

A red ribbon seal with a scalloped edge, containing the text "2018 Version".

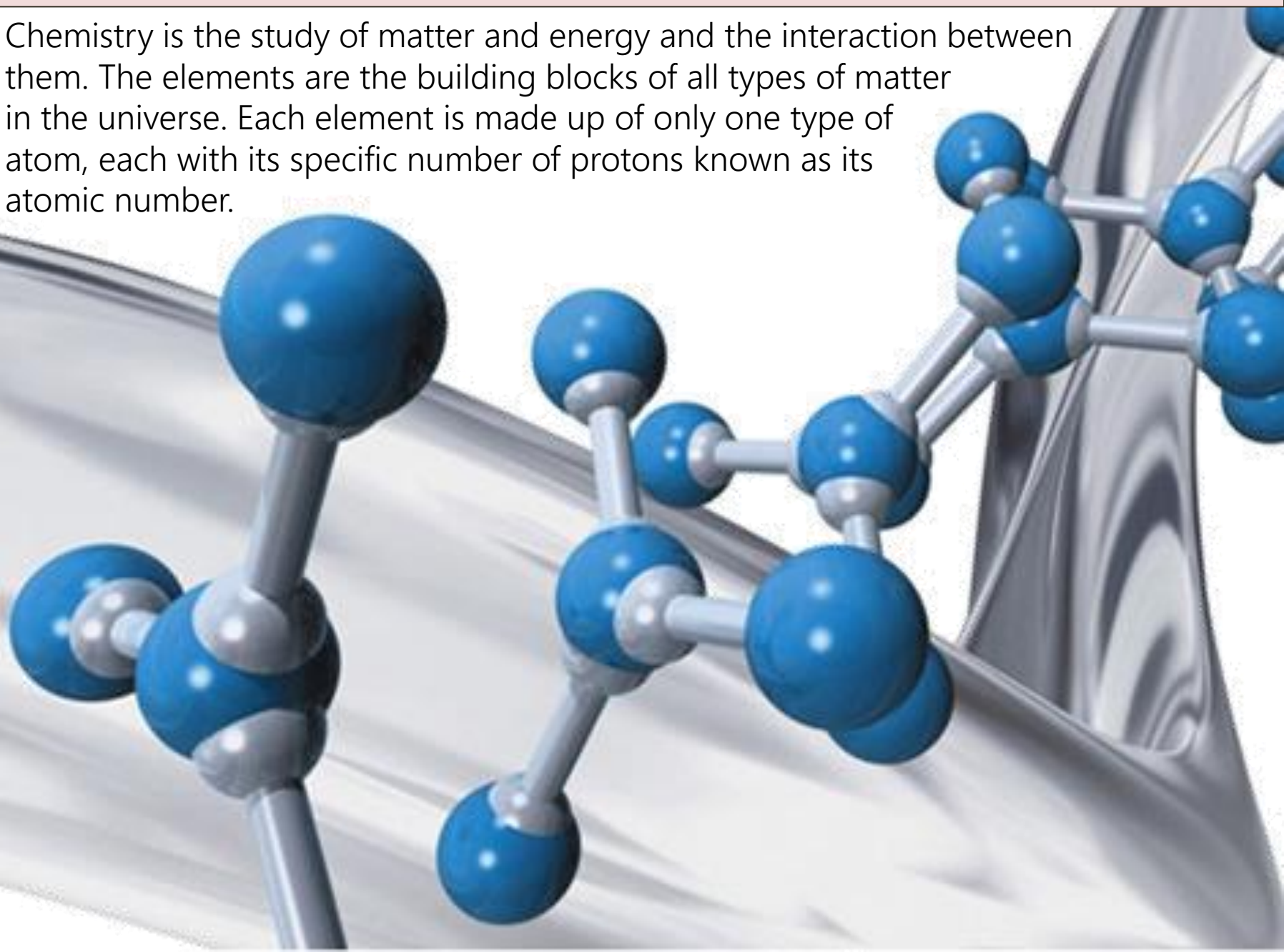
2018
Version

