2019
Version

Atomic Structure
Junior Science

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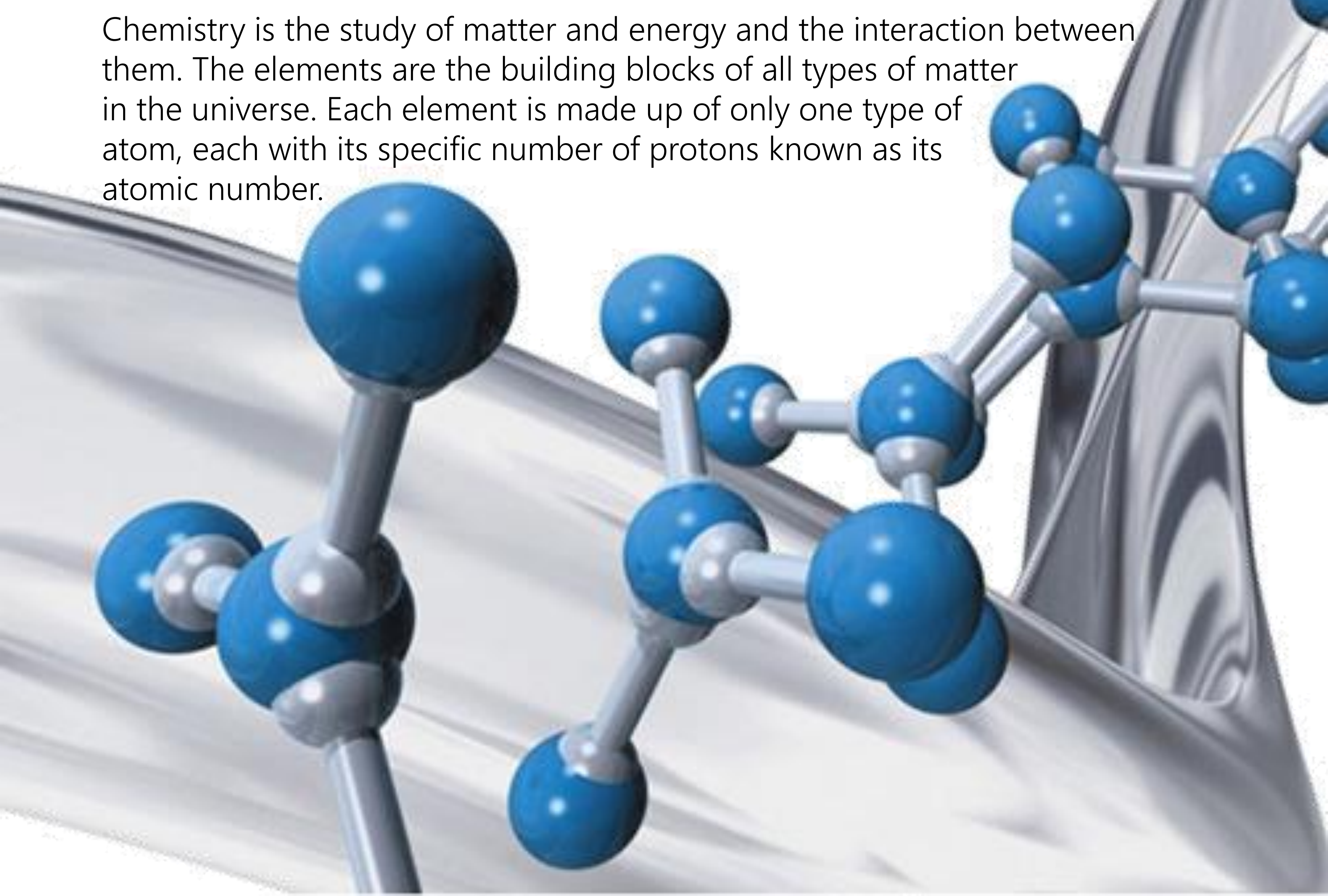
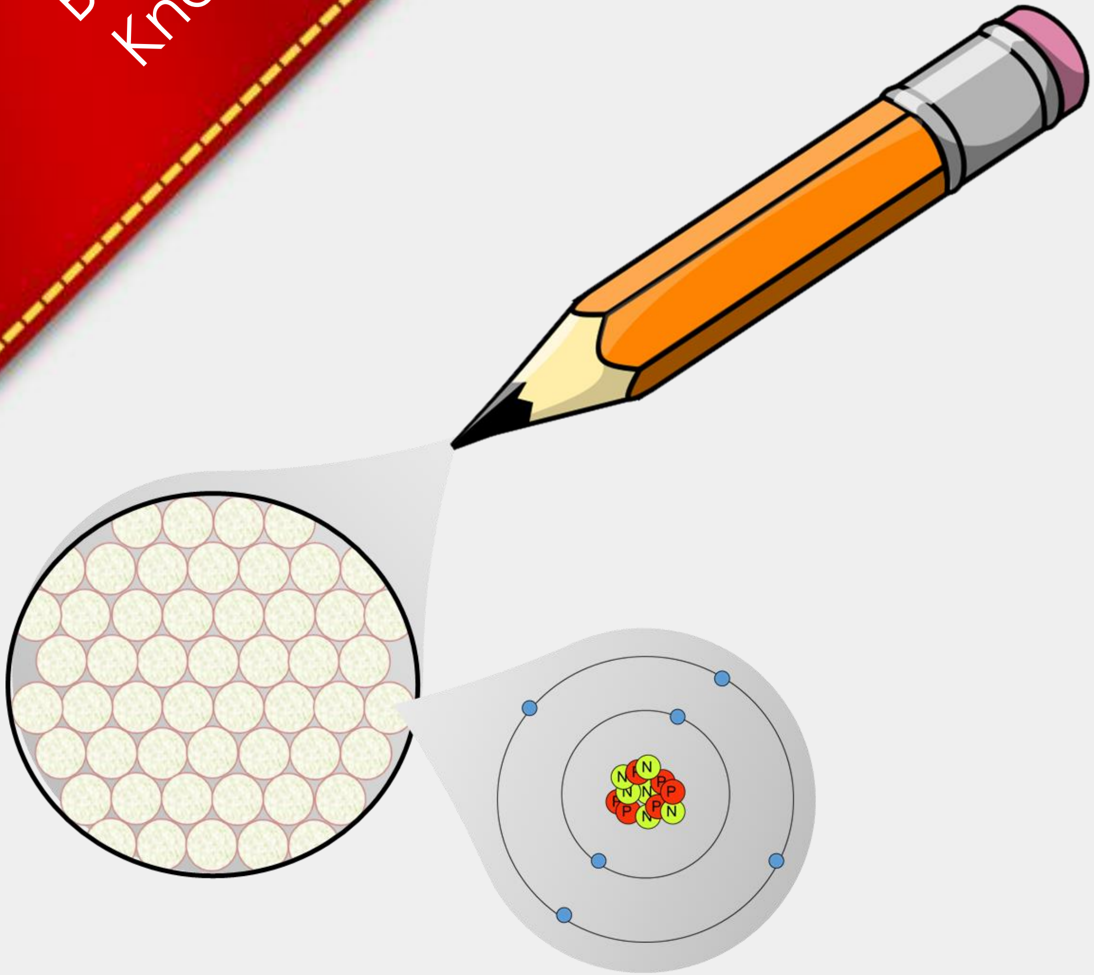
Introduction

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 is made up of only one type of atom, each with its specific number of protons known as its atomic number.



Background Knowledge

Understand that matter is made up of atoms



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.

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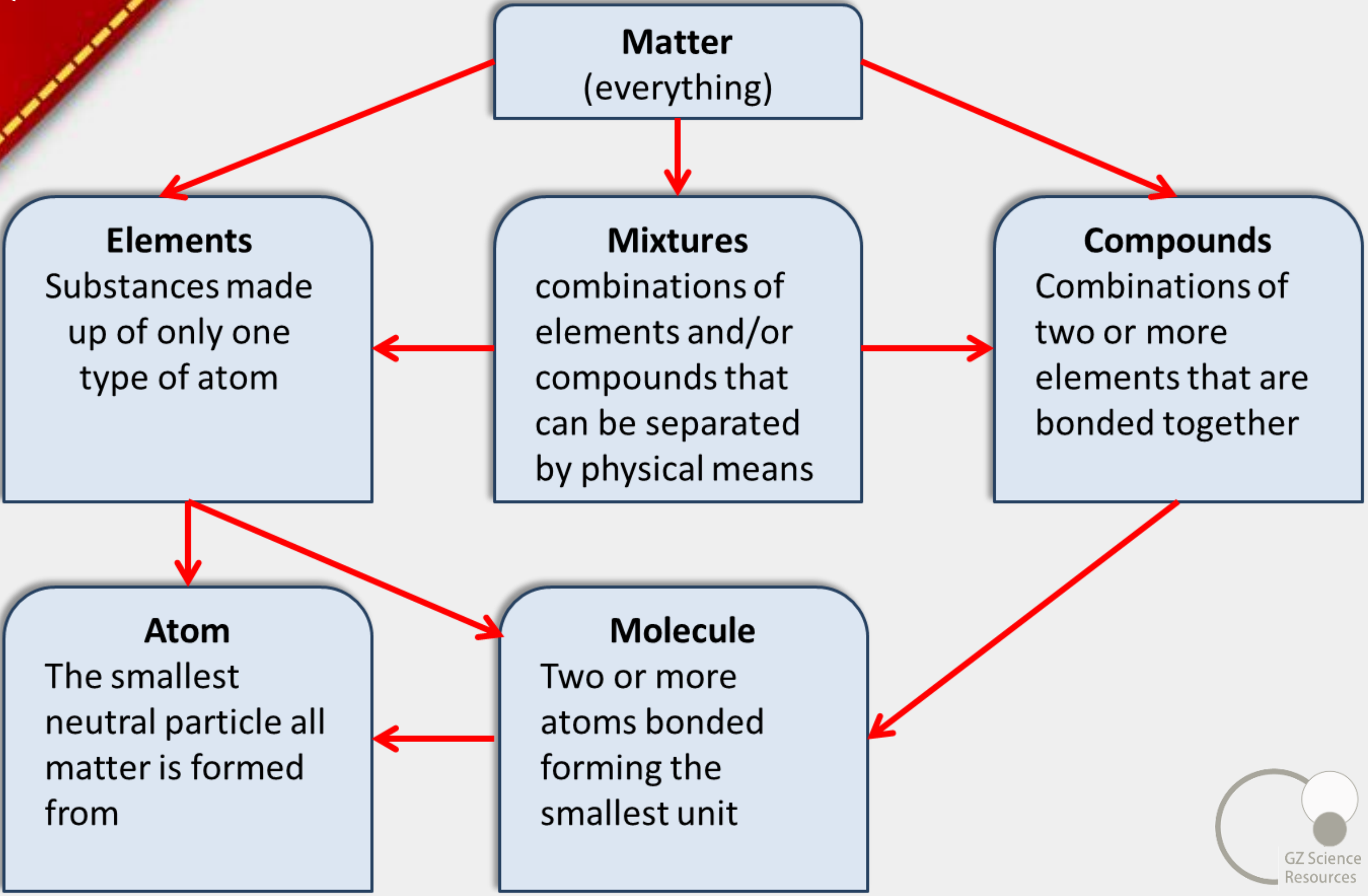
Background Knowledge

Matter is made up of atoms



Matter
(everything)

Elements
Substances made up of only one type of atom

Mixtures
combinations of elements and/or compounds that can be separated by physical means

Compounds
Combinations of two or more elements that are bonded together

Atom
The smallest neutral particle all matter is formed from

Molecule
Two or more atoms bonded forming the smallest unit

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Background Knowledge

The Particle Theory of Matter

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

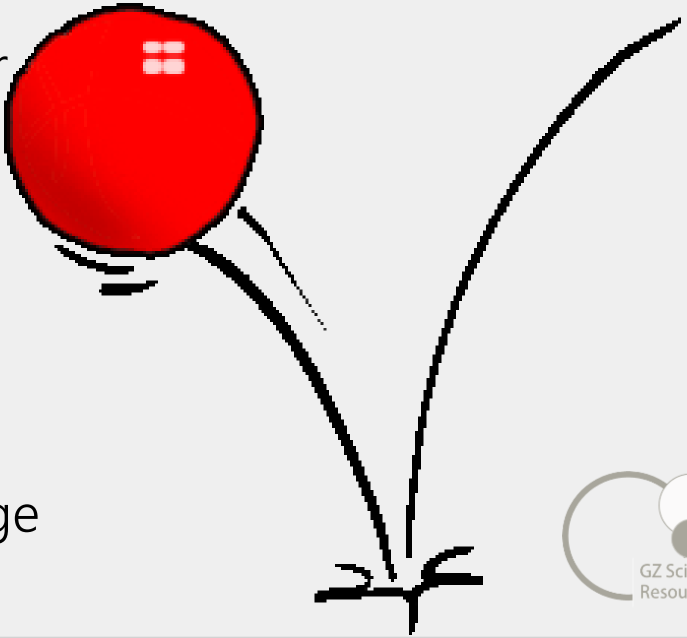
3. There are **spaces between the particles** of matter that are very large compared to the particles themselves

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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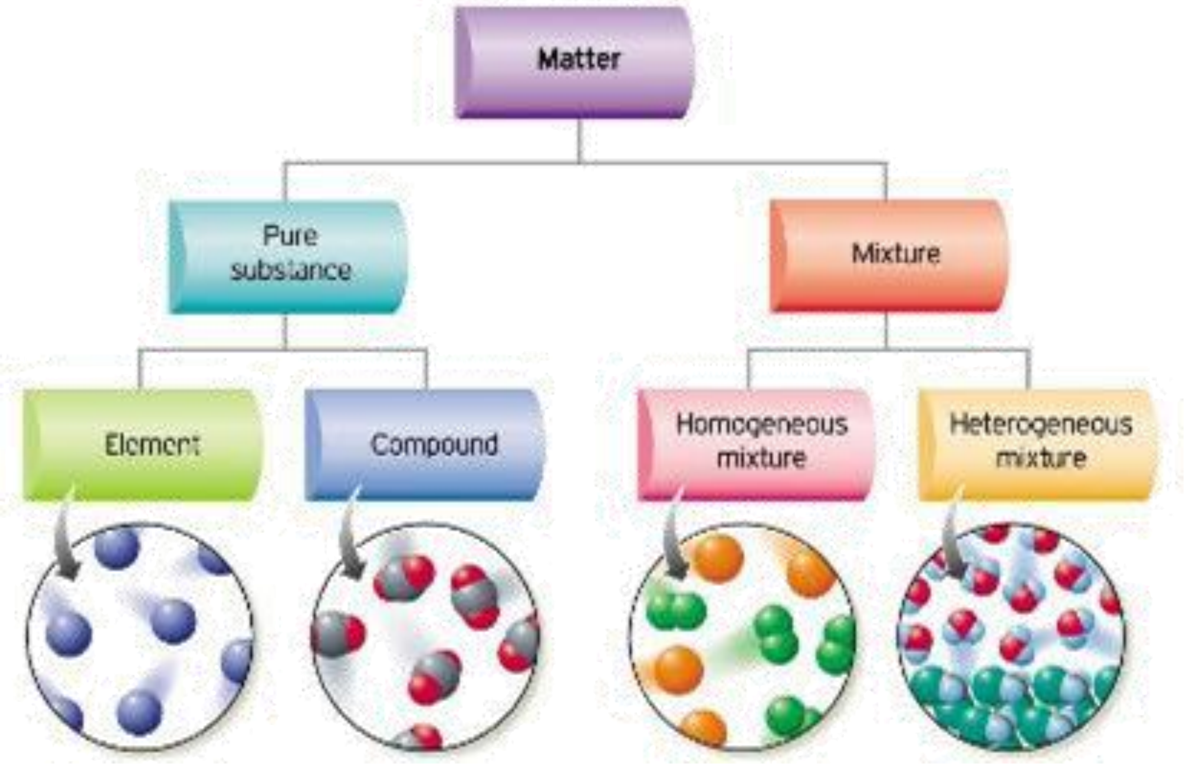
Background Knowledge

Elements are pure substances that combine to make mixtures & compounds

Matter can be divided into **pure substances** which include elements (atoms of the same type) and compounds (different atoms joined together) and **Mixtures** which can either be **homogeneous** (evenly mixed) or **heterogeneous** (unevenly mixed)



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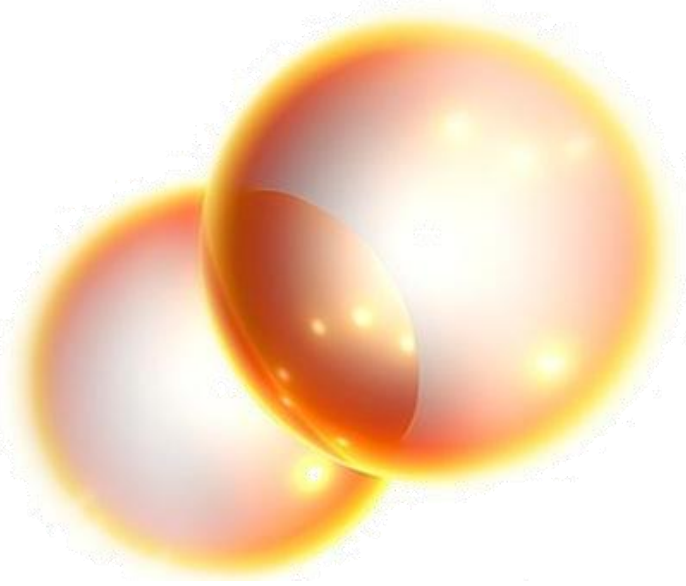
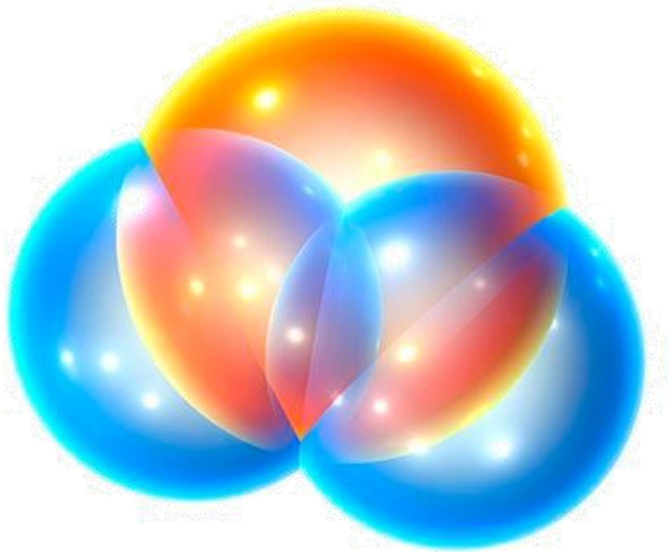
Background Knowledge

Elements are pure substances that combine to make mixtures & compounds

A **molecule** forms when atoms join together – either the same type of atom to form a molecule of an element (such as oxygen gas – O_2) or different types of atom to form a molecule of a compound (such as water - H_2O).



Oxygen Molecule – O_2



Water Molecule – H_2O

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Background Knowledge

Matter exists in different states – solid, liquid and gases

All matter can be found as either solid, liquid or gas depending upon the temperature. Each type of matter has its own specific temperature ranges that it will exist in each of these three states. Gases, liquids and solids can be made up of atoms, molecules, and/or ions.

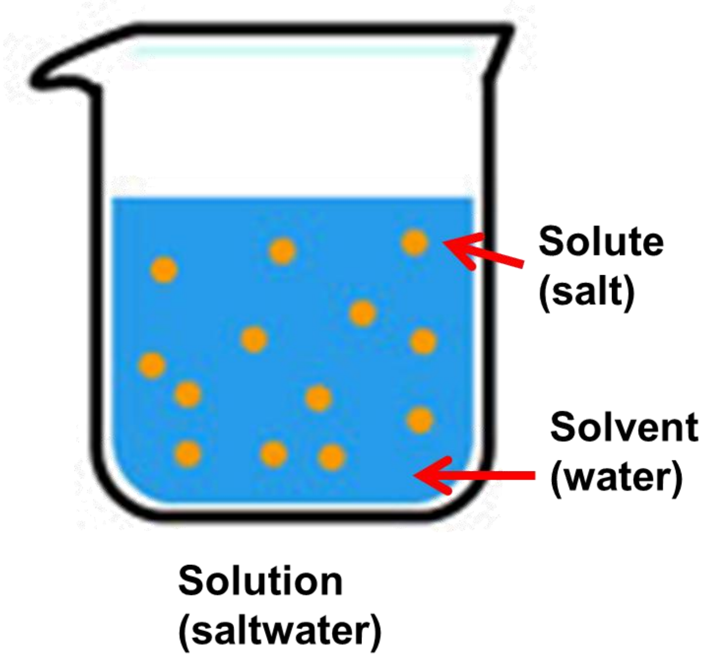
Solid iodine
$I_2(s)$

Liquid bromine
$Br_2(l)$

Gaseous chlorine
$Cl_2(g)$

Background Knowledge

Solutions are made from a solute dissolved in a solvent



A **solution** is made up of a **solvent** and a **solute**. A solvent is a substance such as water that is able to dissolve a solute. The solvent 'pulls apart' the bonds that hold the solute together and the solute particles **diffuse** (spread randomly by hitting into each other) throughout the solvent to create a solution. The solution is a **mixture** with evenly spread solvent and solute particles. These particles can be physically separated by **evaporation**.

