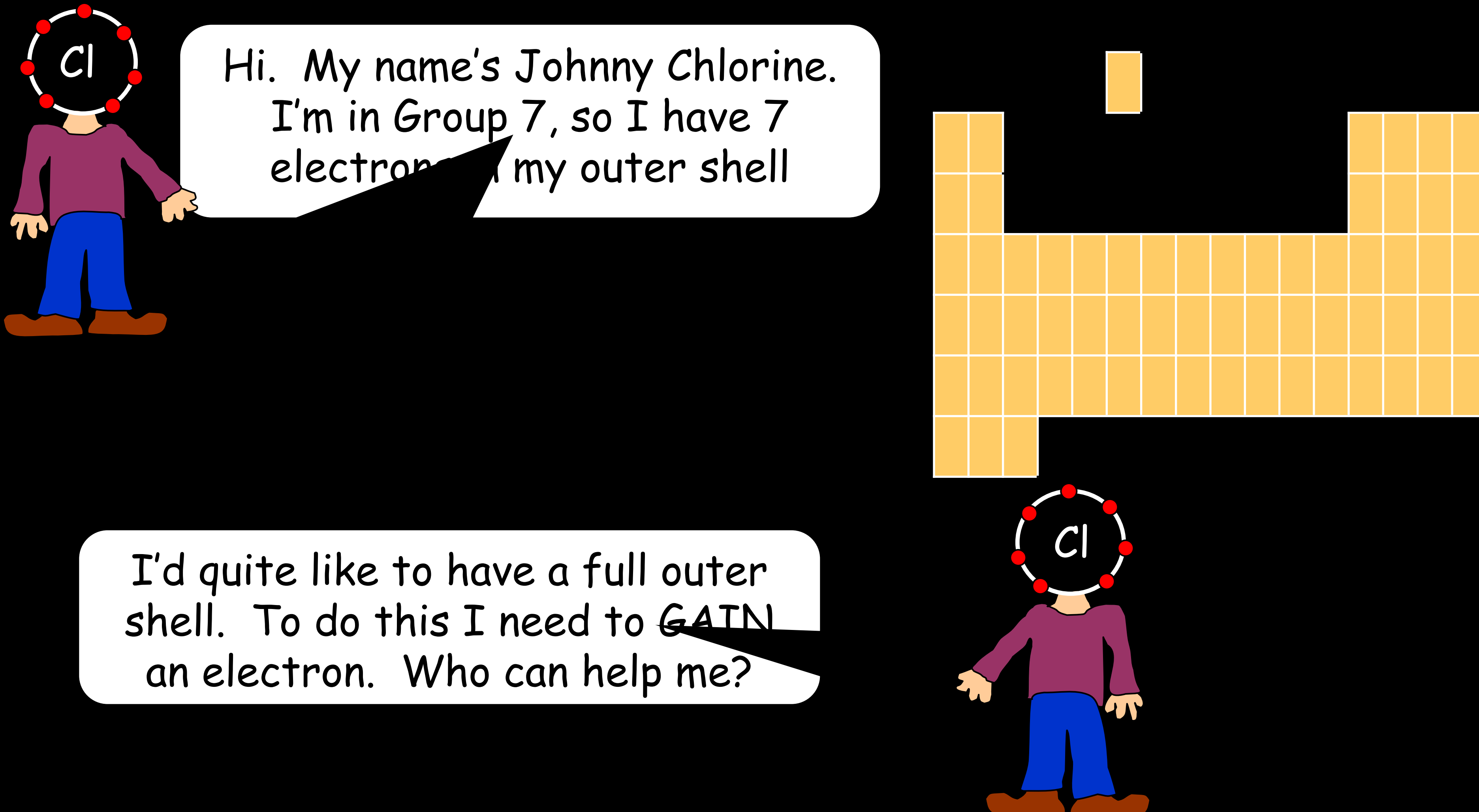


Each different element has a different "signature" when viewed through a spectroscope. This analysis enables us to detect the presence of small amounts of elements and this led to the discovery of new elements including rubidium and caesium.