Atomic Structure and Chemical Reactions

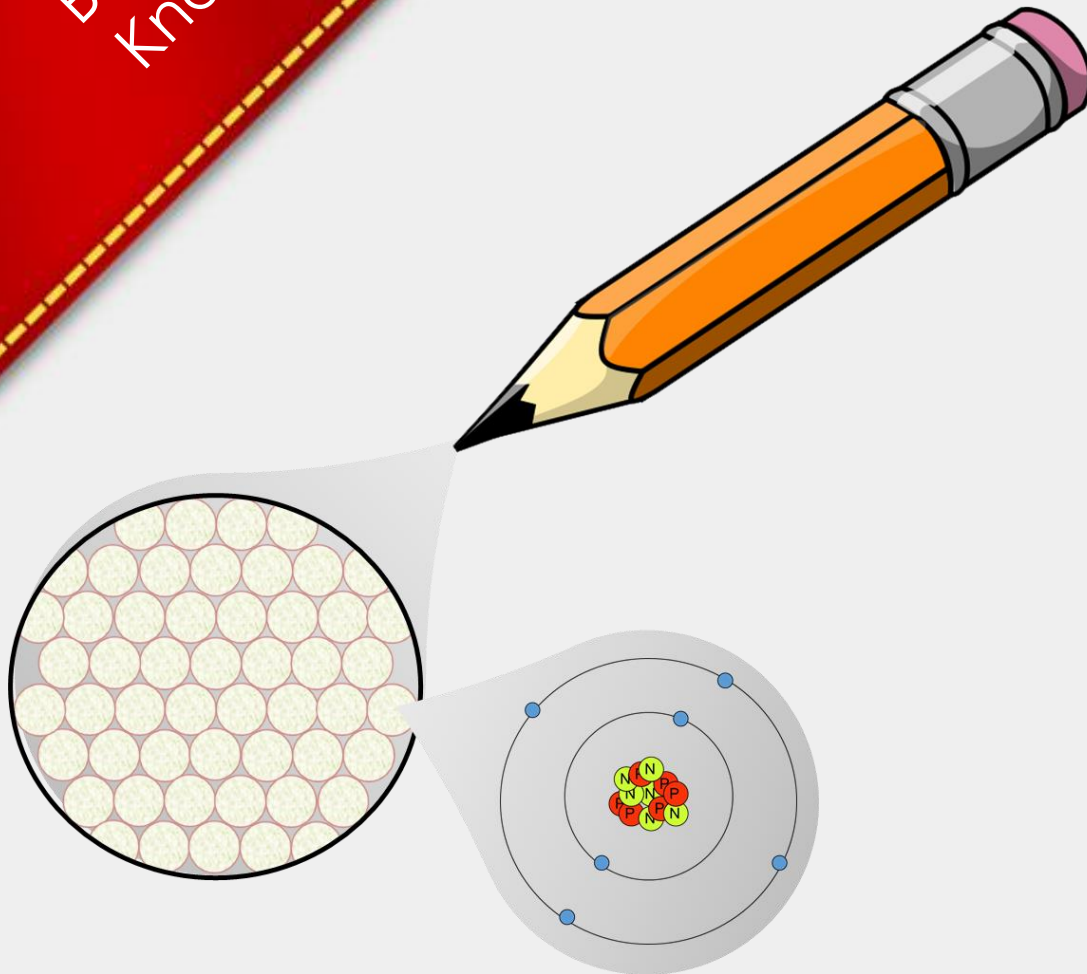
Junior Science

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.