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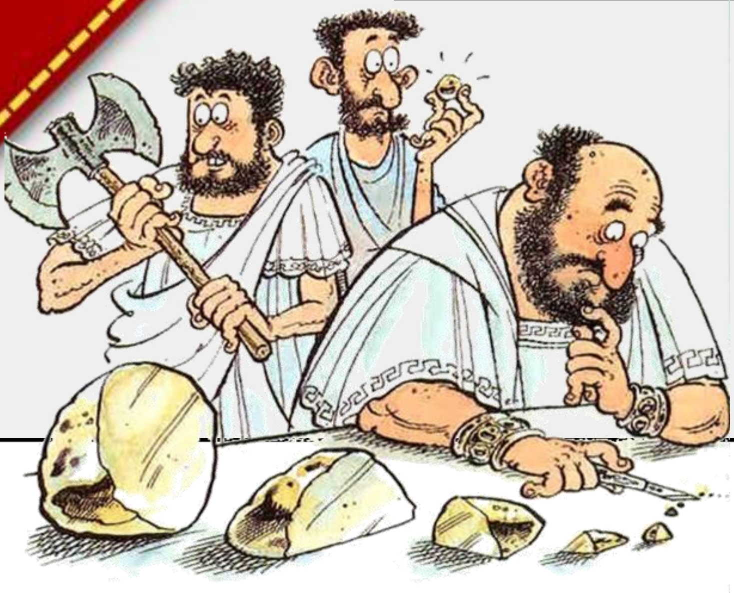
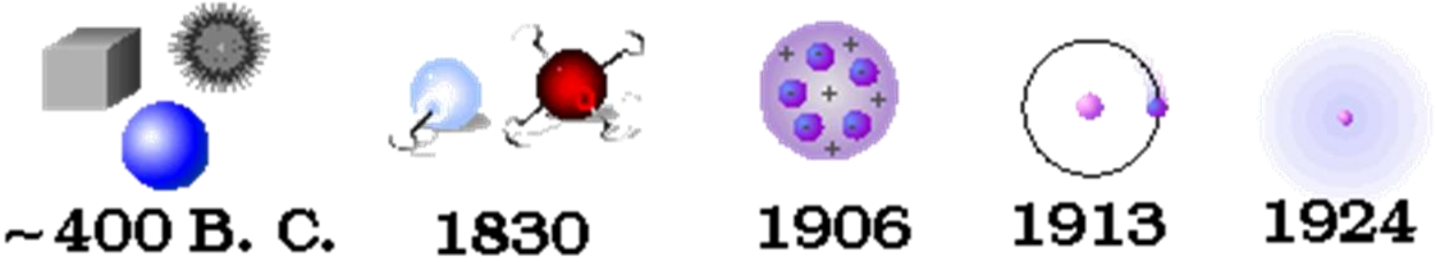
Background Knowledge

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



sites.google.com/site/sec2chemistry2015

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.

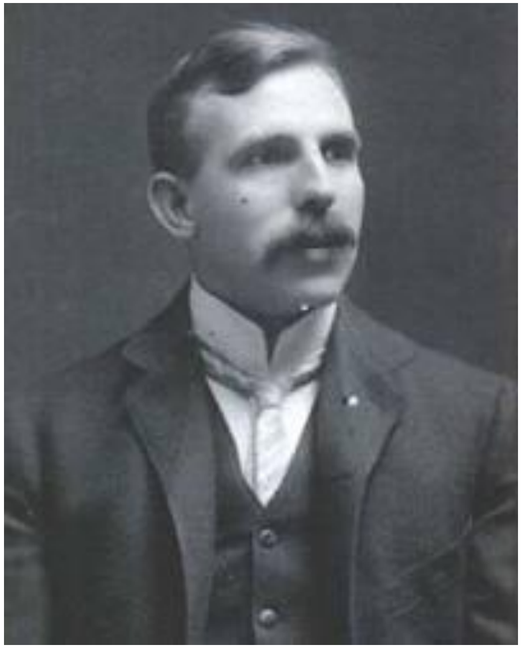


The History of Atomic Theory

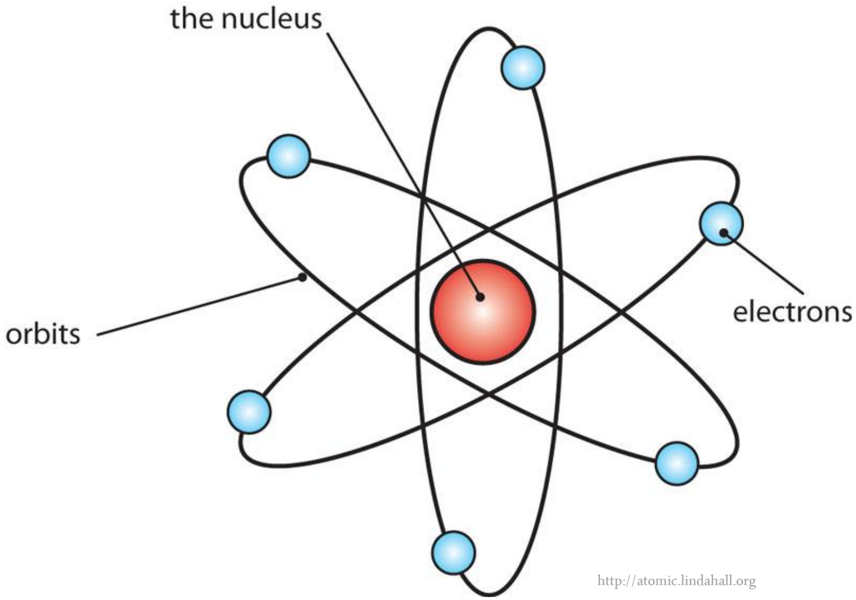
Background Knowledge

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



http://atomic.lindahall.org

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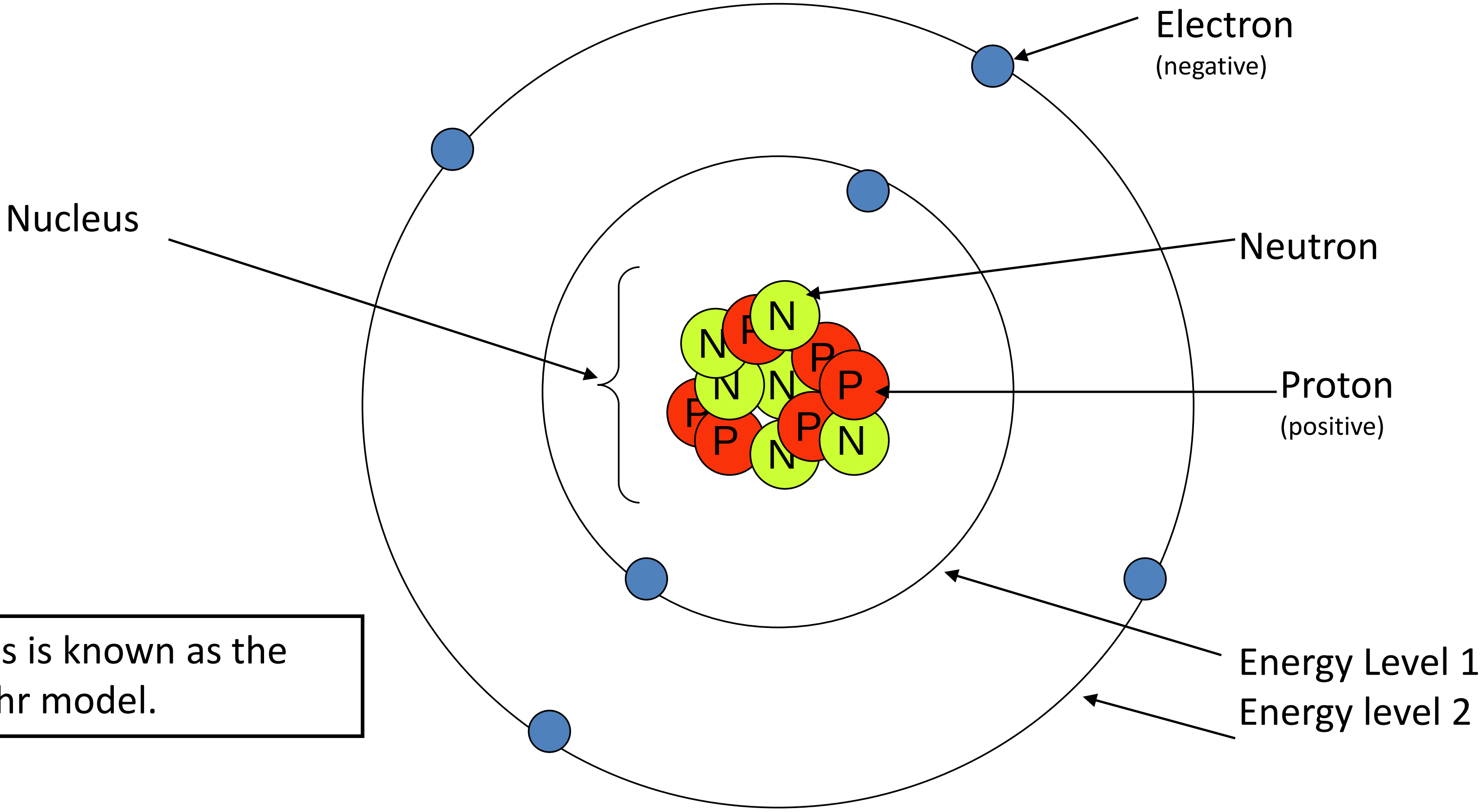
Atoms contain protons, electrons and neutrons

Atoms contain 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.



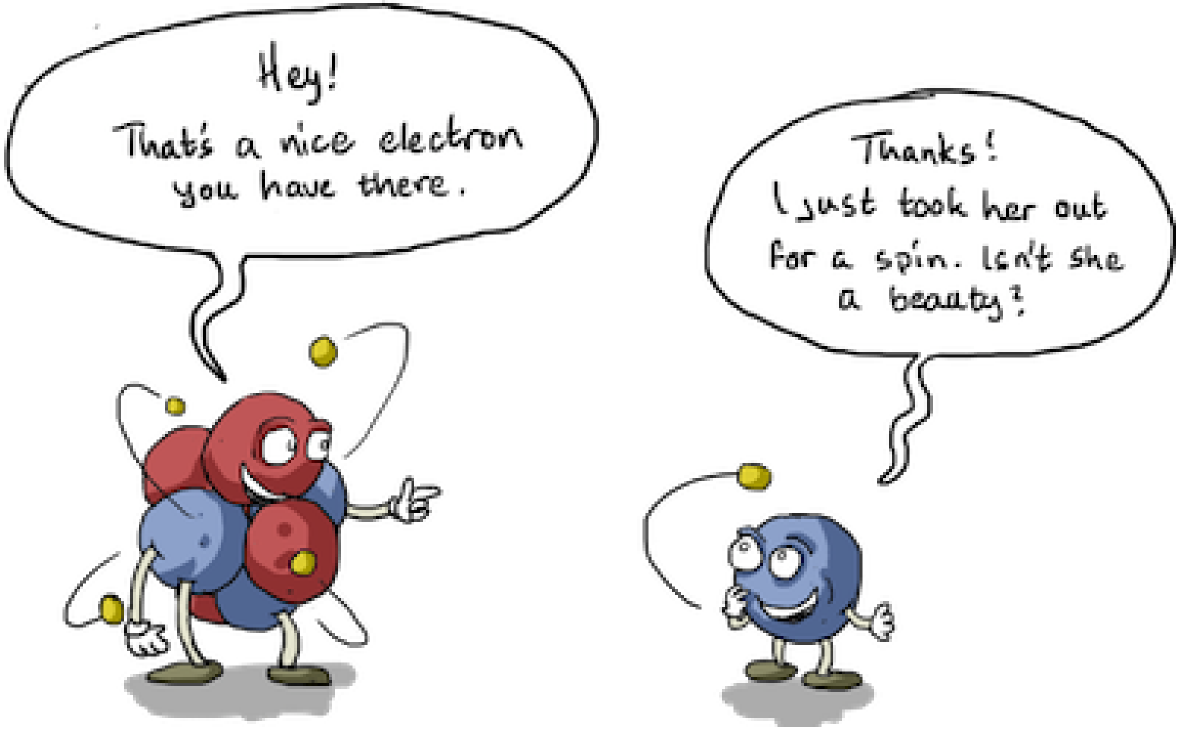
This is known as the Bohr model.

Atoms have equal number of protons and electrons

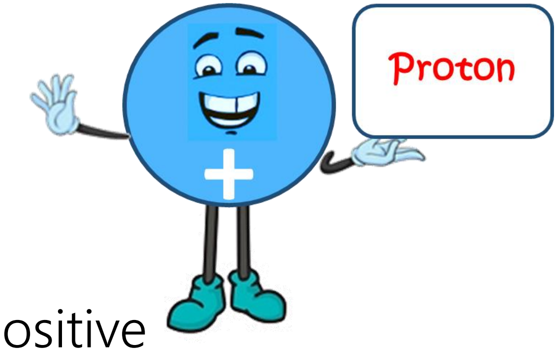
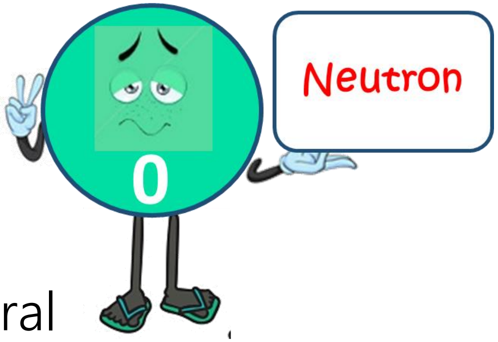
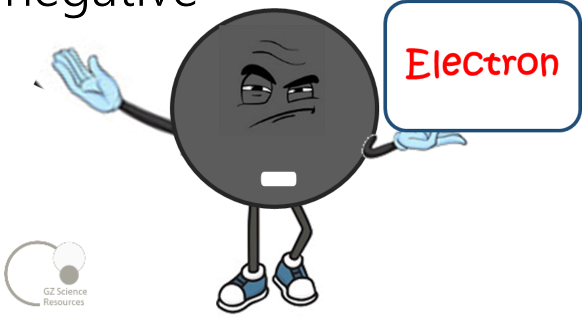
Protons are positively charged; electrons are negatively charged; neutrons have zero electrical charge.
Atoms have no overall charge because the number of protons = number of electrons.

Summary

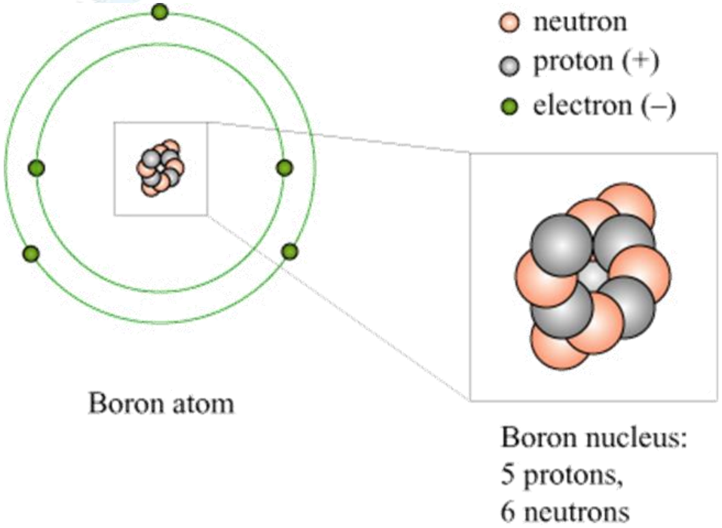
- ☐ All matter is made up of atoms. Atoms consist of protons, neutrons and electrons.
- ☐ The charges of protons and electrons are equal and opposite.

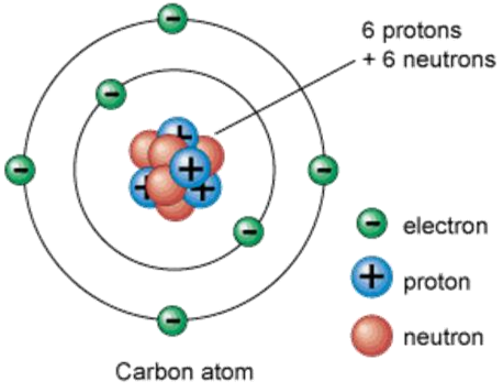


www.shmoop.com

Subatomic particle	symbol	Mass compared to a proton	charge	location
 positive	p	1	+1	In the nucleus
 neutral	n	1	0	In the nucleus
negative 	e	1/1840	-1	Moving outside the nucleus

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 its 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.

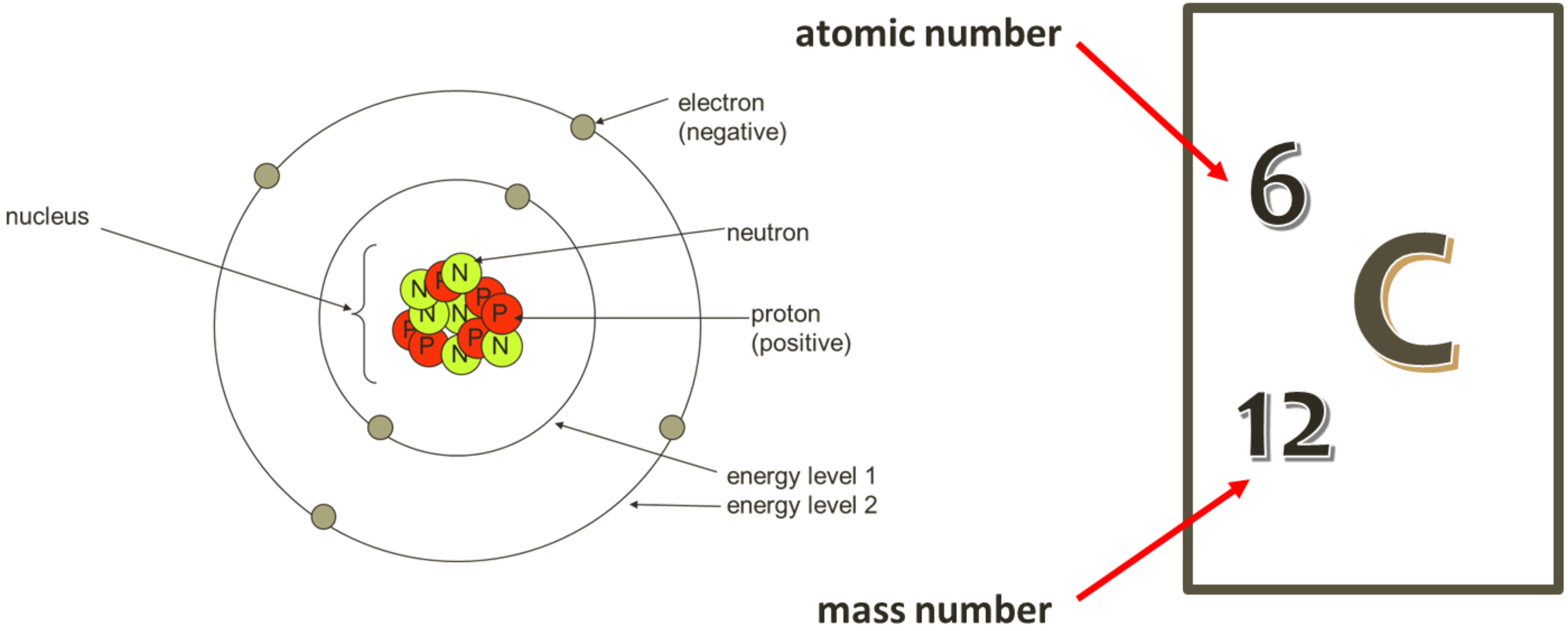
Atomic and Mass number

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** .