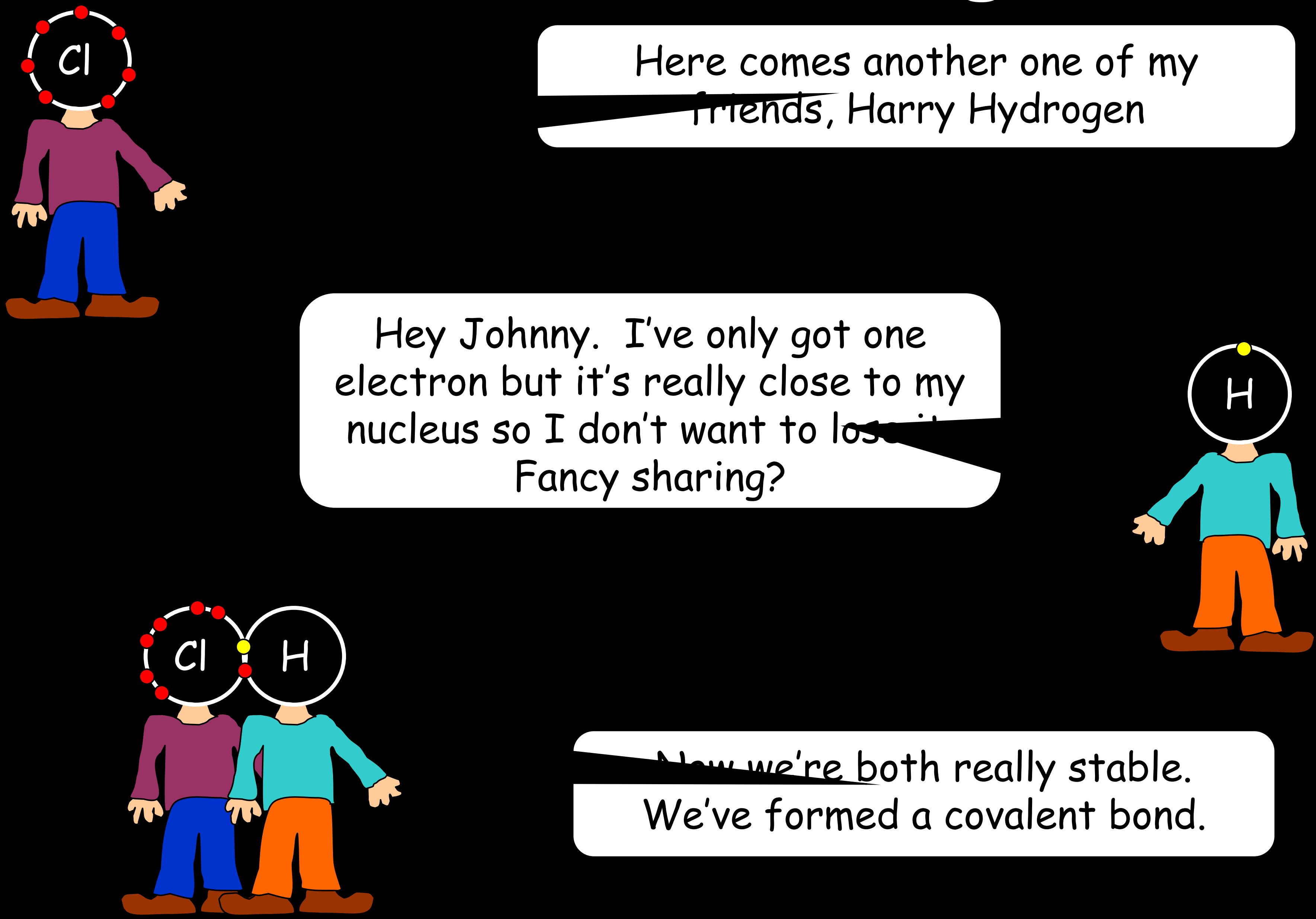
Topic 3 – Covalent Compounds and Separation Techniques