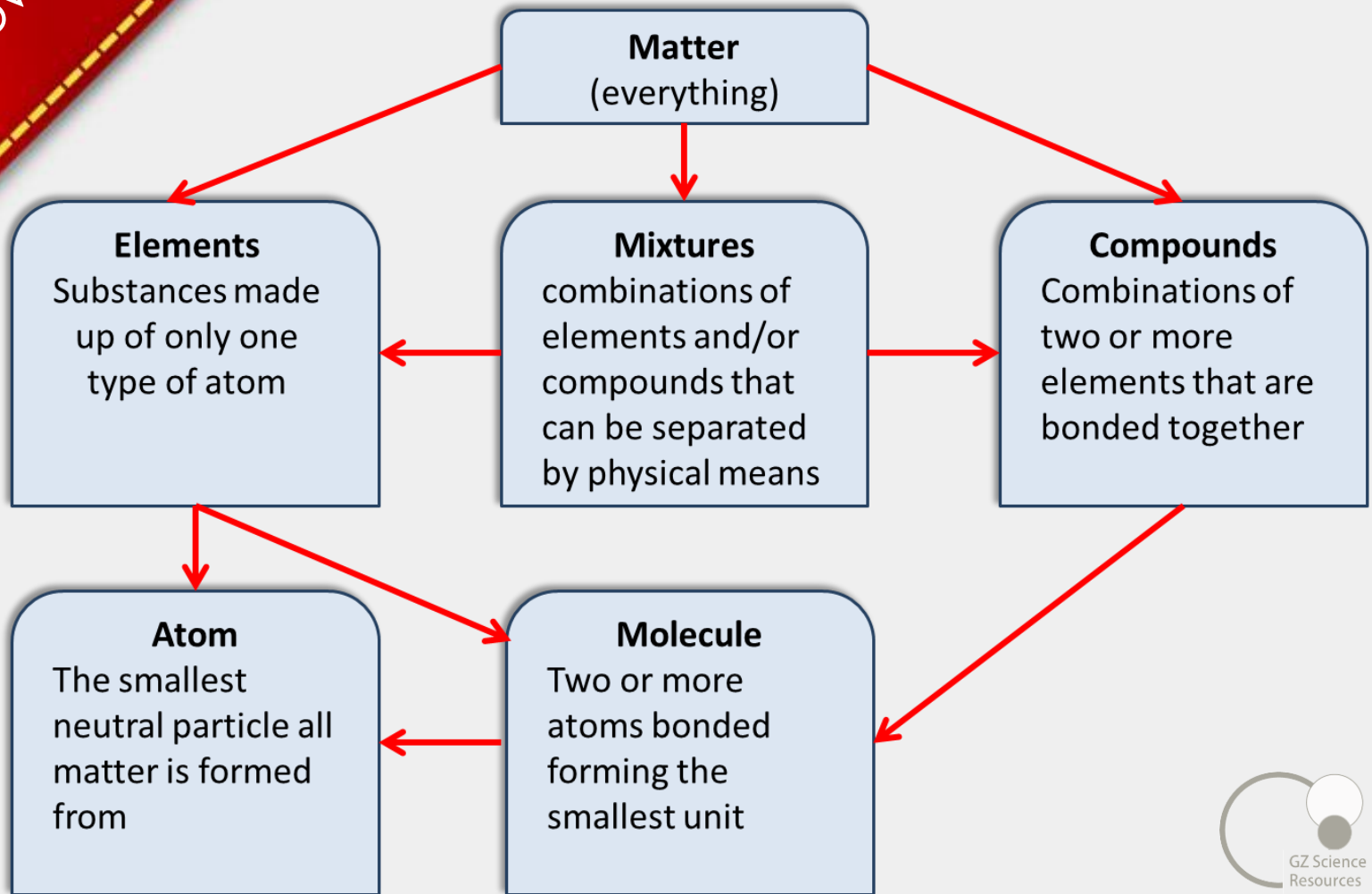
Understand that matter is made up of atoms



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

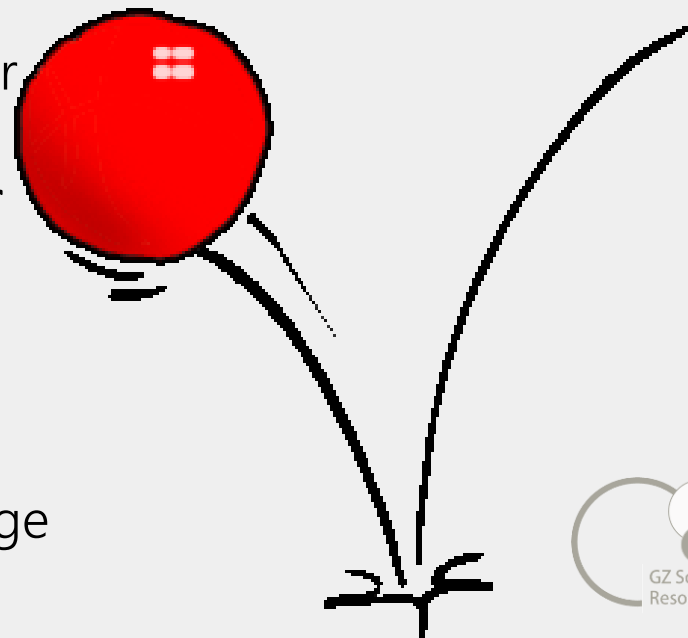
The type of atom and the way these atoms are arranged and connected to each other determines the type of matter – and therefore the **physical** and **chemical** properties of the matter.