The atomic mass (mass number) of an atom is equal to the number of **protons and neutrons.**

Both numbers are normally found in the periodic table.



Calculating protons, neutrons and electrons

Number of protons:

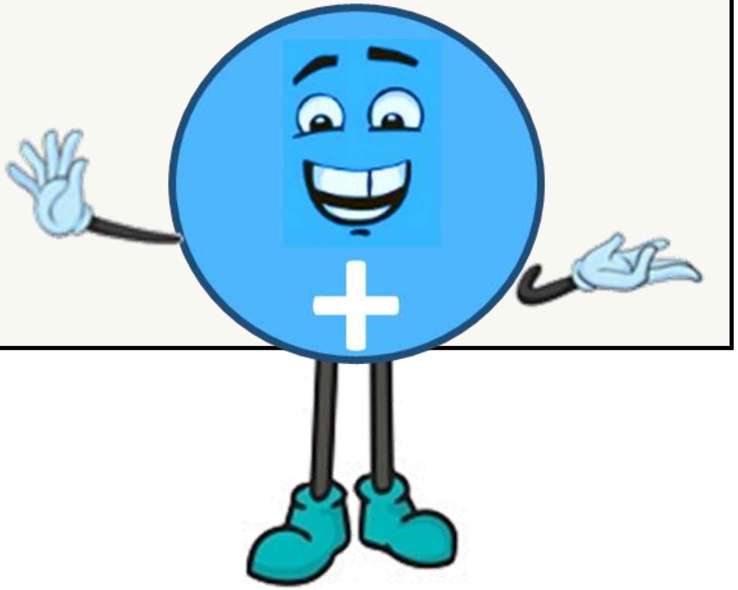
For an atom = atomic number

Number of electrons:

For an atom = atomic number

Number of neutrons:

For an atom = atomic mass - atomic number



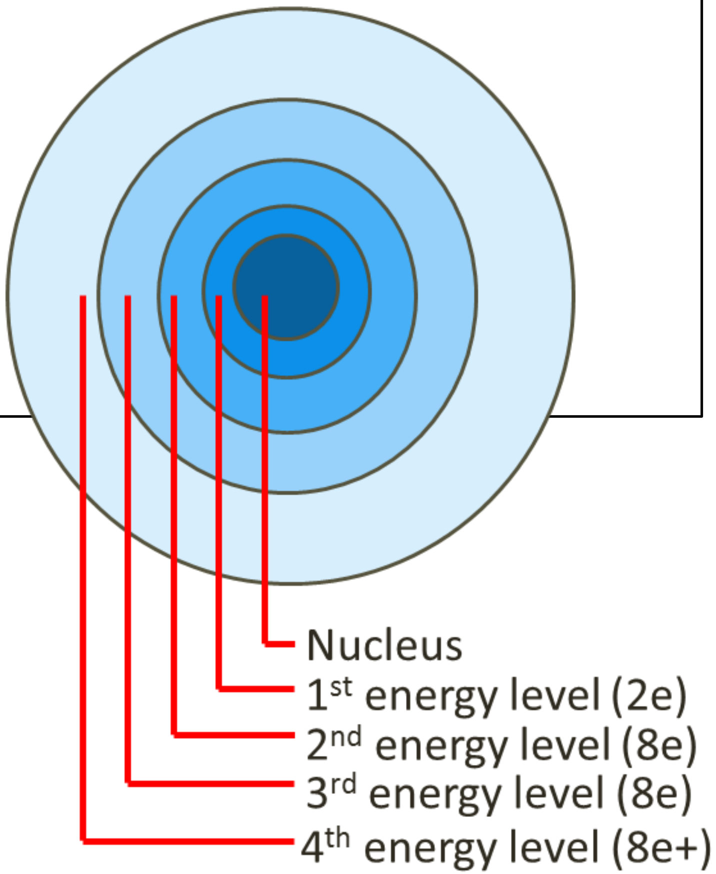
atom or ion	number of protons	Atomic number	number of electrons	number of neutrons	Mass number
carbon (C)	6	6	6	6	12
magnesium (Mg)	12	12	12	12	24
fluorine (F)	9	9	9	10	19

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:

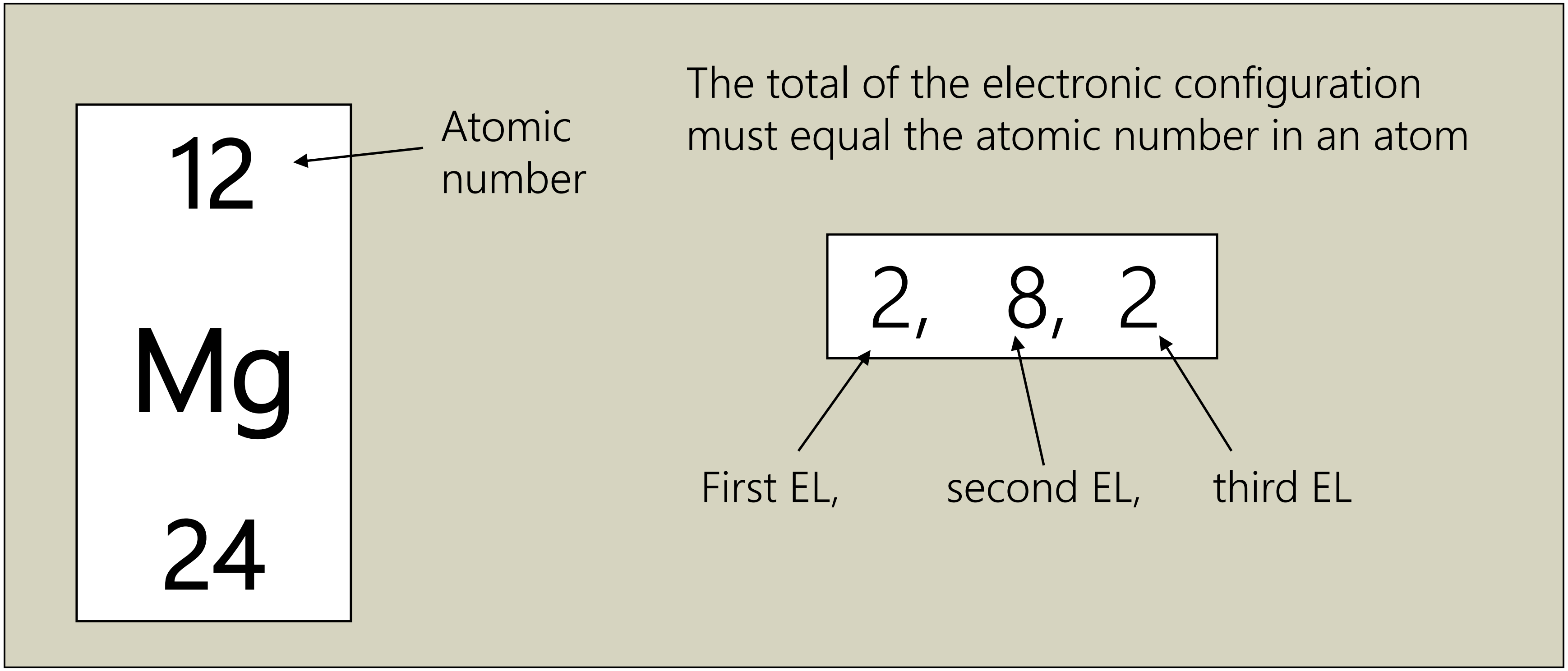
- ☐ 2 in the first EL (nearest the nucleus)
- ☐ 8 in the second EL
- ☐ 8 in the third EL (before the fourth shell starts to fill)
- ☐ 8+ in the fourth EL



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

An atom's electron arrangement is known as its 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). The EL are separated by a comma. The EL are filled until all the electrons are placed.



12

Mg

24

Atomic number

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

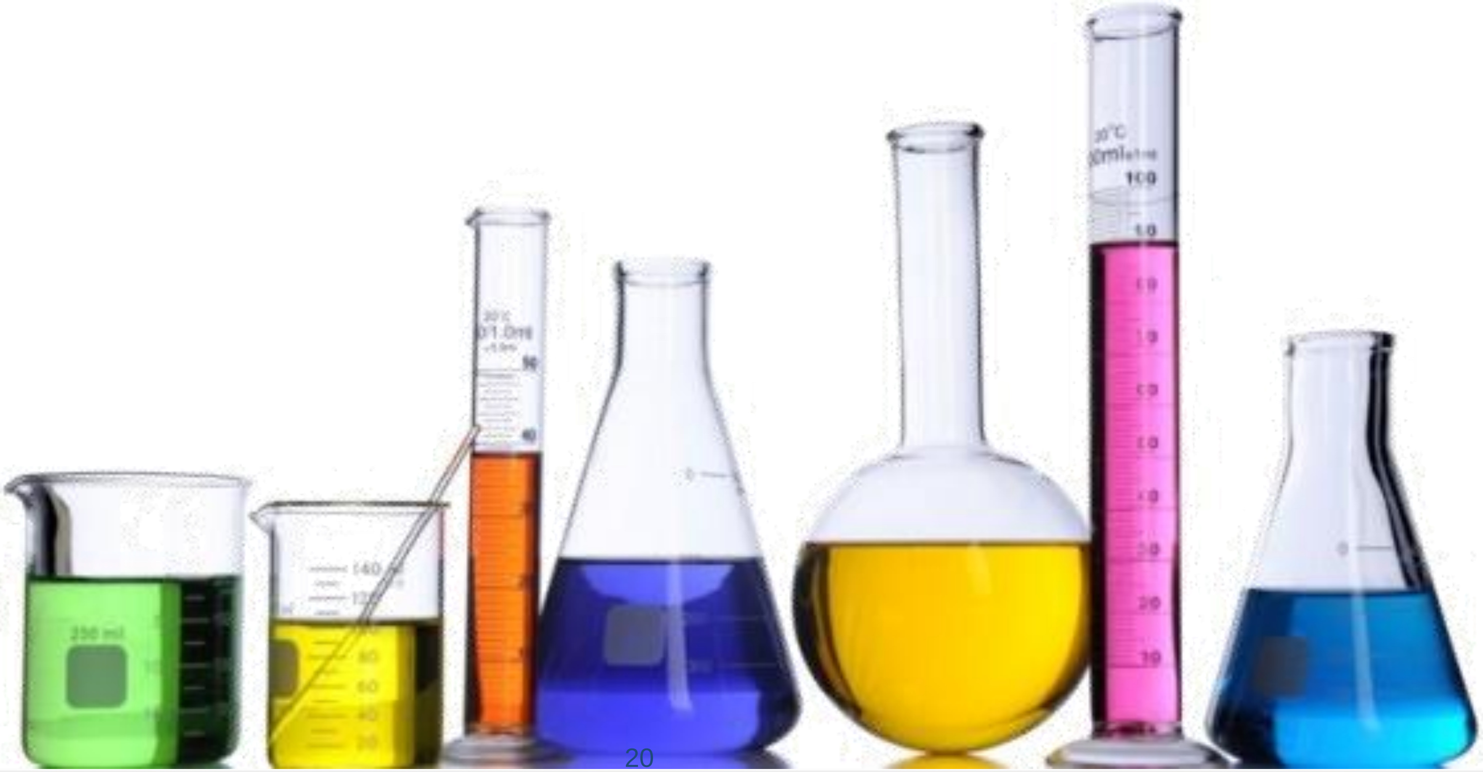
2, 8, 2

First EL, second EL, third EL

Background Knowledge

The elements and Periodic table

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

Dimitry Mendeleev was a Russian Chemist (1834-1907) who created a periodic table based on elements relative atomic mass and he 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 have subsequently been filled.

extra info

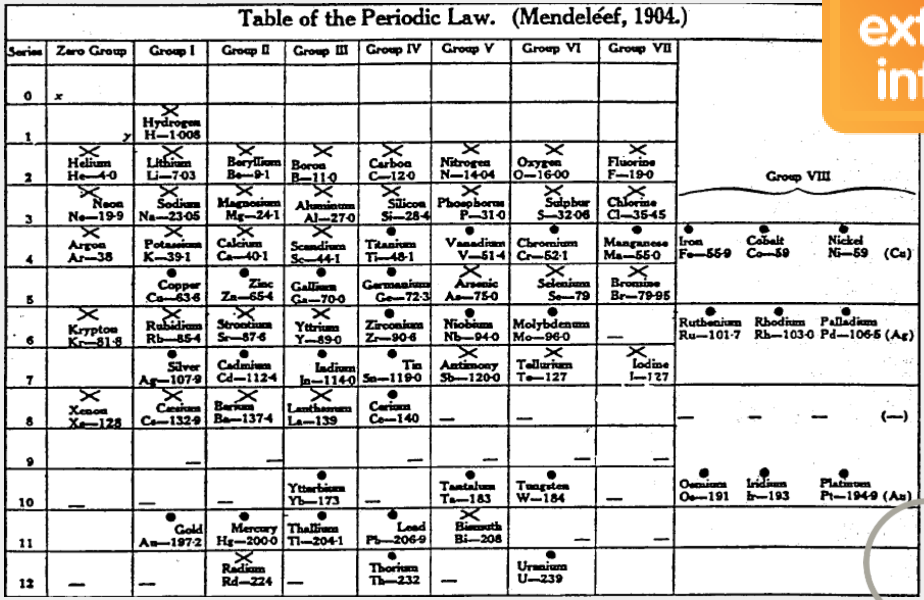


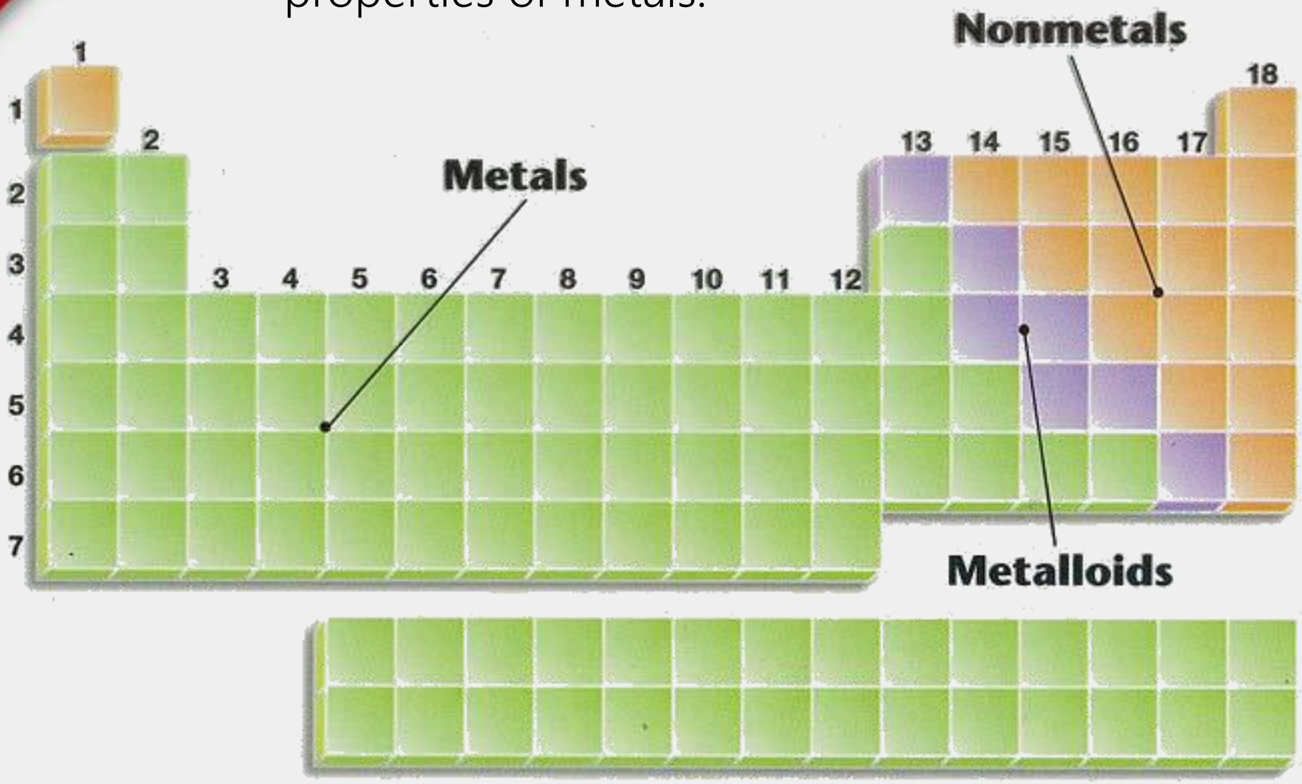
Table of the Periodic Law. (Mendeléef, 1904.)

Series	Zero Group	Group I	Group II	Group III	Group IV	Group V	Group VI	Group VII	Group VIII			
0	*x*											
1	*y*	✕ 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 Mn—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 Ge—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					

Background Knowledge

Metals are placed on the left hand side and non-metals are placed on the right hand side of the periodic table

Elements can be classified as metals or non-metals. A few elements are called semi-metals or metaloids (e.g. boron and silicon), because they show some, but not all, of the properties of metals.



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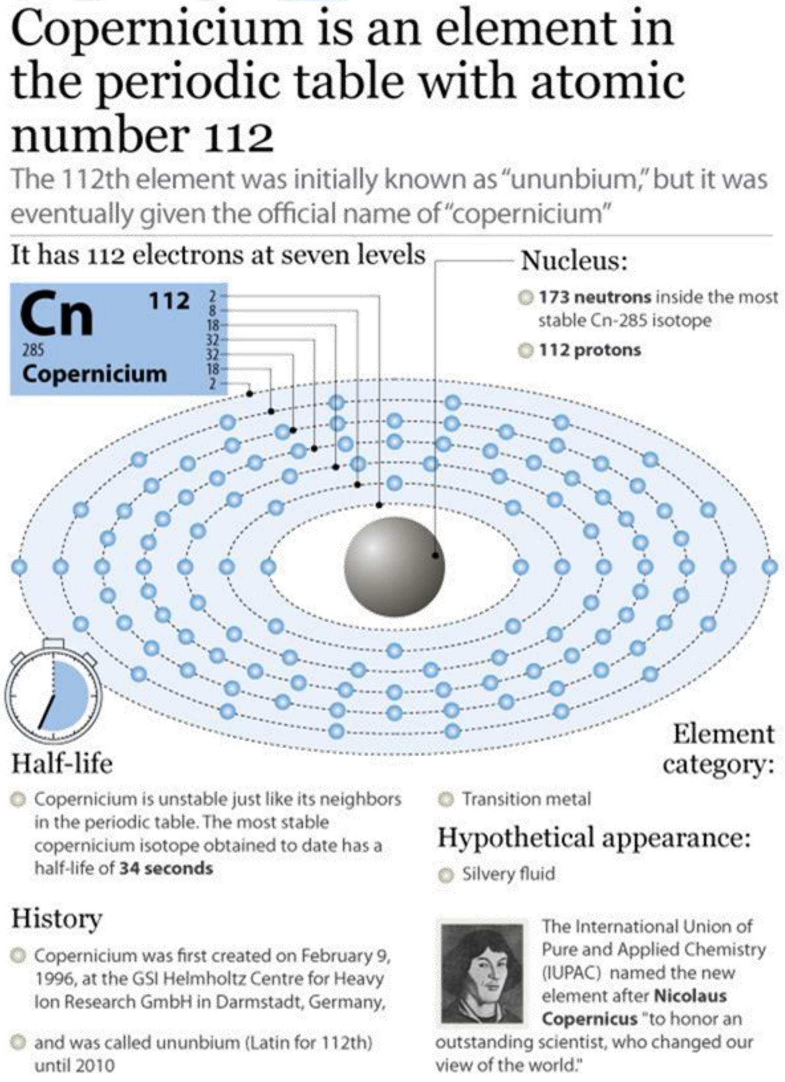
Elements are arranged on the periodic table according to their atomic number



Copernicium is an element in the periodic table with atomic number 112

The 112th element was initially known as "ununbium," but it was eventually given the official name of "copernicium"

It has 112 electrons at seven levels

Nucleus:

- **173 neutrons** inside the most stable Cn-285 isotope
- **112 protons**

Half-life

- Copernicium is unstable just like its neighbors in the periodic table. The most stable copernicium isotope obtained to date has a half-life of **34 seconds**

Element category:

- Transition metal

Hypothetical appearance:

- Silvery fluid

History

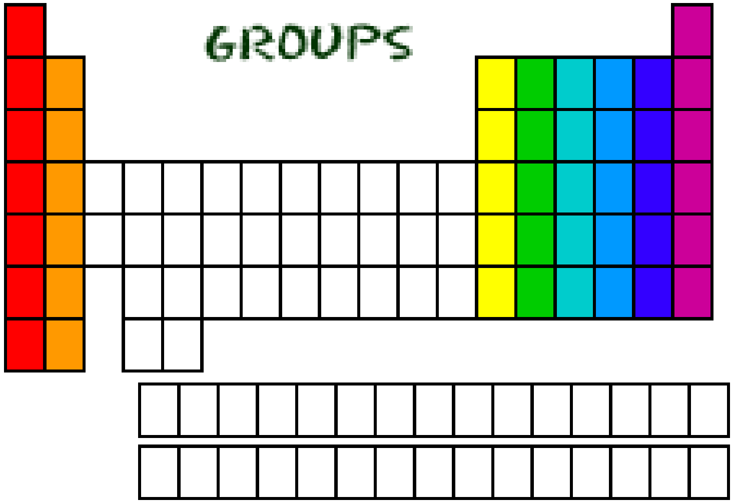
- Copernicium was first created on February 9, 1996, at the GSI Helmholtz Centre for Heavy Ion Research GmbH in Darmstadt, Germany,
- and was called ununbium (Latin for 112th) until 2010

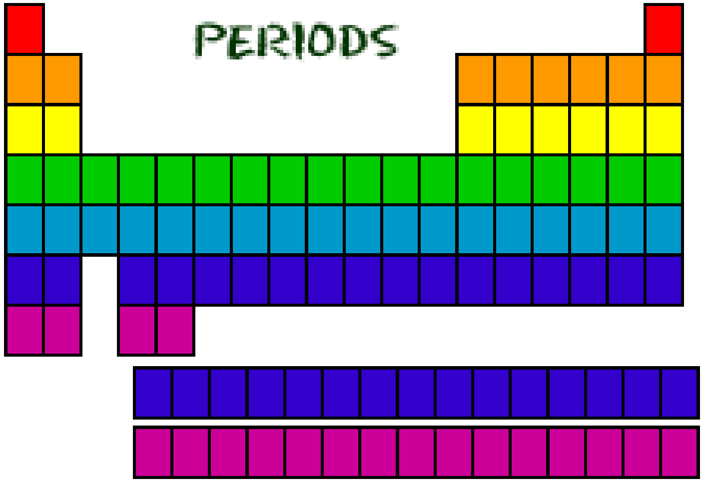
The International Union of Pure and Applied Chemistry (IUPAC) named the new element after **Nicolaus Copernicus** "to honor an outstanding scientist, who changed our view of the world."