*

Introduction to Bonding Revision



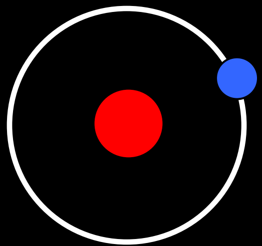
Covalent Bonding



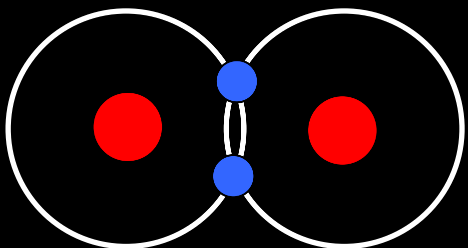
*

Covalent bonding

Consider an atom of hydrogen:

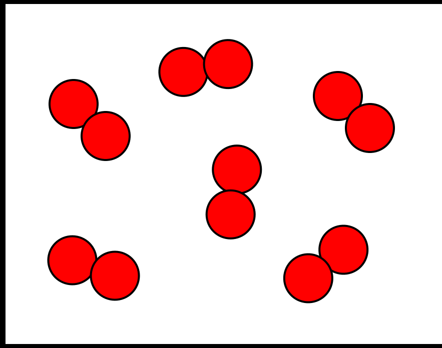


Notice that hydrogen has just __ electron in its outer shell. A full (inner) shell would have __ electrons, so two hydrogen atoms get together and "______" their electrons:



Now they both have a _____ outer shell and are more ______. The formula for this molecule is H_2.

When two or more atoms bond by sharing electrons we call it _______________ BONDING. This type of bonding normally occurs between _________ atoms. It causes the atoms in a molecule to be held together very strongly but there are _____ forces between individual molecules. This is why covalently-bonded molecules have low melting and boiling points (i.e. they are usually _____ or _______).