Matter is made up of atoms



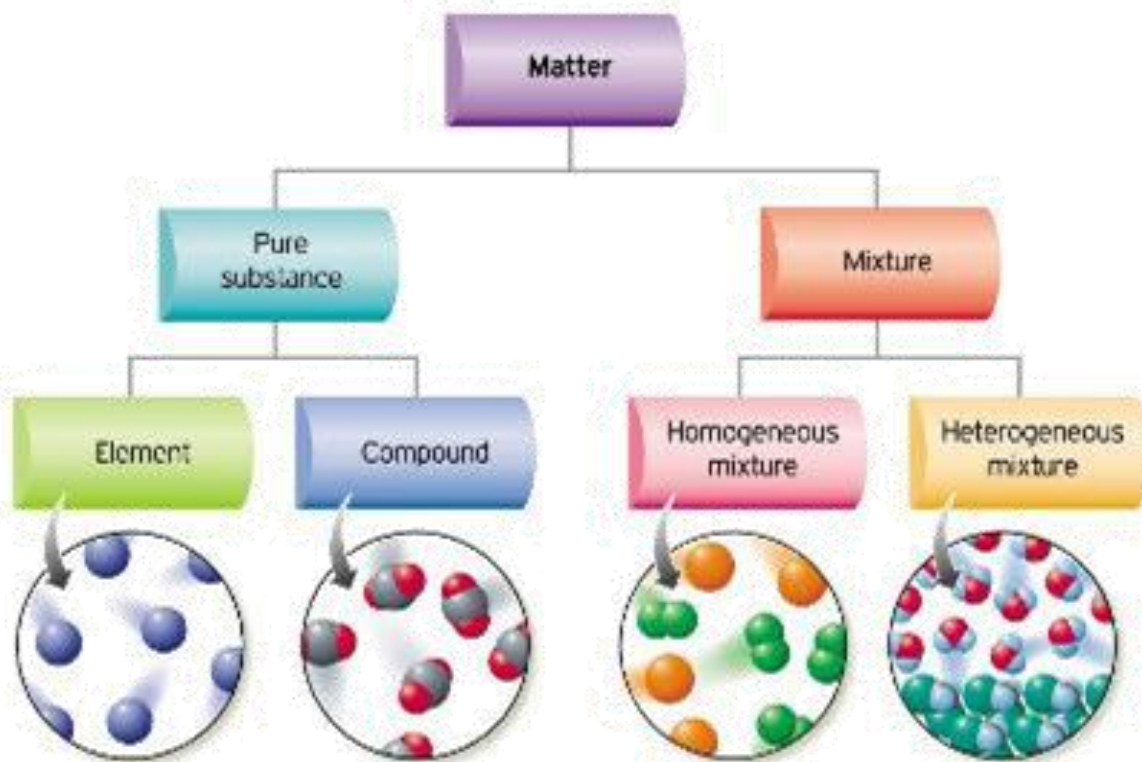
The Particle Theory of Matter

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.



Elements are pure substances that combine to make mixtures & compounds

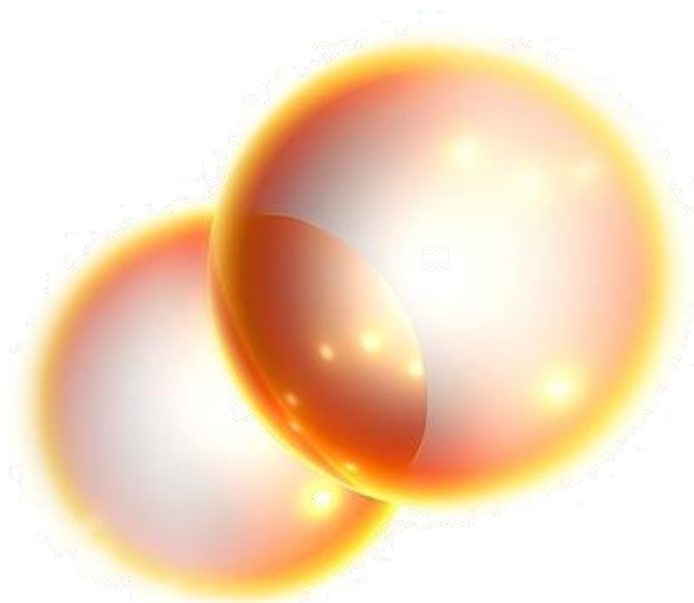
Matter can be divided into **pure substances** which include elements (atoms of the same type) and compounds (different atoms joined together) and **Mixtures** which can either be **homogeneous** (evenly mixed) or **heterogeneous** (unevenly mixed)