Each element has an atomic number, which tells us how many protons are contained inside each atoms nucleus. This number of protons is matched by an equal number of electrons, which move around the nucleus.
The periodic table starts with Hydrogen (H) Atomic number 1 and ends with elements that have over 100 protons such as Copernicium (Cn) Atomic number 112.

Groups are numbered vertical columns and periods are horizontal rows

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

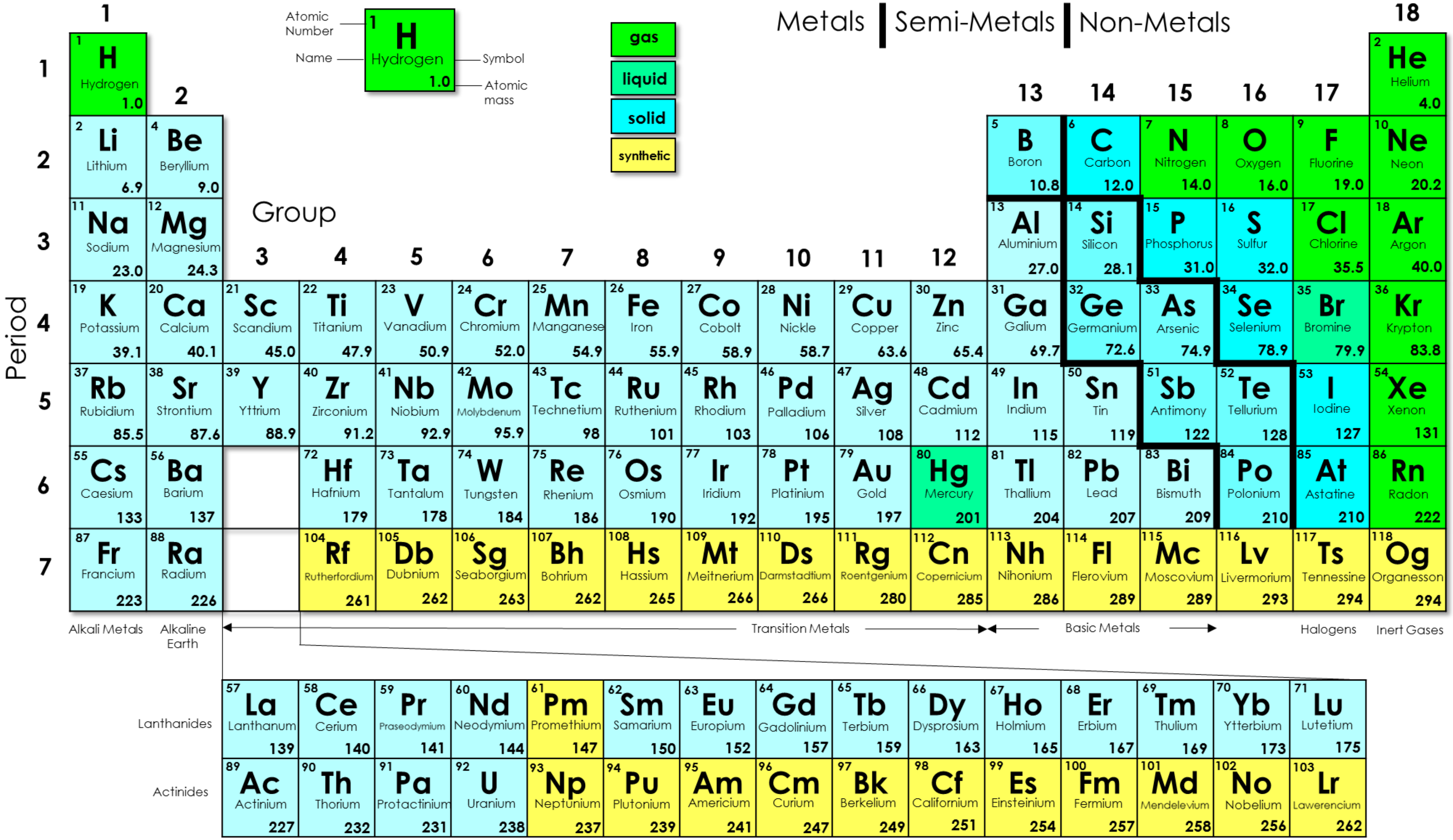




Elements in the same group all have the same number of electrons in their outer (or valence) energy levels.

Elements in the same period all have the same number of energy levels of electrons in their atoms

Periodic Table of the Elements



Atomic Number
Name
1 **H** Hydrogen 1.0
Symbol
Atomic mass

gas
liquid
solid
synthetic

Metals | Semi-Metals | Non-Metals

Group

Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 **H** Hydrogen 1.0																	2 **He** Helium 4.0
2	2 **Li** Lithium 6.9	4 **Be** Beryllium 9.0											5 **B** Boron 10.8	6 **C** Carbon 12.0	7 **N** Nitrogen 14.0	8 **O** Oxygen 16.0	9 **F** Fluorine 19.0	10 **Ne** Neon 20.2
3	11 **Na** Sodium 23.0	12 **Mg** Magnesium 24.3											13 **Al** Aluminium 27.0	14 **Si** Silicon 28.1	15 **P** Phosphorus 31.0	16 **S** Sulfur 32.0	17 **Cl** Chlorine 35.5	18 **Ar** Argon 40.0
4	19 **K** Potassium 39.1	20 **Ca** Calcium 40.1	21 **Sc** Scandium 45.0	22 **Ti** Titanium 47.9	23 **V** Vanadium 50.9	24 **Cr** Chromium 52.0	25 **Mn** Manganese 54.9	26 **Fe** Iron 55.9	27 **Co** Cobolt 58.9	28 **Ni** Nickle 58.7	29 **Cu** Copper 63.6	30 **Zn** Zinc 65.4	31 **Ga** Galium 69.7	32 **Ge** Germanium 72.6	33 **As** Arsenic 74.9	34 **Se** Selenium 78.9	35 **Br** Bromine 79.9	36 **Kr** Krypton 83.8
5	37 **Rb** Rubidium 85.5	38 **Sr** Strontium 87.6	39 **Y** Yttrium 88.9	40 **Zr** Zirconium 91.2	41 **Nb** Niobium 92.9	42 **Mo** Molybdenum 95.9	43 **Tc** Technetium 98	44 **Ru** Ruthenium 101	45 **Rh** Rhodium 103	46 **Pd** Palladium 106	47 **Ag** Silver 108	48 **Cd** Cadmium 112	49 **In** Indium 115	50 **Sn** Tin 119	51 **Sb** Antimony 122	52 **Te** Tellurium 128	53 **I** Iodine 127	54 **Xe** Xenon 131
6	55 **Cs** Caesium 133	56 **Ba** Barium 137		72 **Hf** Hafnium 179	73 **Ta** Tantalum 178	74 **W** Tungsten 184	75 **Re** Rhenium 186	76 **Os** Osmium 190	77 **Ir** Iridium 192	78 **Pt** Platinium 195	79 **Au** Gold 197	80 **Hg** Mercury 201	81 **Tl** Thallium 204	82 **Pb** Lead 207	83 **Bi** Bismuth 209	84 **Po** Polonium 210	85 **At** Astatine 210	86 **Rn** Radon 222
7	87 **Fr** Francium 223	88 **Ra** Radium 226		104 **Rf** Rutherfordium 261	105 **Db** Dubnium 262	106 **Sg** Seaborgium 263	107 **Bh** Bohrium 262	108 **Hs** Hassium 265	109 **Mt** Meitnerium 266	110 **Ds** Darmstadtium 266	111 **Rg** Roentgenium 280	112 **Cn** Copernicium 285	113 **Nh** Nihonium 286	114 **Fl** Flerovium 289	115 **Mc** Moscovium 289	116 **Lv** Livermorium 293	117 **Ts** Tennessine 294	118 **Og** Organesson 294
	Alkali Metals	Alkaline Earth	Transition Metals										Basic Metals				Halogens	Inert Gases

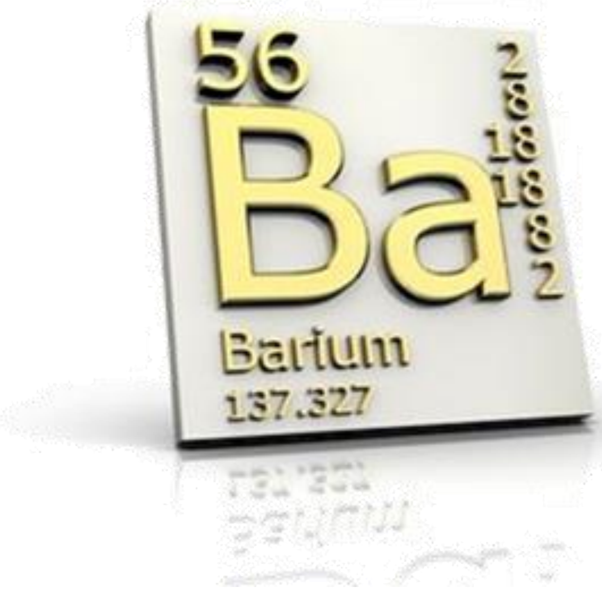
Lanthanides	57 **La** Lanthanum 139	58 **Ce** Cerium 140	59 **Pr** Praseodymium 141	60 **Nd** Neodymium 144	61 **Pm** Promethium 147	62 **Sm** Samarium 150	63 **Eu** Europium 152	64 **Gd** Gadolinium 157	65 **Tb** Terbium 159	66 **Dy** Dysprosium 163	67 **Ho** Holmium 165	68 **Er** Erbium 167	69 **Tm** Thulium 169	70 **Yb** Ytterbium 173	71 **Lu** Lutetium 175
Actinides	89 **Ac** Actinium 227	90 **Th** Thorium 232	91 **Pa** Protactinium 231	92 **U** Uranium 238	93 **Np** Neptunium 237	94 **Pu** Plutonium 239	95 **Am** Americium 241	96 **Cm** Curium 247	97 **Bk** Berkelium 249	98 **Cf** Californium 251	99 **Es** Einsteinium 254	100 **Fm** Fermium 257	101 **Md** Mendelevium 258	102 **No** Nobelium 256	103 **Lr** Lawerencium 262

Background Knowledge

Each element is named and has a specific symbol.

Elements consist of only one type of atom.

Each element can be represented by a chemical symbol.



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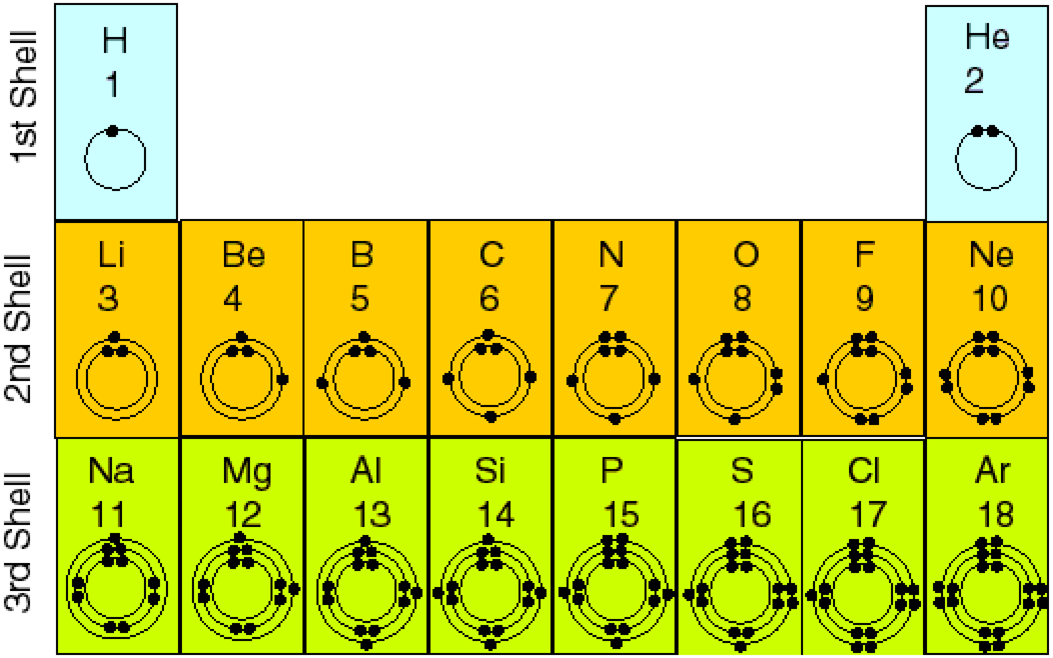
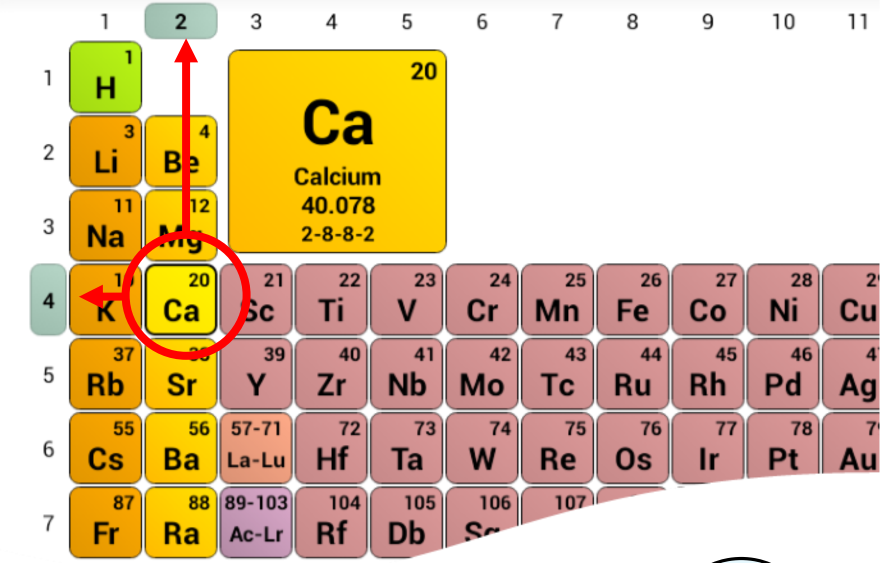
There is a relationship between the period number and the number of electron energy levels an atom has.



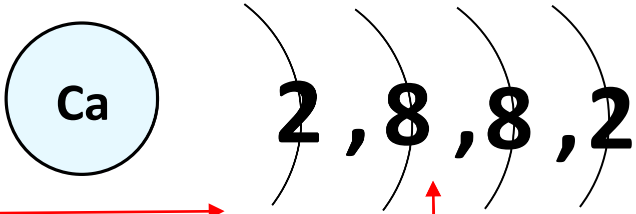
At this time, the maximum number of electron energy levels for any element is seven.

In the periodic table, elements have something in common if they are in the same row. 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 goes down the periodic table like that.

Using the Periodic table to write electron arrangements



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



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

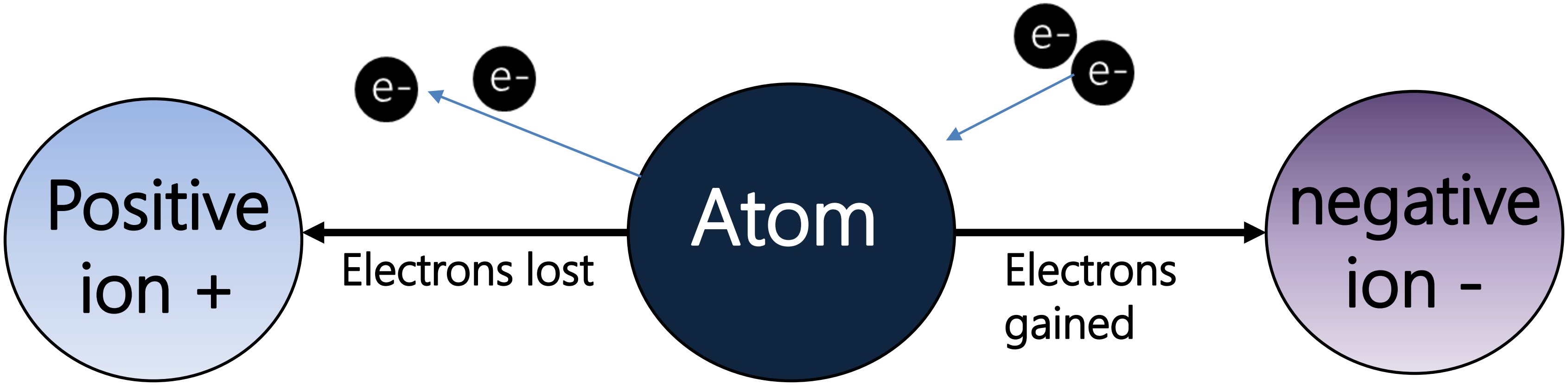
Step 3. backfill all energy levels with 8 electrons (2 in first) and add commas between each

Ions

An ion is an atom or group of atoms which has gained or lost electrons.

Elements are most stable when the outer energy level (valence shell) is full. The first energy level needs 2 electrons to be stable. The other energy levels need 8 electrons to be stable.

Elements can lose or gain electrons when they react with other chemicals to form ions and achieve stability.



Positive ion +

Electrons lost

Atom

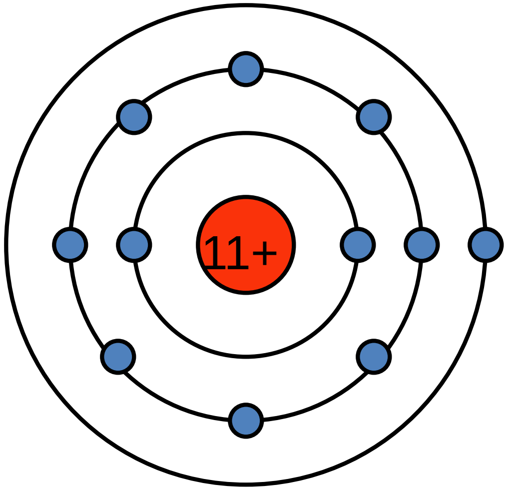
Electrons gained

negative ion -

Ions are formed by the gain or loss of electrons.