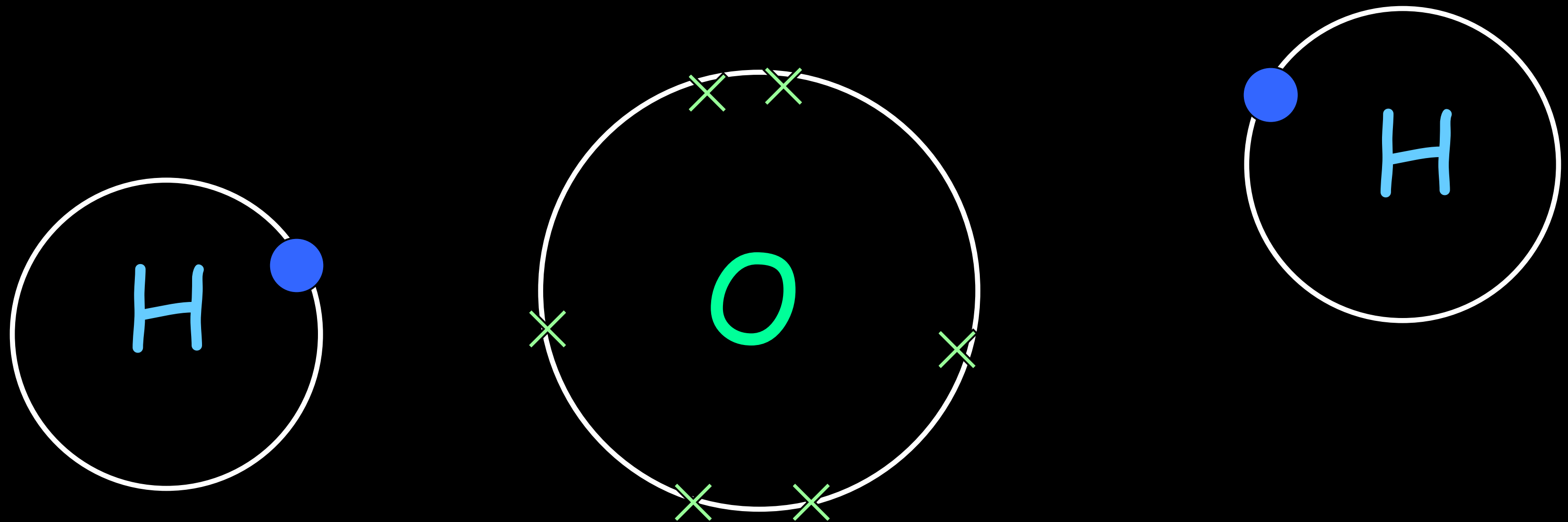


Words – gas, covalent, non-metal, 1, 2, liquid, share, full, weak, stable

Dot and Cross Diagrams

*

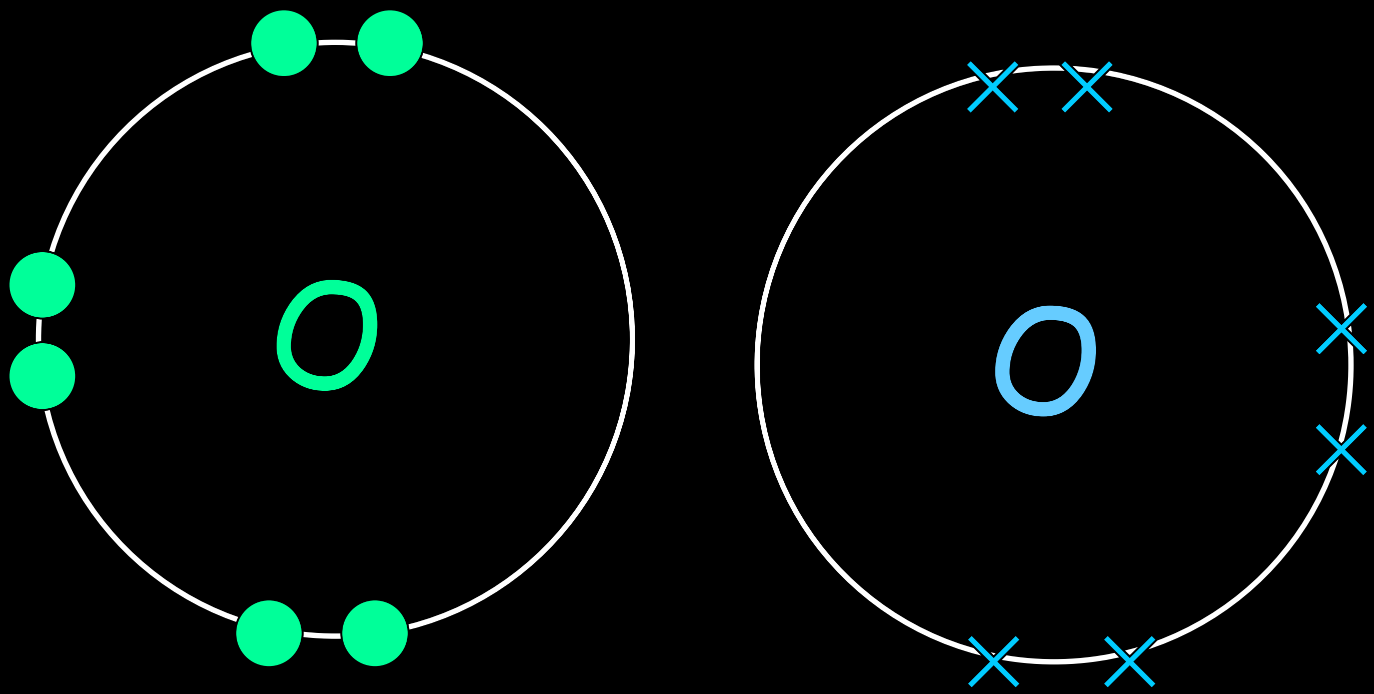
Water, H_2O:



Dot and Cross Diagrams

*

Oxygen, O_2:

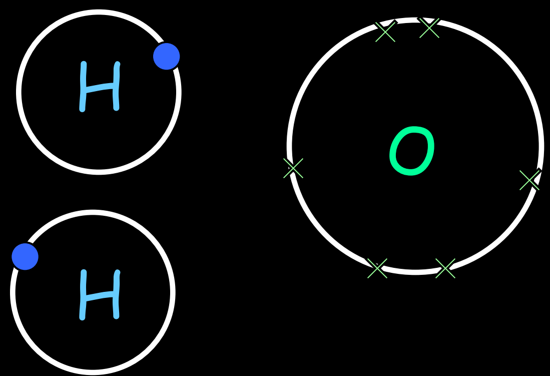


Dot and cross diagrams

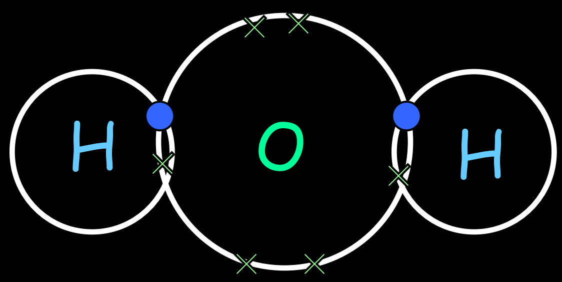
*

Water, H_2O:

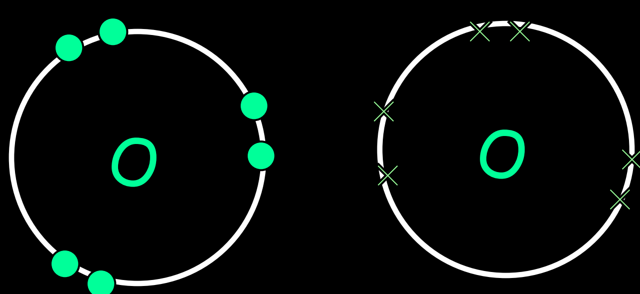
Step 1: Draw the atoms with their outer shell:

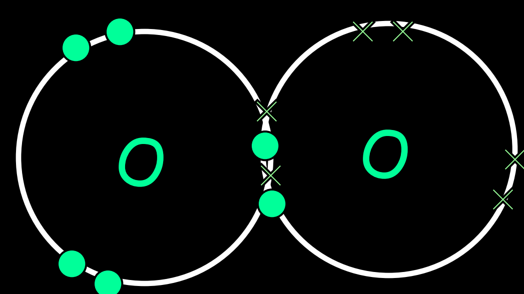


Step 2: Put the atoms together and check they all have a full outer shell:



Oxygen, O_2:

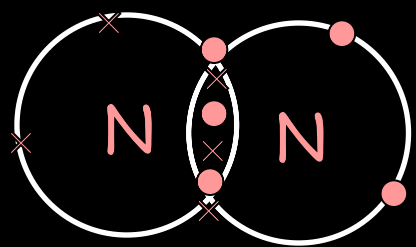




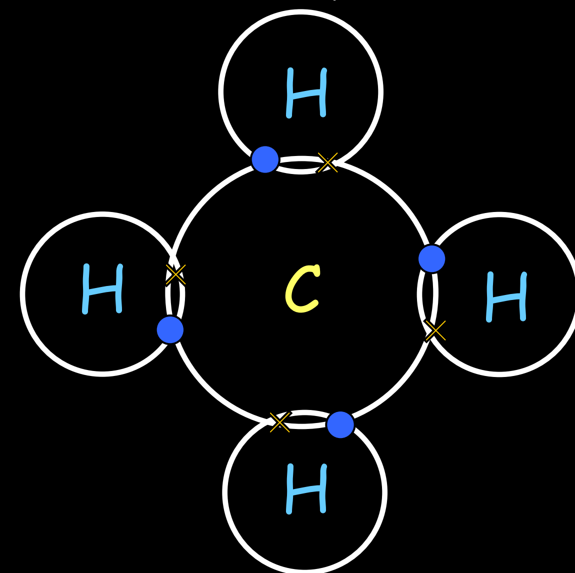
Dot and cross diagrams

*

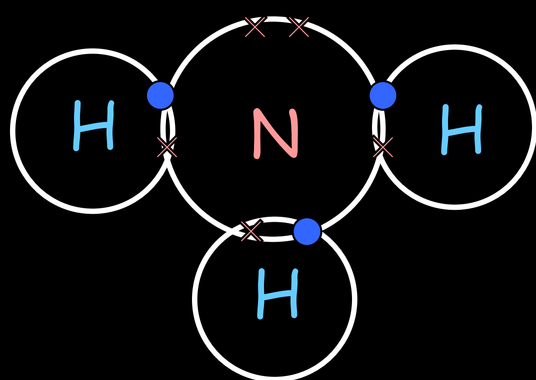
Nitrogen, N_2:



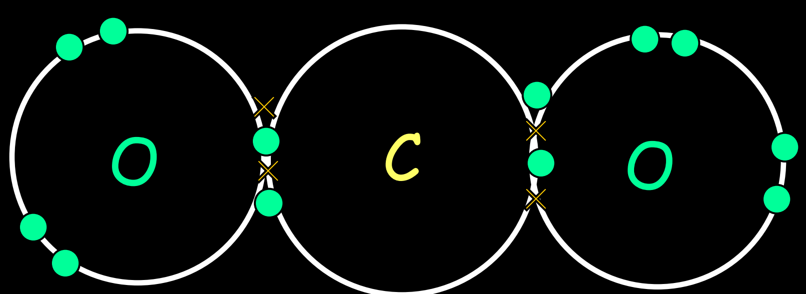
Methane CH_4:



Ammonia NH_3:

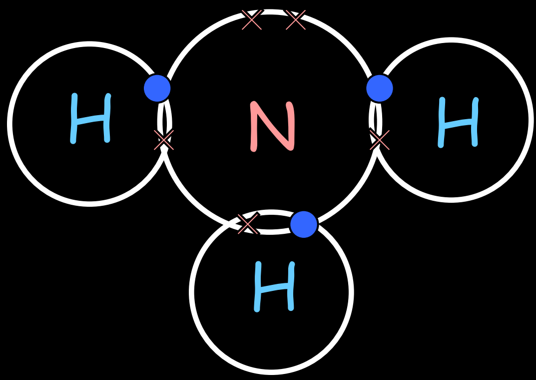


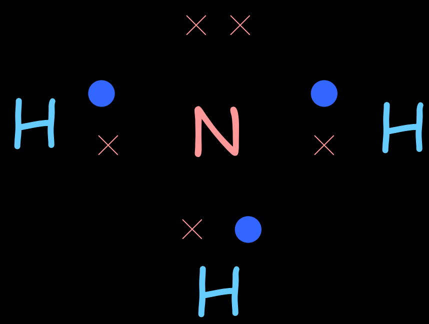
Carbon dioxide, CO_2:

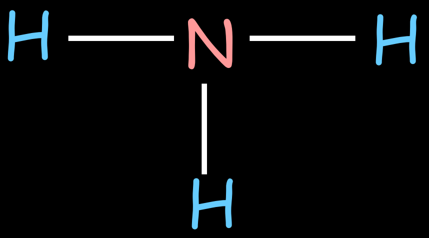


Other ways of drawing covalent bonds

Consider ammonia (NH_3):