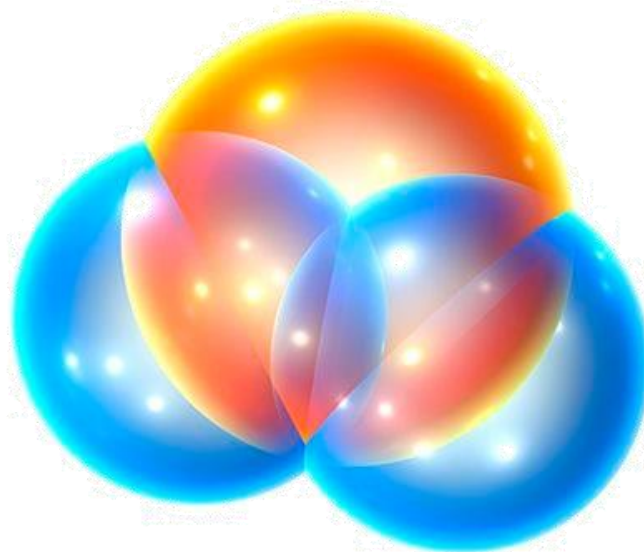
Background Knowledge

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

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 and liquids can be made up of atoms, molecules, and/or ions.



Solid iodine
 $I_2(s)$



Liquid bromine
 $Br_2(l)$

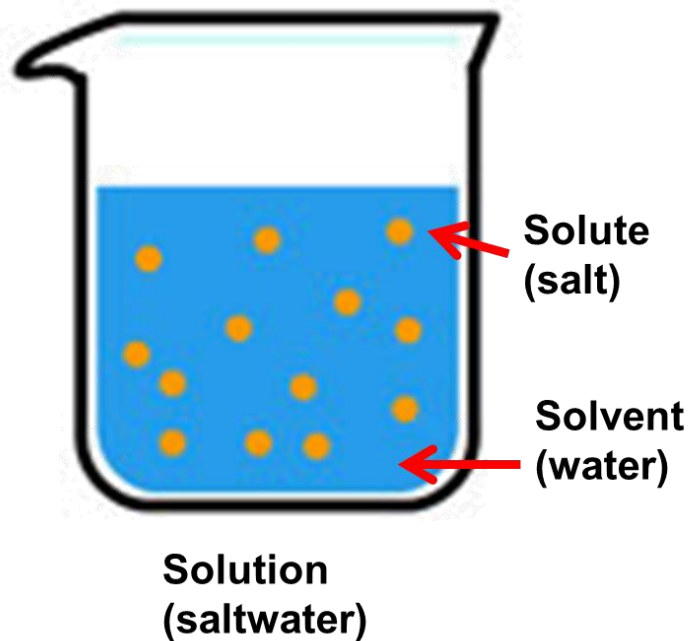


Gaseous chlorine
 $Cl_2(g)$

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**.

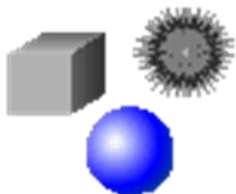


Background Knowledge

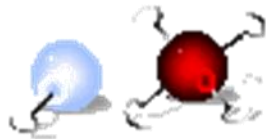
Scientists use models to show the relationship of protons, electrons and neutrons within atoms and ions



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.



~ 400 B. C.