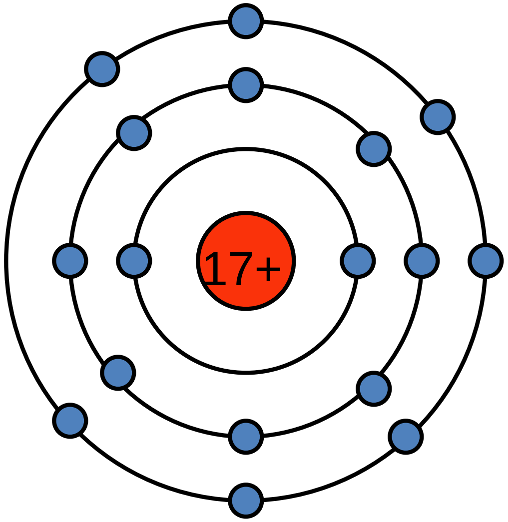
Ions are atoms or groups of atoms with electrical charges. Ions normally form in pairs of atoms when one or more electrons are passed between them. Depending on how many electrons are present in the outside energy level or how many are "missing" determines the total number of electrons transferred.

Cation Sodium (Na)



Sodium now becomes the sodium ion Na$^+$

Anion Chlorine (Cl)

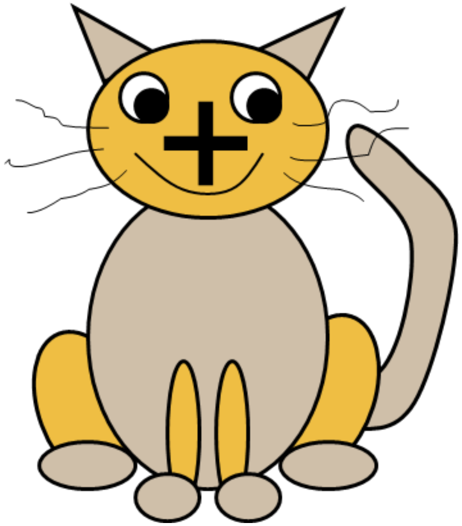


Chlorine now becomes the chloride ion Cl$^-$

Ions are formed by the 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

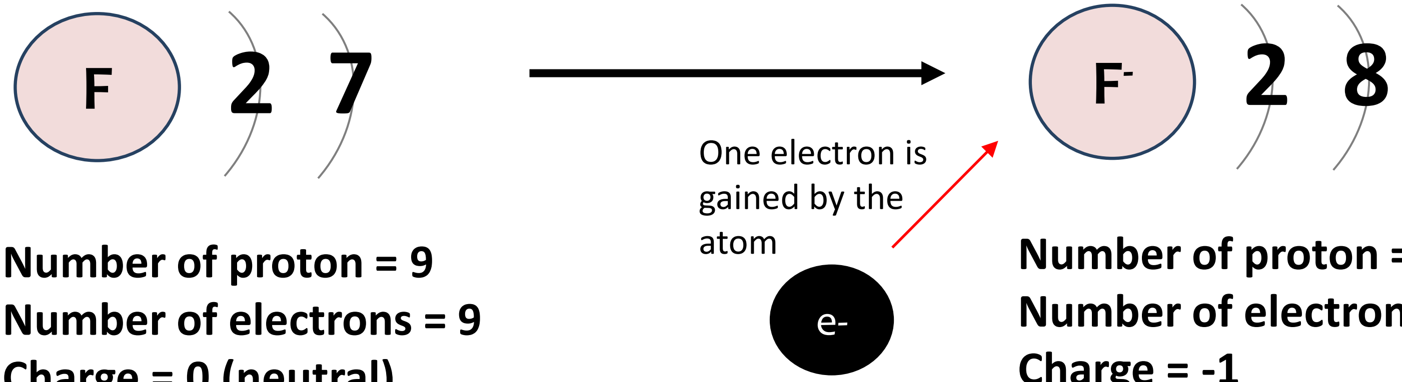
Anion (an Iron)

Non-Metals gain electrons to form Anions. They have 5-7 electrons in their outside energy level.

The number of protons compared to electrons determines the charge

If an atom has the same number of electrons as it does protons then it will be neutral. A negative ion will have more electrons than protons. A positive ion will have less electrons than protons.

	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

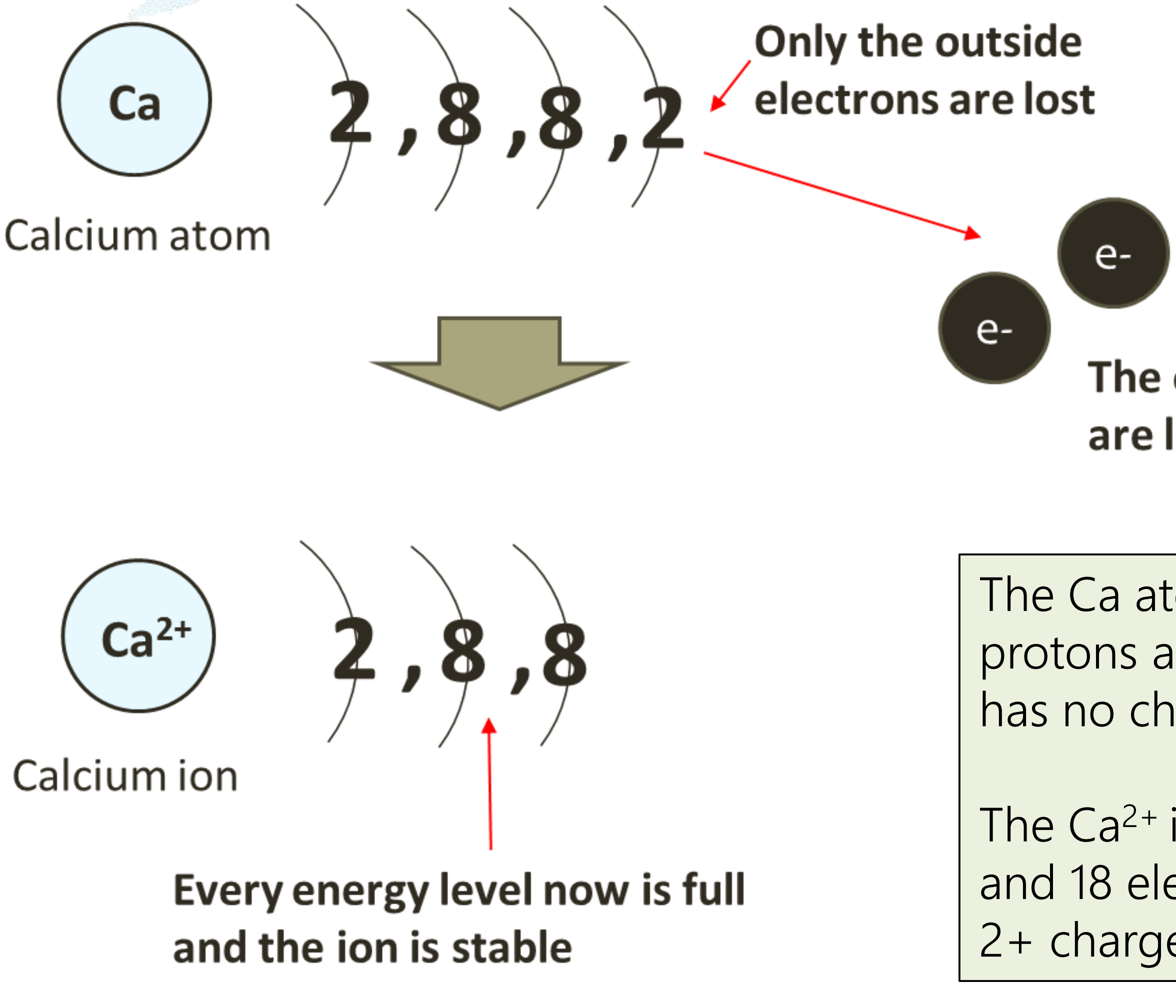


Number of proton = 9
Number of electrons = 9
Charge = 0 (neutral)

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

Electron arrangement of positive ions (metals)

Extension



Calcium atom

Only the outside electrons are lost

The outside electrons are lost

Calcium ion

Every energy level now is full and the ion is stable

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.

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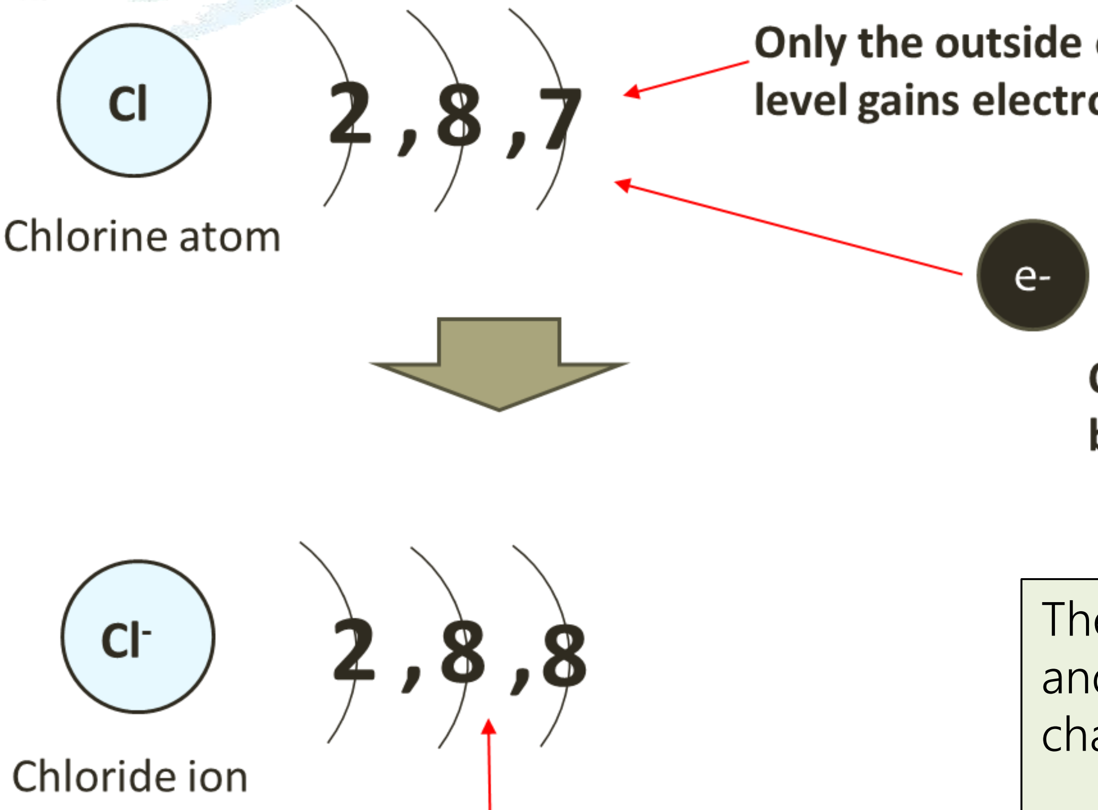
Electron arrangement of negative ions (non-metals)

Extension



Chlorine atom

Only the outside energy level gains electrons

One electrons is gained by the atom

Chloride ion

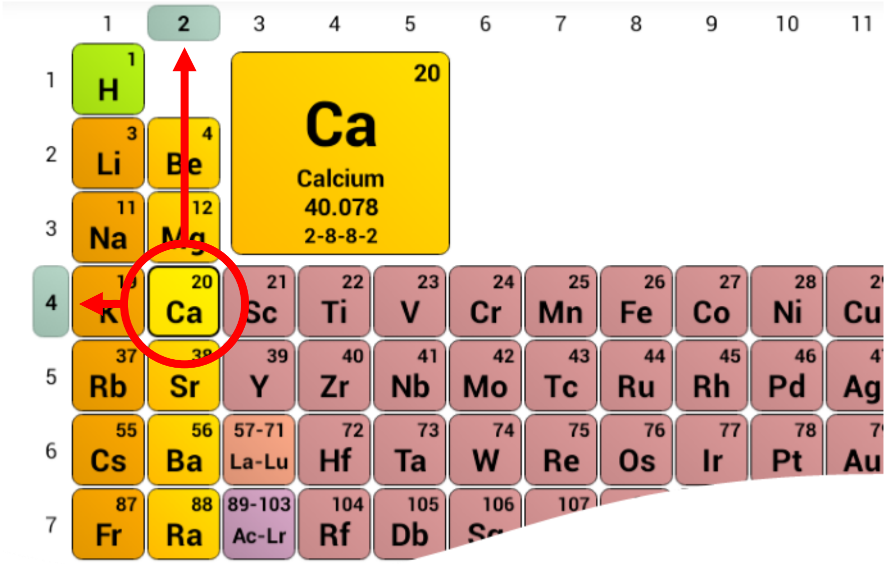
Every energy level now is full and the ion is stable

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.

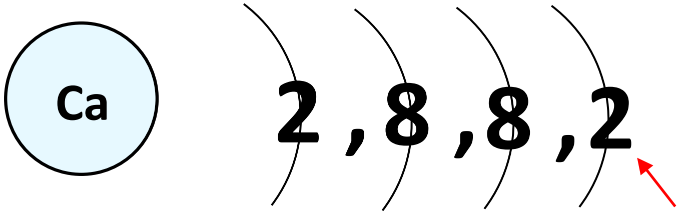
The position of an element on the Periodic table determines the ion

Extension



The (last) number of the group on a periodic table gives the number of electrons in the outside Energy Level. If there is 3 or less, in groups 1,2 or 13 then electrons will be lost to form positive ions.
If there is 5, 6 or 7, in groups 15, 16 or 17 then electrons will be gained to form negative ions

NOTE: We are only focusing on drawing ions from the first 20 elements so you don't need to worry about elements in groups 3-12 at this stage



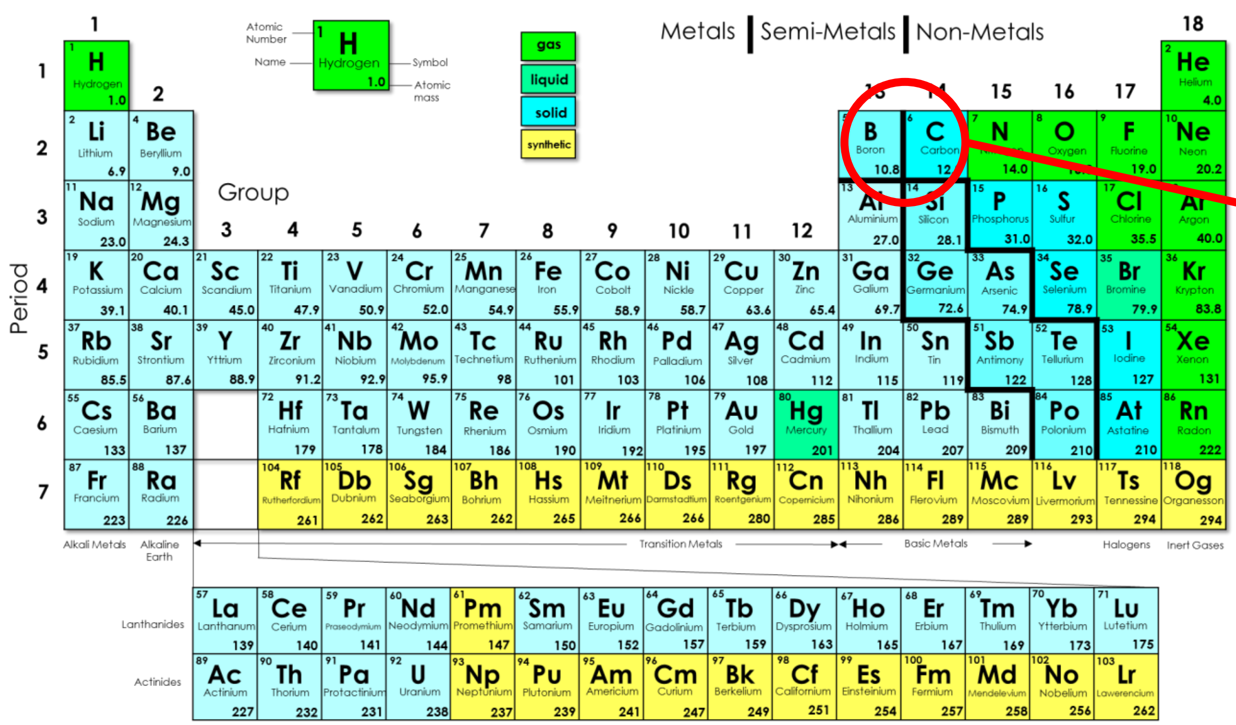
Ca in in group 2 so has 2 electrons in the outside energy level

Ca will lose 2 electrons to become a positive Ca^{2+} ion

Not all elements form ions

extra info

Periodic Table of the Elements



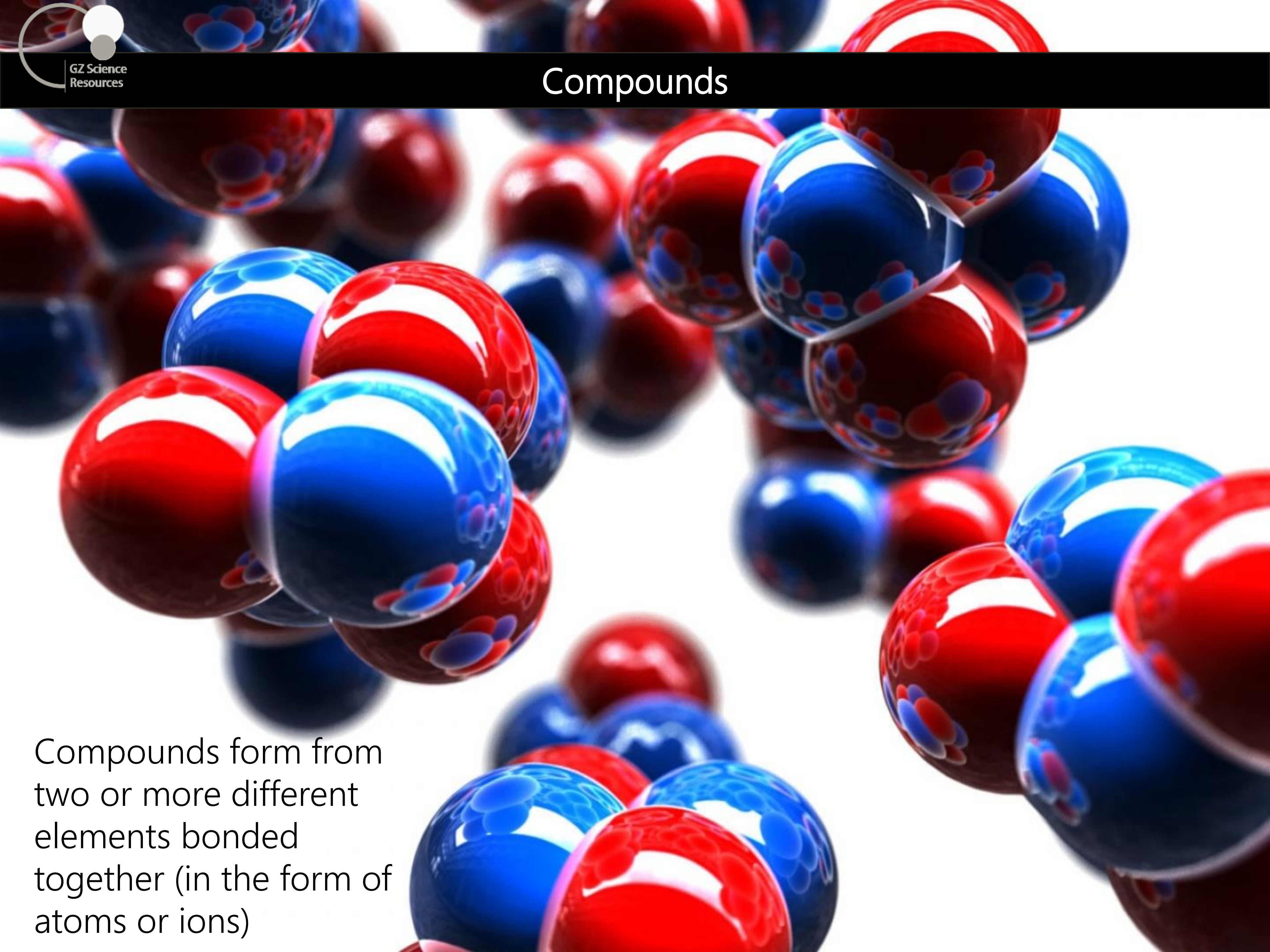
Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H Hydrogen 1.0																	2 He Helium 4.0
2	2 Li Lithium 6.9	4 Be Beryllium 9.0											5 B Boron 10.8	6 C Carbon 12	7 N [illegible] 14.0	8 O Oxygen [illegible]	9 F Fluorine 19.0	10 Ne Neon 20.2
3	11 Na Sodium 23.0	12 Mg Magnesium 24.3											13 Al Aluminium 27.0	14 Si Silicon 28.1	15 P Phosphorus 31.0	16 S Sulfur 32.0	17 Cl Chlorine 35.5	Ar Argon 40.0
4	19 K Potassium 39.1	20 Ca Calcium 40.1	21 Sc Scandium 45.0	22 Ti Titanium 47.9	23 V Vanadium 50.9	24 Cr Chromium 52.0	25 Mn Manganese 54.9	26 Fe Iron 55.9	27 Co Cobolt 58.9	28 Ni Nickle 58.7	29 Cu Copper 63.6	30 Zn Zinc 65.4	31 Ga Galium 69.7	32 Ge Germanium 72.6	33 As Arsenic 74.9	34 Se Selenium 78.9	35 Br Bromine 79.9	36 Kr Krypton 83.8
5	37 Rb Rubidium 85.5	38 Sr Strontium 87.6	39 Y Yttrium 88.9	40 Zr Zirconium 91.2	41 Nb Niobium 92.9	42 Mo Molybdenum 95.9	43 Tc Technetium 98	44 Ru Ruthenium 101	45 Rh Rhodium 103	46 Pd Palladium 106	47 Ag Silver 108	48 Cd Cadmium 112	49 In Indium 115	50 Sn Tin 119	51 Sb Antimony 122	52 Te Tellurium 128	53 I Iodine 127	54 Xe Xenon 131
6	55 Cs Caesium 133	56 Ba Barium 137		72 Hf Hafnium 179	73 Ta Tantalum 178	74 W Tungsten 184	75 Re Rhenium 186	76 Os Osmium 190	77 Ir Iridium 192	78 Pt Platinium 195	79 Au Gold 197	80 Hg Mercury 201	81 Tl Thallium 204	82 Pb Lead 207	83 Bi Bismuth 209	84 Po Polonium 210	85 At Astatine 210	86 Rn Radon 222
7	87 Fr Francium 223	88 Ra Radium 226		104 Rf Rutherfordium 261	105 Db Dubnium 262	106 Sg Seaborgium 263	107 Bh Bohrium 262	108 Hs Hassium 265	109 Mt Meitnerium 266	110 Ds Darmstadtium 266	111 Rg Roentgenium 280	112 Cn Copernicium 285	113 Nh Nihonium 286	114 Fl Flerovium 289	115 Mc Moscovium 289	116 Lv Livermorium 293	117 Ts Tennessine 294	118 Og Organesson 294