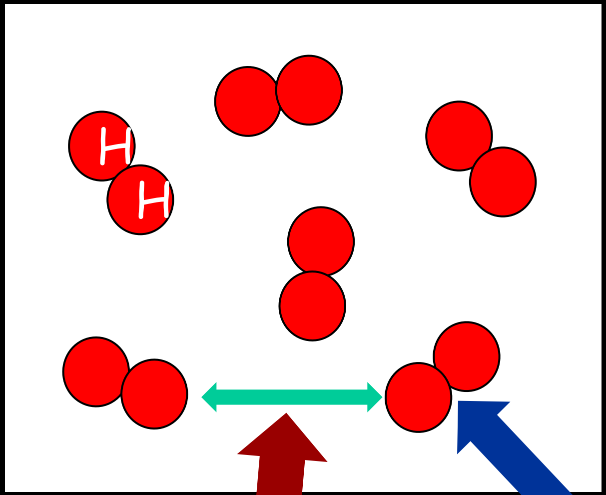




Bonds formed between non-metals are usually covalent.
Common examples are NH_3, CO_2, CH_4, H_2O etc.

Properties of covalent molecules

Recall our model of a simple covalent compound like hydrogen, H_2:



Hydrogen has a very low melting point and a very low boiling point. Why?

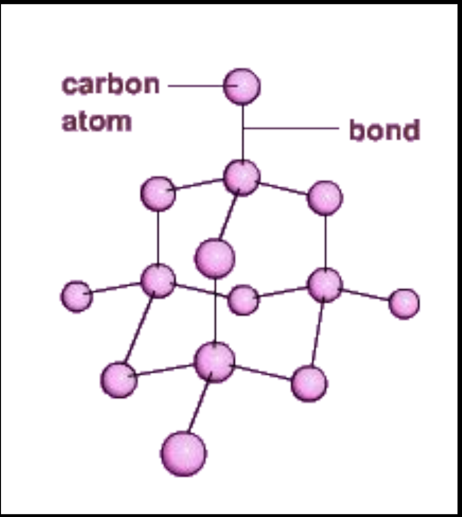
1) The intermolecular forces are very weak so each one of these H_2 molecules doesn't really care about the others – it's very easy to pull them apart.

2) When a substance is heated it is the intermolecular forces that are overcome, NOT the covalent bond in each molecule, which is much stronger!

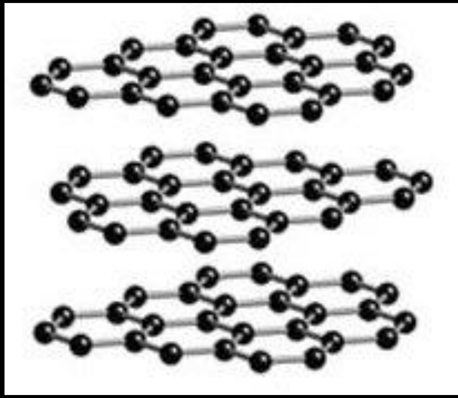
Also, the molecules do not carry a charge so covalent compounds usually do not conduct electricity.

Giant Covalent structures ("lattices") *

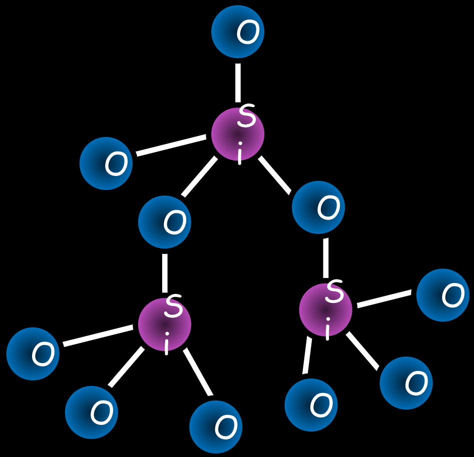
Notice that giant covalent structures have very different properties to individual covalent molecules:



1. Diamond – a giant covalent structure with a very _____ melting point due to _______ bonds between carbon atoms



2. Graphite – carbon atoms arranged in a layered structure, with free ________ in between each layer enabling carbon to conduct ___________ (like metals)



3. Silicon dioxide (sand) – a giant covalent structure of silicon and oxygen atoms with strong ______ causing a high _______ point and it's a good insulator as it has no free electrons

Words – melting, high, electrons, bonds, strong, electricity