1830



1906



1913



1924

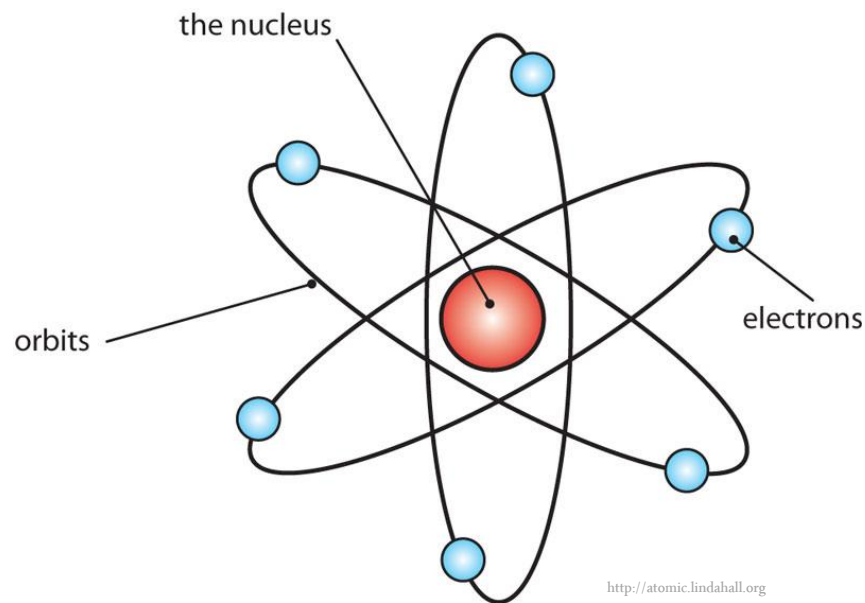
The History of Atomic Theory

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.