Lanthanides	57 La Lanthanum 139	58 Ce Cerium 140	59 Pr Praseodymium 141	60 Nd Neodymium 144	61 Pm Promethium 147	62 Sm Samarium 150	63 Eu Europium 152	64 Gd Gadolinium 157	65 Tb Terbium 159	66 Dy Dysprosium 163	67 Ho Holmium 165	68 Er Erbium 167	69 Tm Thulium 169	70 Yb Ytterbium 173	71 Lu Lutetium 175
Actinides	89 Ac Actinium 227	90 Th Thorium 232	91 Pa Protactinium 231	92 U Uranium 238	93 Np Neptunium 237	94 Pu Plutonium 239	95 Am Americium 241	96 Cm Curium 247	97 Bk Berkelium 249	98 Cf Californium 251	99 Es Einsteinium 254	100 Fm Fermium 257	101 Md Mendelevium 258	102 No Nobelium 256	103 Lr Lawerencium 262

In the first 20 elements of the periodic table not all elements form ions. Some elements like Boron (B), Carbon (C) and Silicon (Si) “share” their electrons with other atoms to become stable compounds. The type of bond these elements make with each other are called **covalent bonds**

Other elements like the ‘inert gases’ in group 18 have a full outer shell so do not need to lose or gain electrons for stability and therefore do not form ions

Compounds

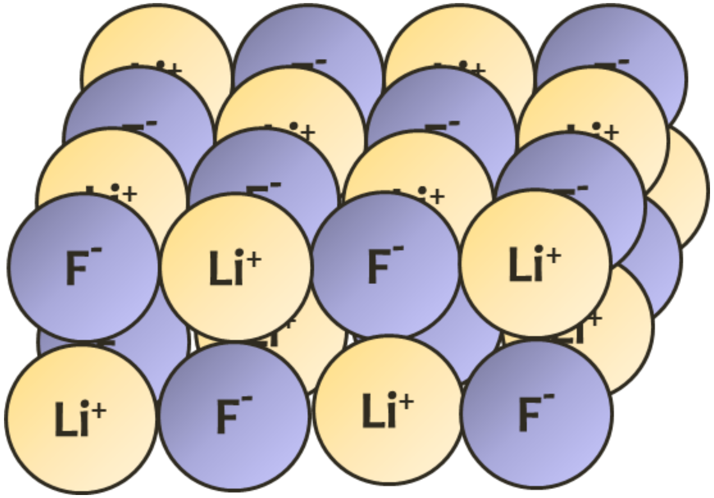


Compounds form from two or more different elements bonded together (in the form of atoms or ions)

Background Knowledge

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

Ionic compounds are made up of a fixed ratio of cations and anions. They exist in huge structures in a lattice structure. We call these structures crystals.



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

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.

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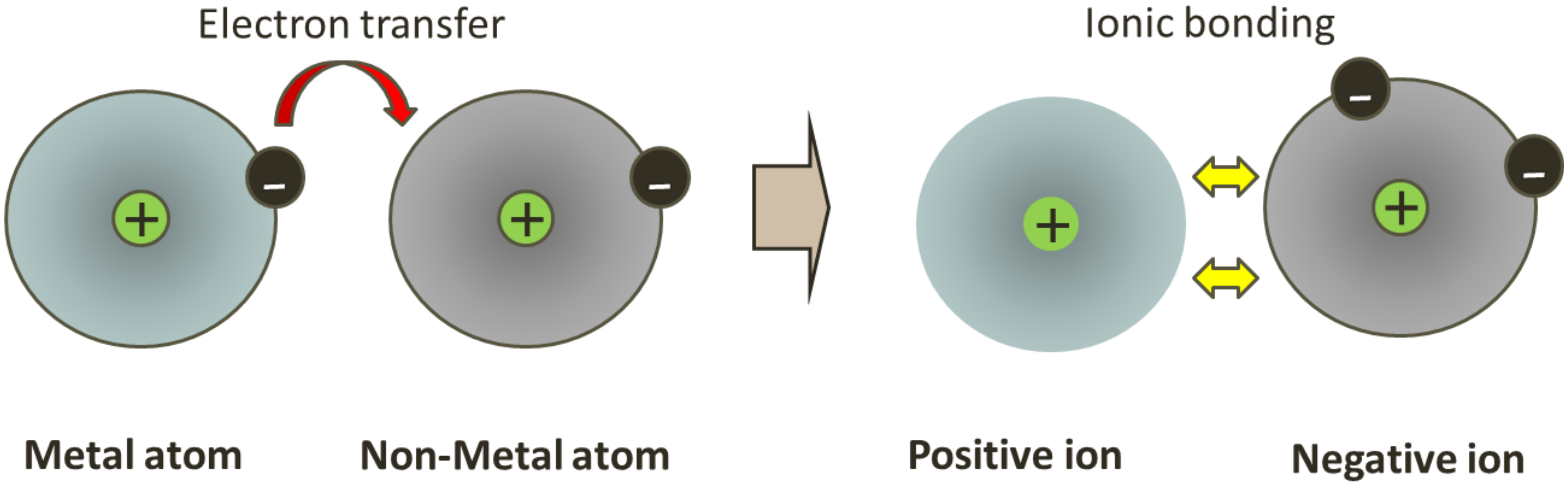
Ionic Bonding

Extension

Ionic Bonding is where one atom completely 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.



Ion table – Positive ions (Cations)

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+}	NOTE: while most positive ions in this group are made up from only one type of original element some ions are made up from a compound with more than one type of element – they have less total electrons than total protons.
ammonium NH_4^+	zinc Zn^{2+}	
Hydrogen H^+	barium Ba^{2+}	
Lithium Li^+	lead Pb^{2+}	

Yellow Shaded ions will be more commonly used in class

Ion table – Negative ions (Anions)

1-		2-	
chloride	Cl^-	carbonate	CO_3^{2-}
hydroxide	OH^-	sulfide	S^{2-}
hydrogen carbonate	HCO_3^-	sulfate	SO_4^{2-}
fluoride	F^-	NOTE: while many negative ions in this group are made up from only one type of original element some negative ions are made up from a compound with more than one type of element – they have more total electrons than total protons.	
bromide	Br^-		
nitrate	NO_3^-		

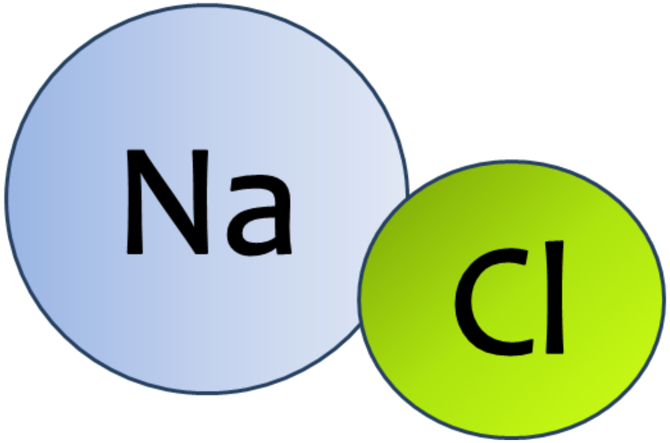
Yellow Shaded ions will be more commonly used in class

Naming a compound

Extension

A compound is named after the atoms or ions that make it up. Many compounds are made up of ions, a positive and negative ion bonded together known as ionic compounds. Other compounds are made up of atoms bonded together.
All compounds are neutral and have the same total number of protons as the total number of electrons. Some compounds have common names such as water.

Sodium chloride (NaCl)

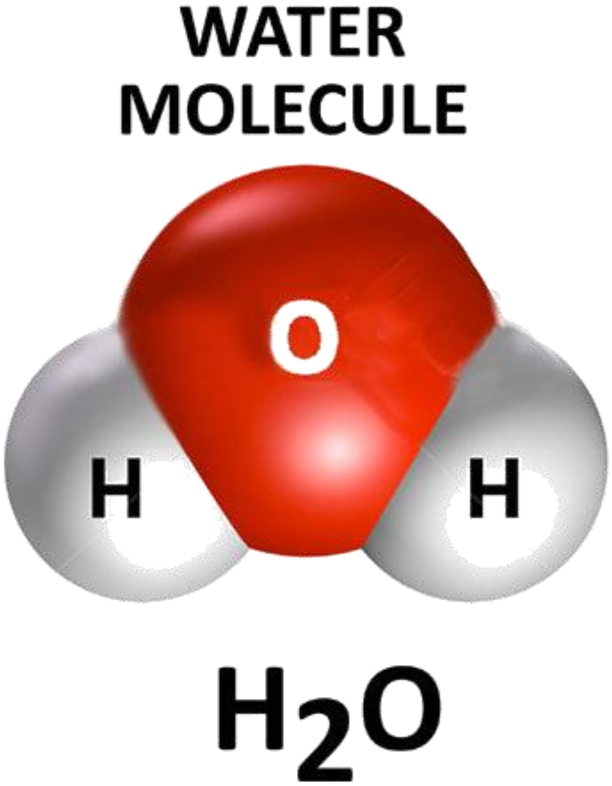


Ionic compounds (made of ions bonded) have names of two parts. The positive ion (Metal) is first then followed by the negative ion(non-metal). The compound sodium chloride is made of a sodium ion bonded to a chloride ion.

Chemical compound formula

Extension

Elements in a compound combine in fixed amounts. It is possible to write a **formula** for a compound. Each compound has a chemical formula indicating the proportions of each combined element.



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

Elements in a compound combine in fixed amounts. It is possible to write a formula for a compound.
A formula tells you the type of atoms that are in a compound and the number of each atom.

Extension

2 Mg atoms

4 N atoms

12 O atoms

$$2Mg(NO_3)_2$$

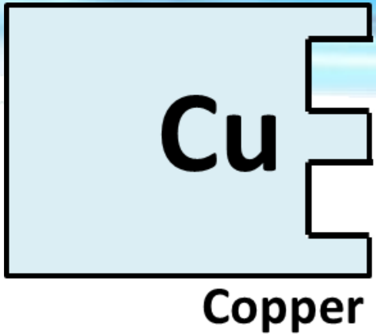
A number in front of the compound tells you how many molecules there are.

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.

The visual method for balancing compounds

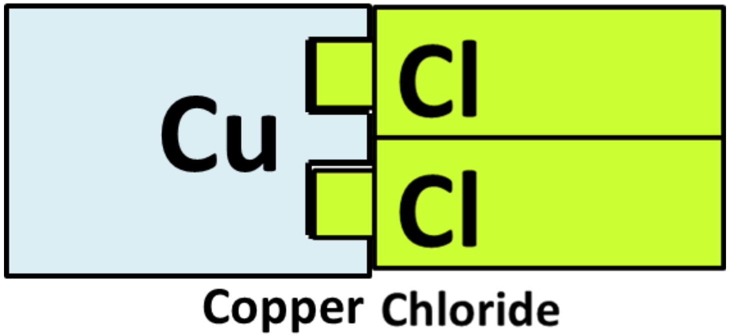
Extension



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.

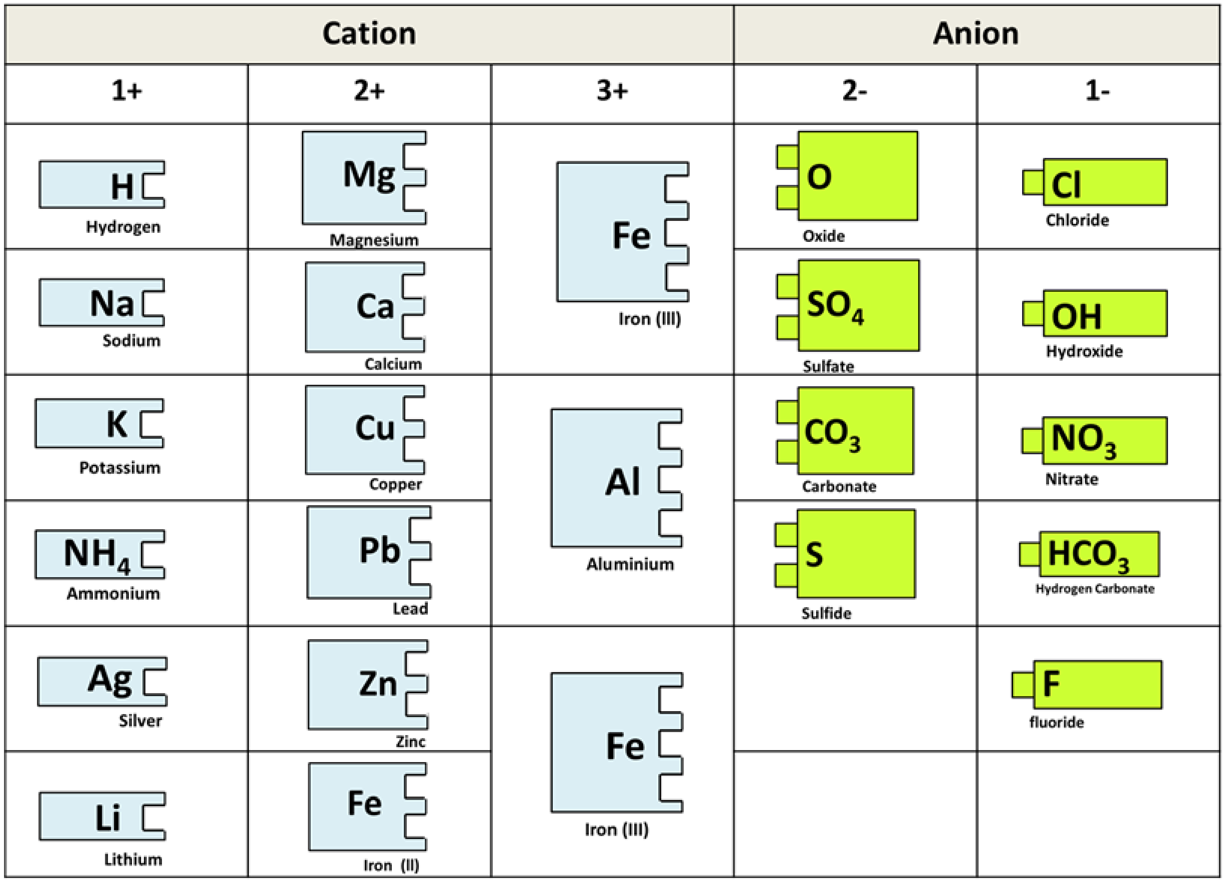


Copper chloride has a formula of $CuCl_2$

Chemical reactions

Extension

When products are made in a reaction the name of it is often a combination of the names of the chemicals it is formed from. For example $MgCl_2$ is called magnesium chloride

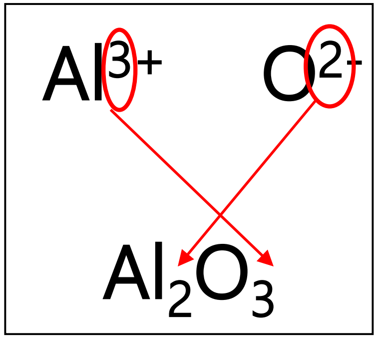


Cation			Anion	
1+	2+	3+	2-	1-
H Hydrogen	Mg Magnesium	Fe Iron (III)	O Oxide	Cl Chloride
Na Sodium	Ca Calcium		SO_4 Sulfate	OH Hydroxide
K Potassium	Cu Copper	Al Aluminium	CO_3 Carbonate	NO_3 Nitrate
NH_4 Ammonium	Pb Lead		S Sulfide	HCO_3 Hydrogen Carbonate
Ag Silver	Zn Zinc	Fe Iron (III)		F fluoride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

Cross and Drop method for balancing ionic compounds

Extension

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



Al^{3+} O^{2-}

Al_2O_3

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

H^+ SO_4^{-2}

$H_2(SO_4)_1 \longrightarrow H_2SO_4$

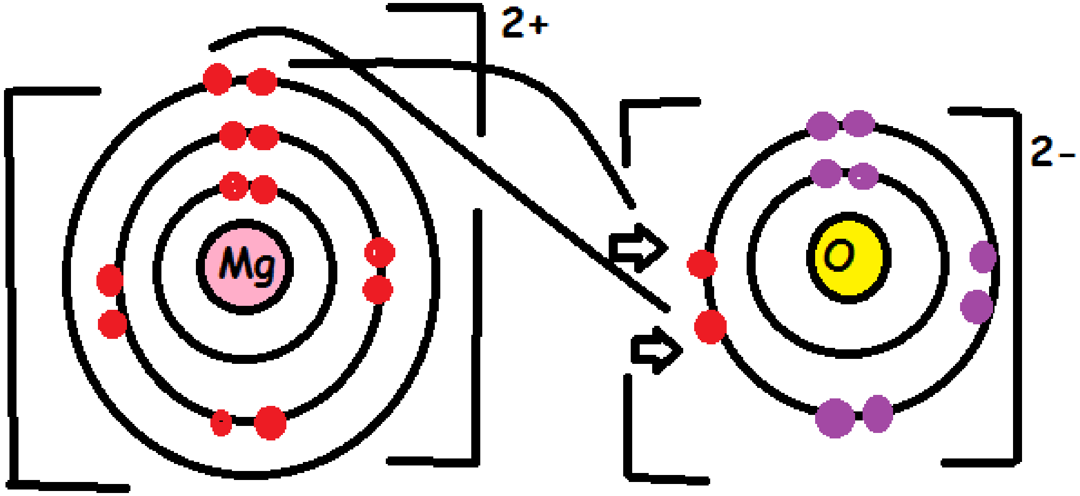
Charged ions make neutral Ionic Compounds

Extension

The formula for magnesium oxide is MgO made of Magnesium ion has a charge of +2 and oxide ion has a charge of –2.

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.

The charge on the ions arises as magnesium has to lose two electrons in order to have a full outer energy level and gets a charge of +2, and oxygen has to gain two electrons in order to have a full outer energy level and gets a charge of –2.



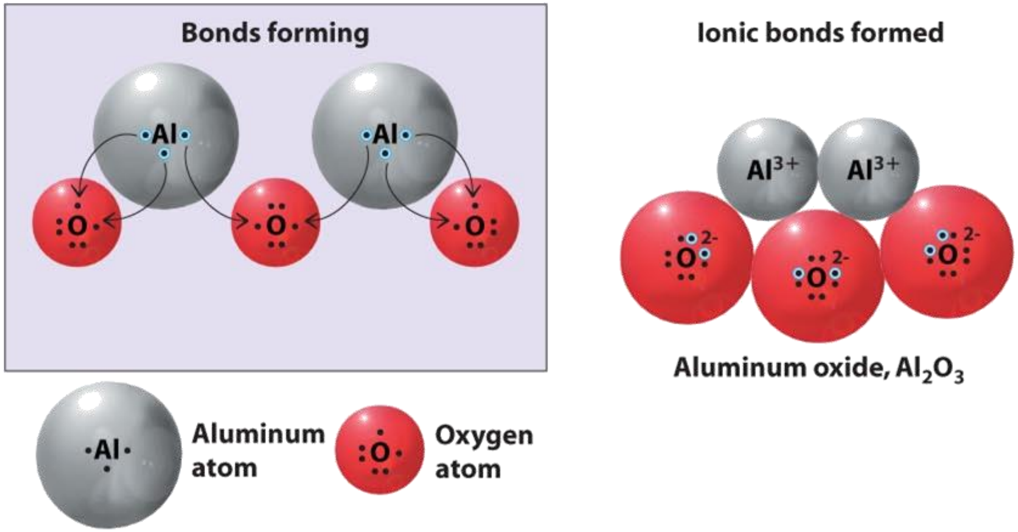
Charged ions make neutral Ionic Compounds

Extension

The formula for aluminium oxide is Al_2O_3 but the Aluminium ion has a charge of +3, and oxide ion has a charge of -2.

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.

The charge on the ions arises as aluminium has to lose three electrons in order to have a full outer energy level and gets a charge of +3, and oxygen has to gain two electrons in order to have a full outer energy level and gets a charge of –2



Background Knowledge

Chemical and Physical change

Physical changes are concerned with energy and states of matter. A physical change does not produce a new substance. The starting and ending materials of a physical change are the same, even though they may look different.
Changes in state (melting, freezing, vaporization, condensation, sublimation) are physical changes.
Examples of physical changes include bending a piece of wire, melting icebergs, and breaking a bottle

A **chemical change** makes a substance that wasn't there before.
Evidence for a chemical change could be a colour change, a new smell, the chemicals get hotter or colder or a gas is produced.

Background Knowledge

Observing reactions

To observe means to record or make note of something we have experienced. We also think of observations as watching something, but in Science, observations may be made with any of our senses (by seeing, feeling, hearing, tasting, or smelling) or even using tools to make observations that are then changed into something our senses detect.

GZ Science Resources

Testing for Oxygen gas

How to test for Oxygen Gas

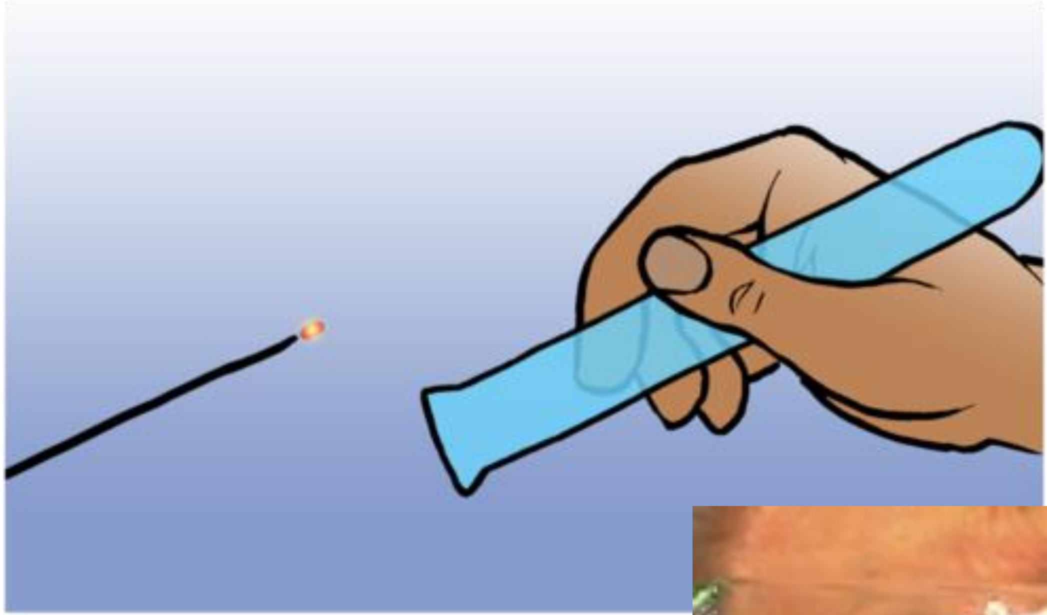
1. Put a small amount of Manganese dioxide into a boiling tube and add hydrogen peroxide. **BE CAREFUL WITH THESE CHEMICALS and ALWAYS FOLLOW LAB SAFETY RULES**
2. Put a bung with a delivery tube over the boiling tube and put the delivery tube into an upside down test tube to collect any gas.
3. Heat the tube gently with a Bunsen burner.
4. Remove delivery tube and place thumb over test tube.
5. Remove thumb quickly and place a glowing splint into the test tube.
6. If the splint re-ignites then it is likely the gas produced was oxygen.

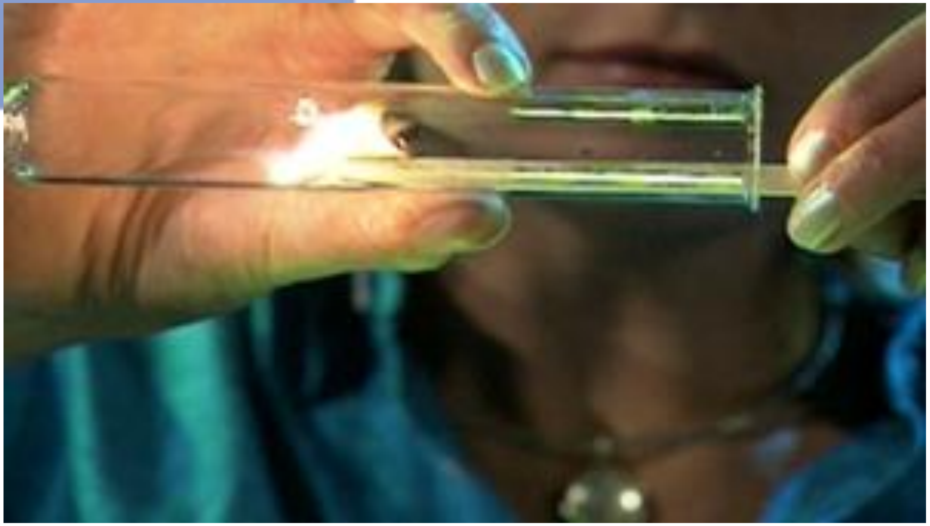
Oxygen gas is a molecule formed from two bonded oxygen atoms

Oxygen in the air combines with iron to form rust.

Testing for Oxygen gas

All types of combustion (burning) need oxygen. By supplying pure oxygen the glowing splint begins to combust at a faster rate, which we see as flames.





Testing for Hydrogen gas

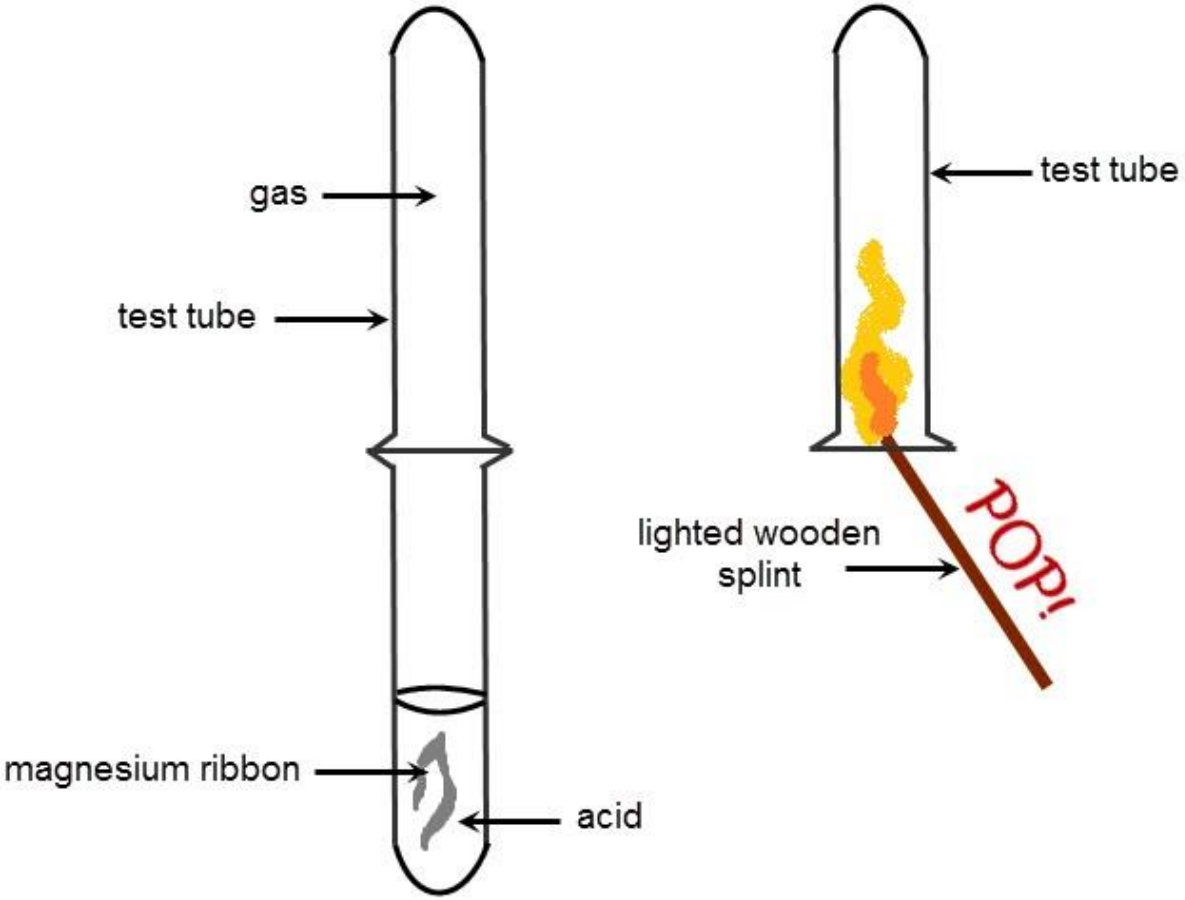
How to test for Hydrogen Gas

1. Put a small piece of magnesium metal into a test tube with a small amount of dilute hydrochloric acid.
2. Place another test tube upside down over top of the first test tube
3. Collect the gas in the upside down test-tube.
4. Place thumb over top of the test tube
5. Hold a lit match at the mouth of the test tube and remove thumb quickly
6. If the gas makes a loud 'pop' then it is likely that the gas produced is hydrogen.

Hydrogen in Jupiter's Atmosphere

Rocket fueled by liquid hydrogen

Testing for Hydrogen gas

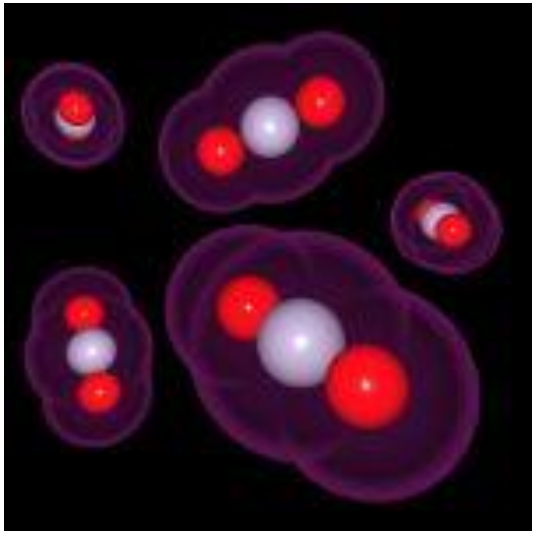


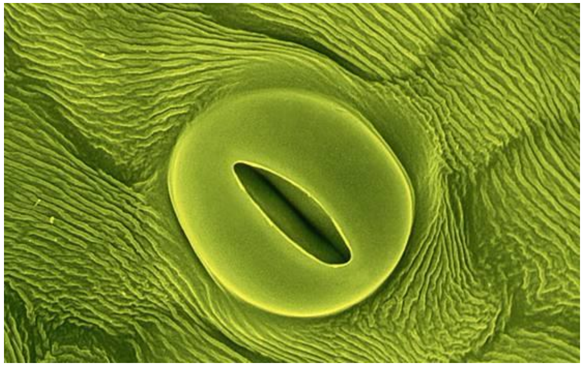
Hydrogen gas is lighter than air so it will rise to the top of any container. Hydrogen is very reactive so with the flame as **activation energy** it will react with the oxygen in the air to form a much more stable water molecule. The difference in energy levels between the reactants (hydrogen and oxygen) and the products (water) is released as an explosion.

Testing for Carbon Dioxide gas

How to test for Carbon Dioxide Gas

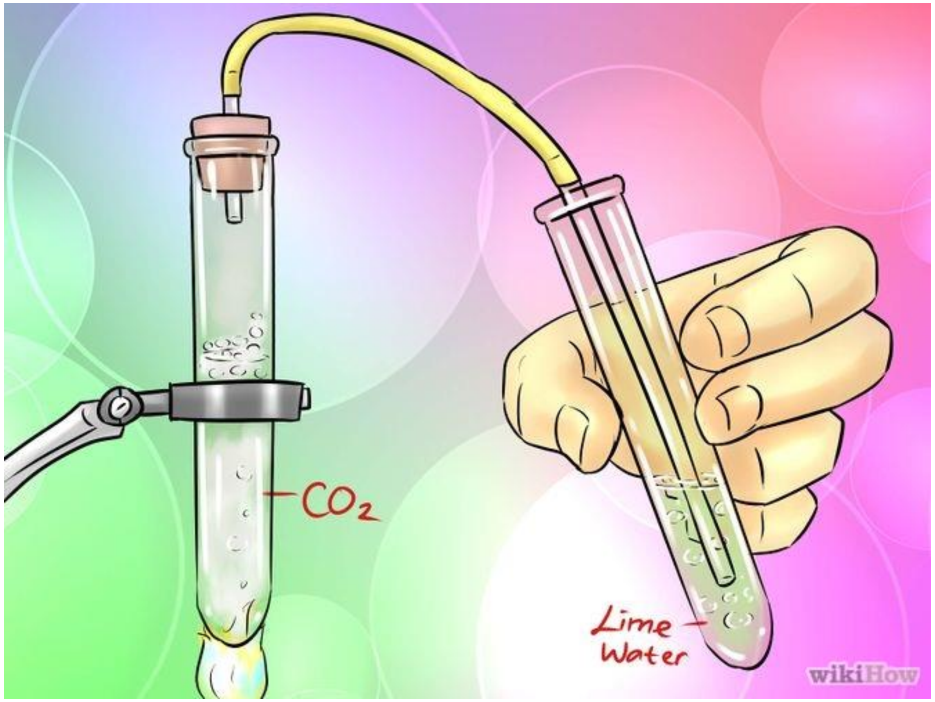
1. Put a small amount of calcium carbonate with dilute hydrochloric acid into a boiling tube.
2. Put a bung with a delivery tube over the boiling tube.
3. Place the delivery tube into a test-tube filled with clear limewater
4. Observe the gas bubbling into the limewater.
5. If the limewater turns cloudy then it is likely that the gas produced is carbon dioxide.

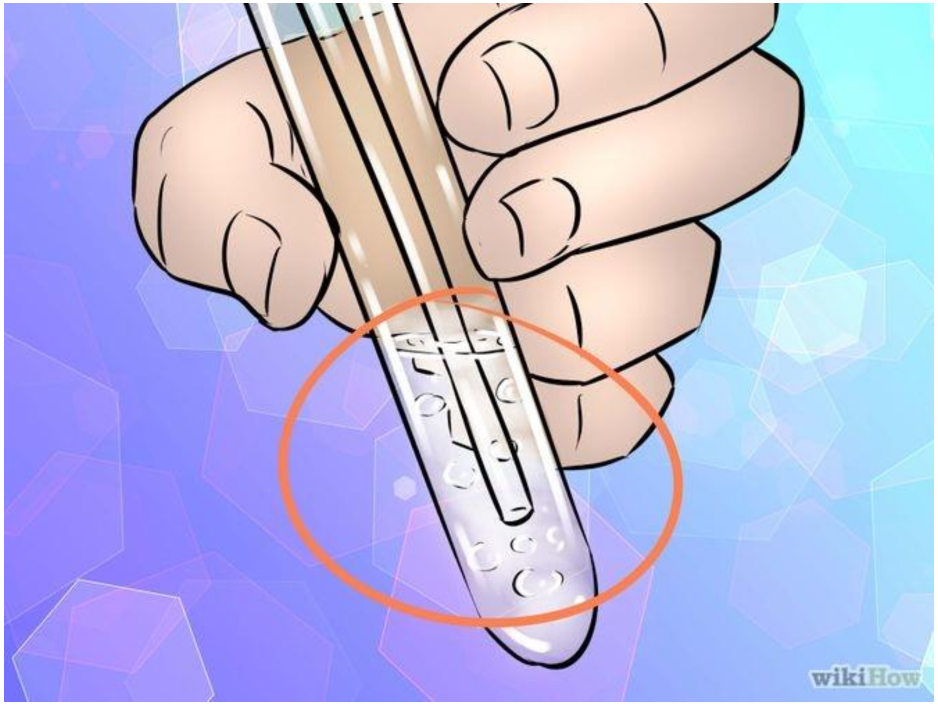




Plant stomata which allows CO_2 gas into the leaf

Testing for Carbon Dioxide gas





Carbon Dioxide is a colourless gas and limewater is a solution of calcium hydroxide in water which is also colourless. The carbon dioxide gas reacts with the limewater and changes it into calcium carbonate which is not soluble (can not dissolve) in water and appears as a milky white colour.

Chemical reactions - naming reactants & products

A **chemical reaction** is a process that produces a chemical change to one or more substances.

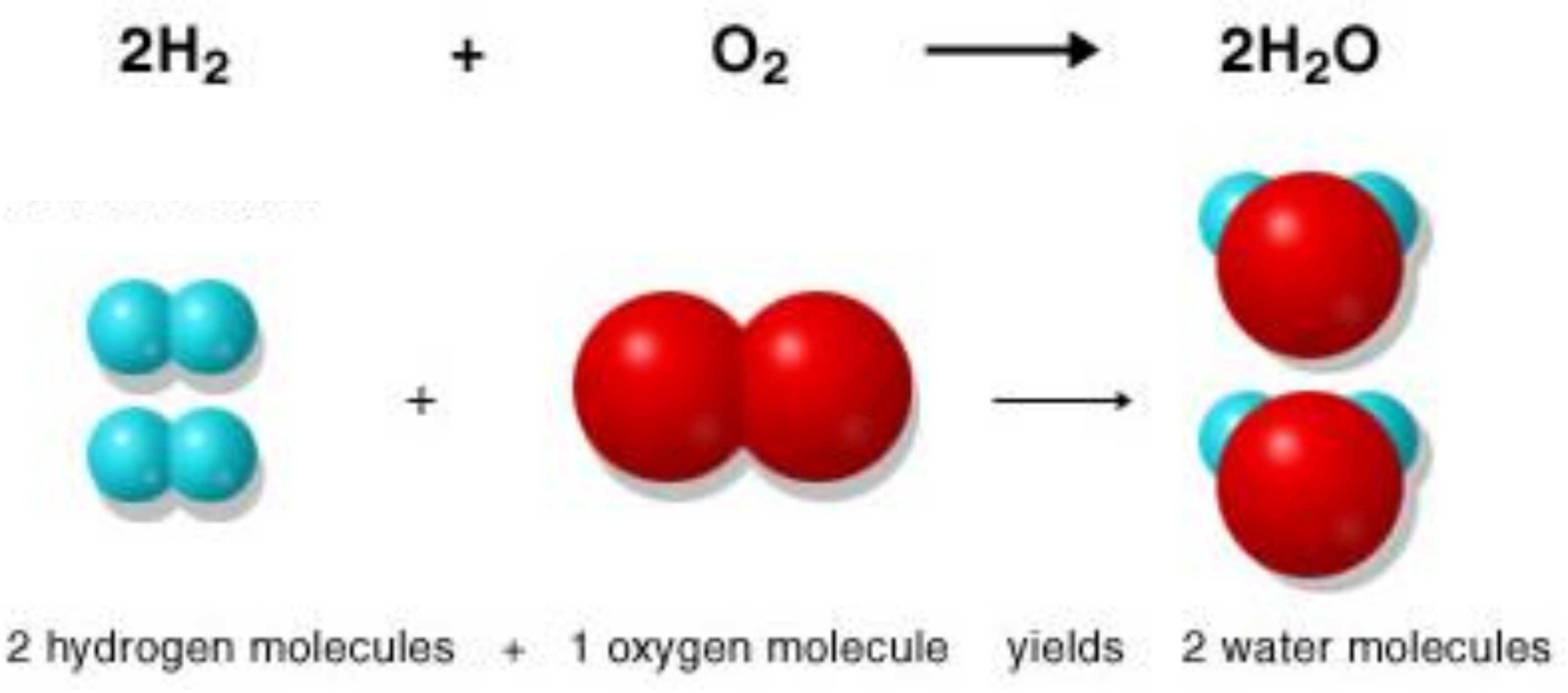
A chemical reaction will produce a **new substance.** Chemicals that are used in a chemical reaction are known as **reactants**. Those that are formed are known as **products**. Other observations of a chemical reaction may include a temperature change, a colour change or production of gas.

Reactants: $Zn + I_2$ ⟶ Product: $Zn I_2$

Reactants join together to form new products during chemical reactions

The atoms present in the **reactants** rearrange themselves in different combinations and form new bonds. The new combinations of atoms are called **products** and can either be single atoms or molecules.

Reactants **Products**



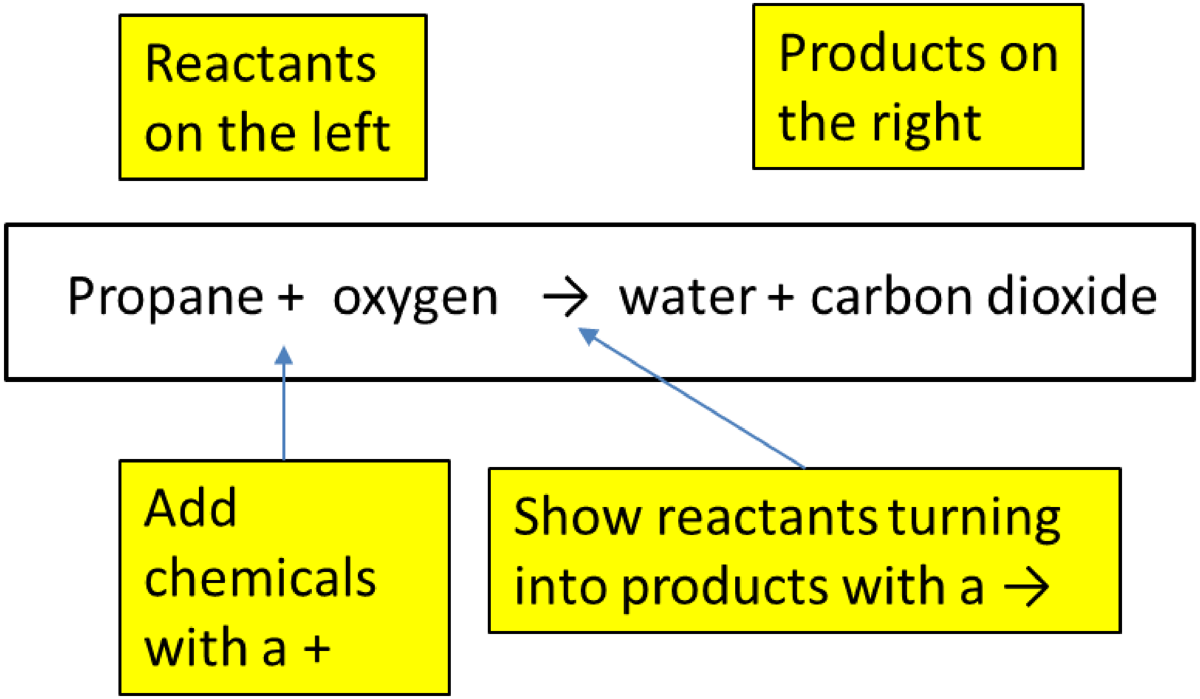
$$2H_2 + O_2 \longrightarrow 2H_2O$$

Chemical reactions – word equations

When we convert descriptions of reactions into word equations there is a set way of writing it. Once we have a word equation we can write a formula equation.

For example: When we use a BBQ we cook with propane gas (C_3H_8) which needs oxygen gas in the air (O_2) to combust (or burn). The burning process creates water (H_2O) and carbon dioxide gas (CO_2)

The word equation therefore will be:



Reactants on the left

Products on the right

Propane + oxygen → water + carbon dioxide

Add chemicals with a +

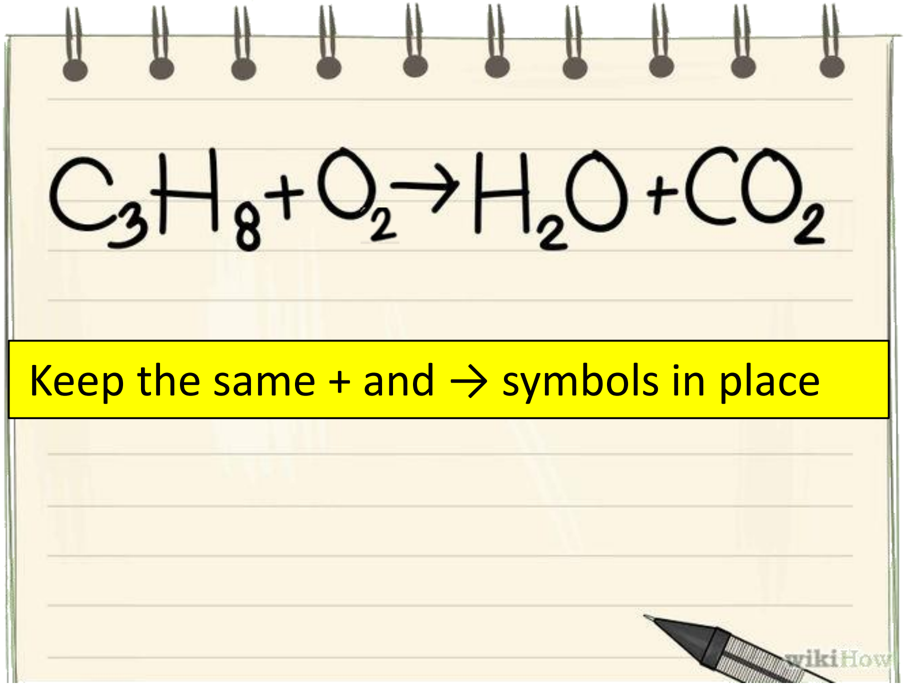
Show reactants turning into products with a →

Writing symbol equations

Extension

The word equation is:

Propane + oxygen → water + carbon dioxide



Keep the same + and → symbols in place

Once you can write word equations practice by writing the formula underneath

You are expected to know the formula for simple compounds
water – H_2O
Carbon dioxide – CO_2
Oxygen gas – O_2
Hydrogen gas – H_2

You will also need to remember formula for common acids and bases (given later in the unit)

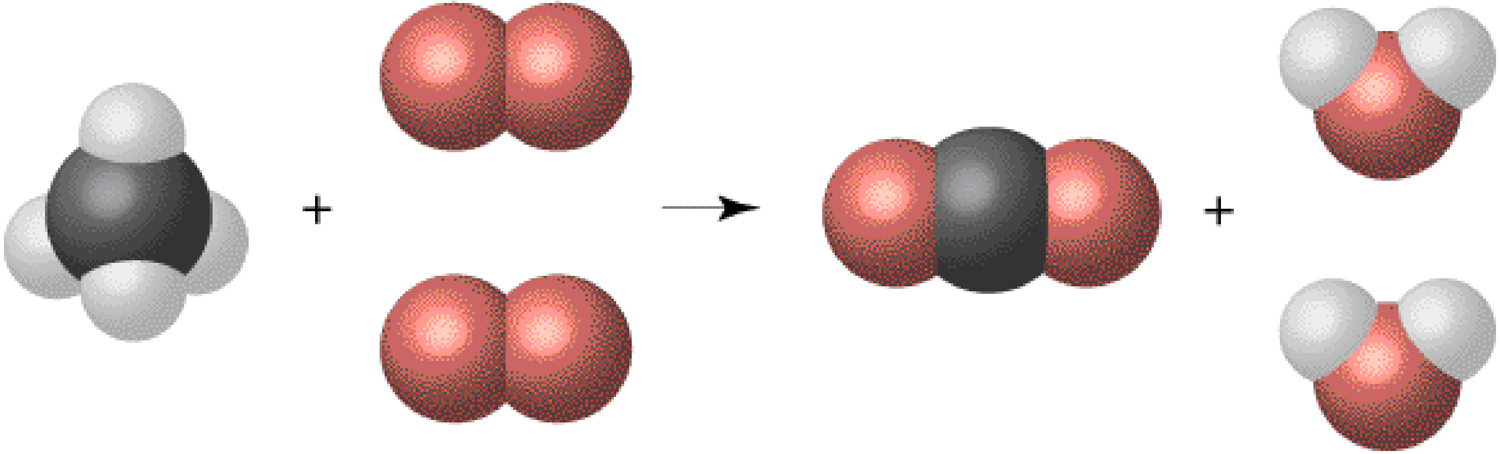
You will need to use ion charts to write the formula for compounds made of ions.

http://www.wikihow.com/Balance-Chemical-Equations

Balancing Chemical equations

Extension

In a chemical equation the **total number of atoms in the reactants must equal the total number of atoms in the products** as no atoms are created or destroyed just rearranged with new bonds formed or bonds broken

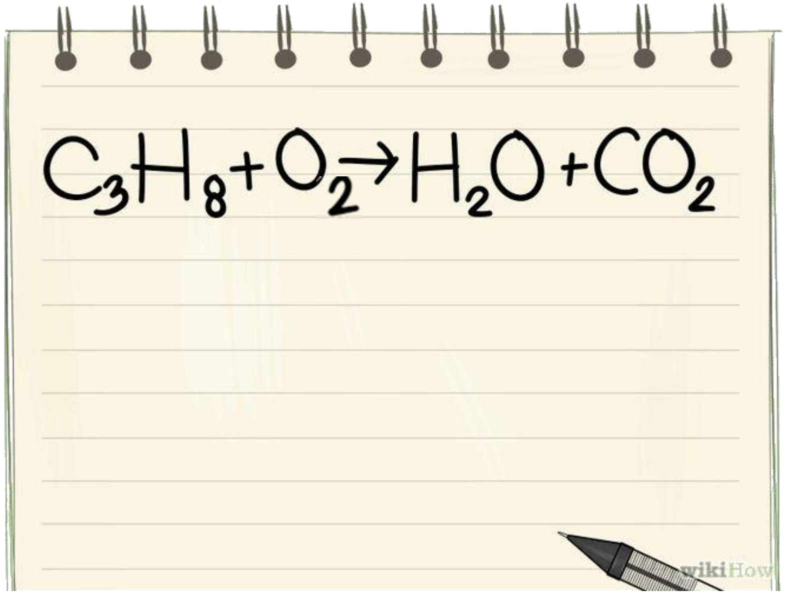


One methane molecule		Two oxygen molecules	→	One carbon dioxide molecule		Two water molecules
CH_4	+	$2O_2$	→	CO_2	+	$2H_2O$
$\begin{pmatrix} 1\ C \\ 4\ H \end{pmatrix}$		(4 O)		$\begin{pmatrix} 1\ C \\ 2\ O \end{pmatrix}$		$\begin{pmatrix} 2\ O \\ 4\ H \end{pmatrix}$

Balancing Chemical equations

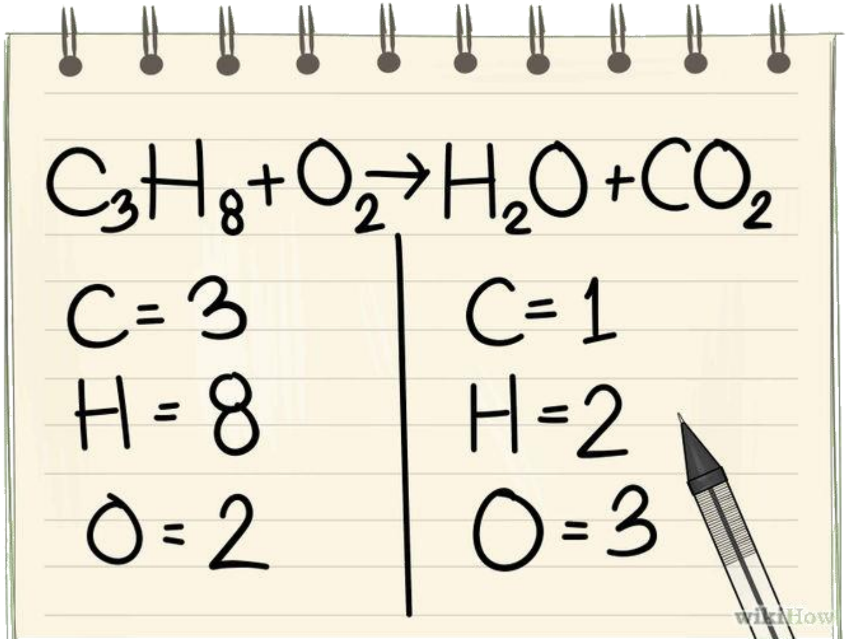
Extension

1. To balance an equation first write down the equation



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

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



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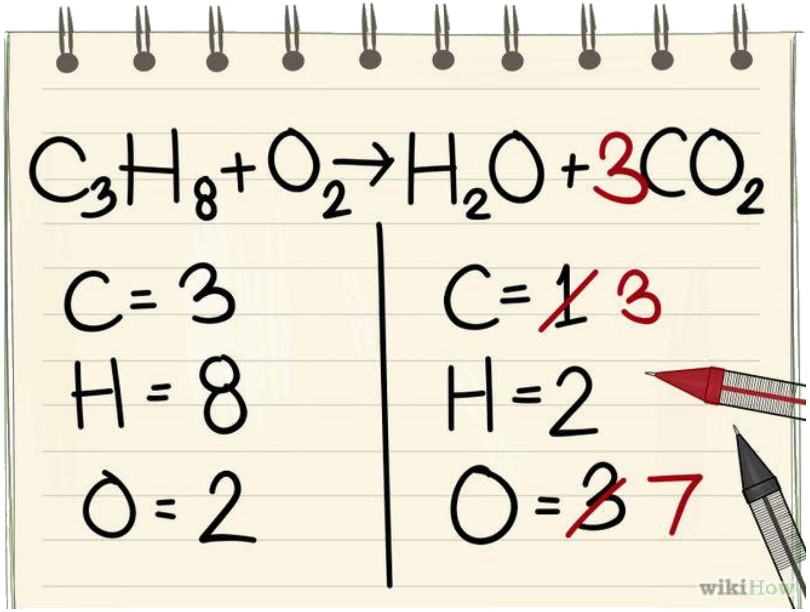
Balancing Chemical equations

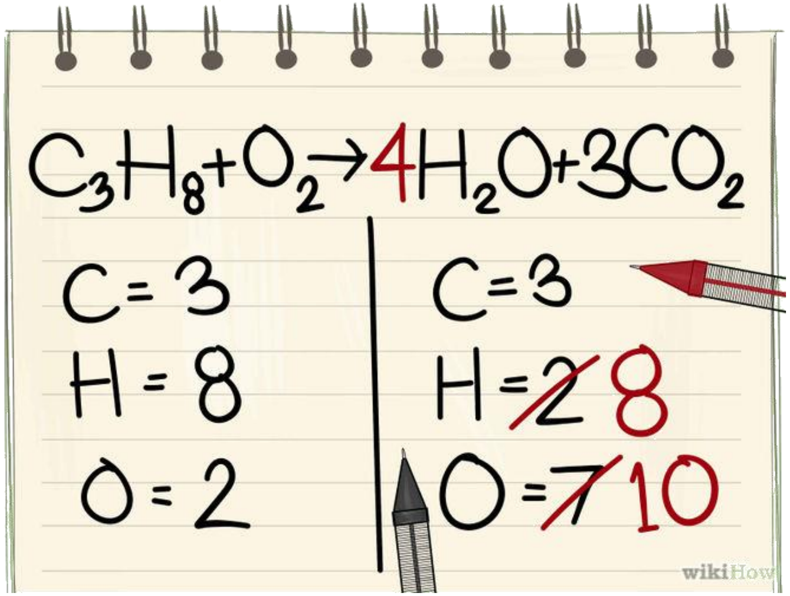
Extension

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

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



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



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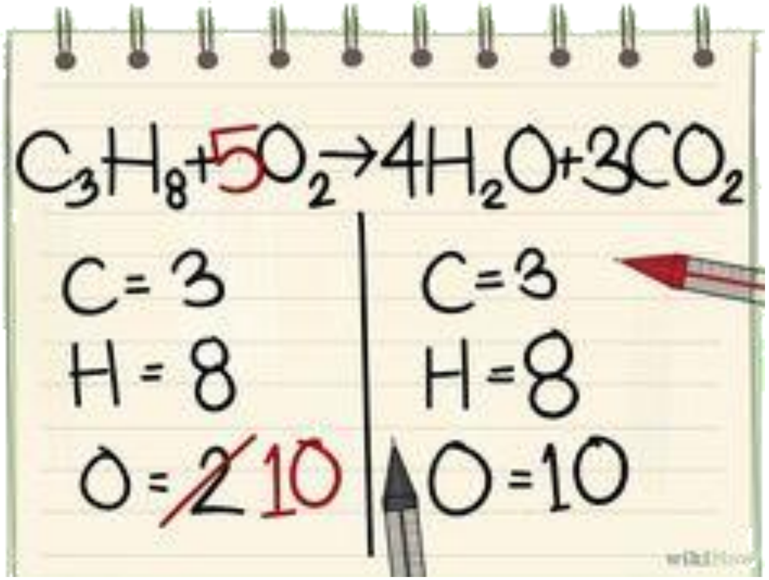
Balancing Chemical equations

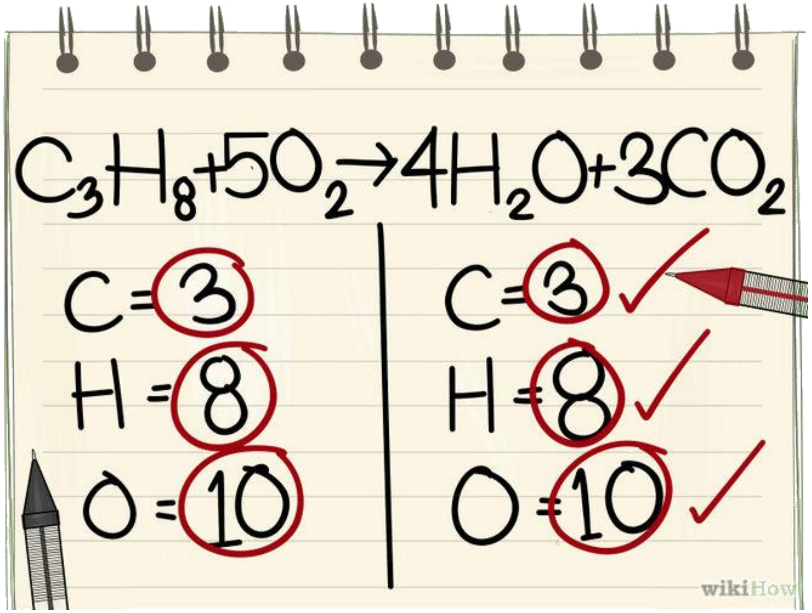
Extension

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**!



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