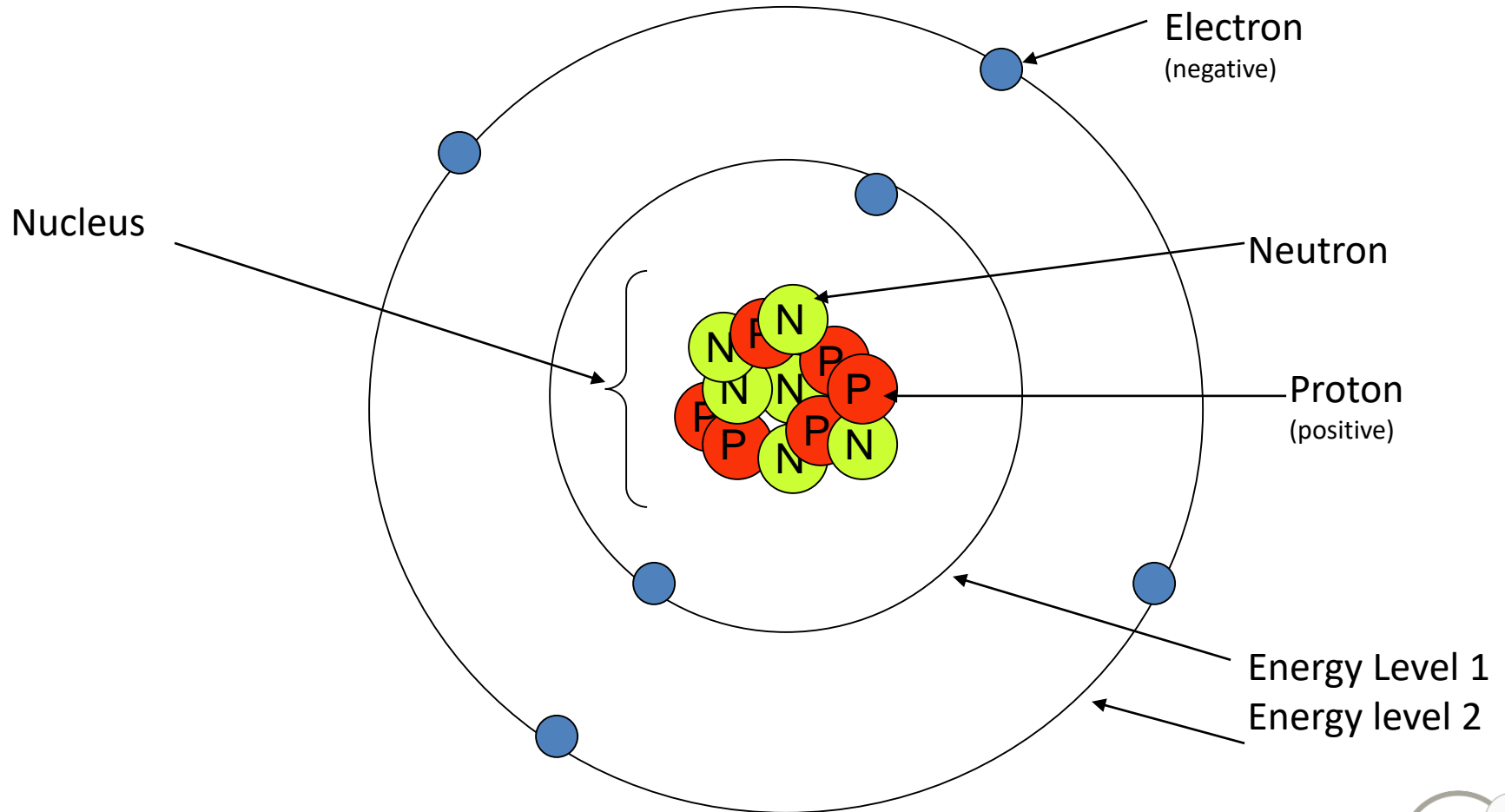


Rutherford's model of an atom



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.

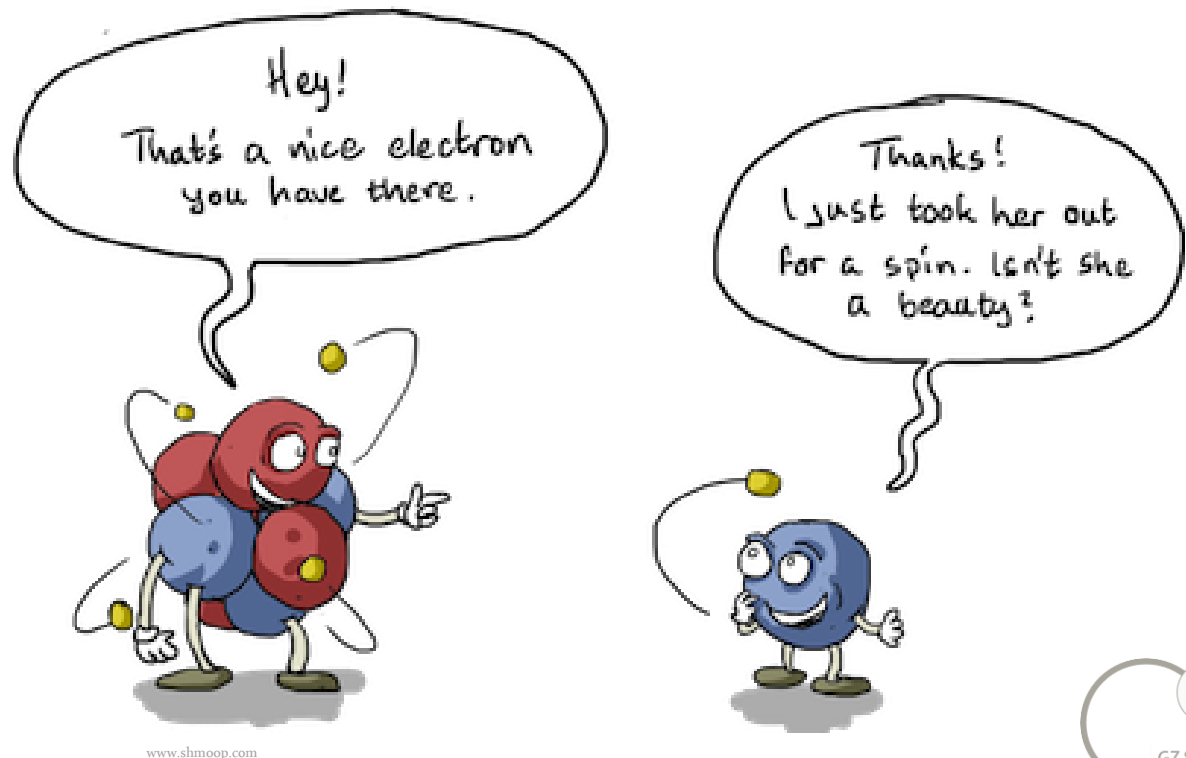


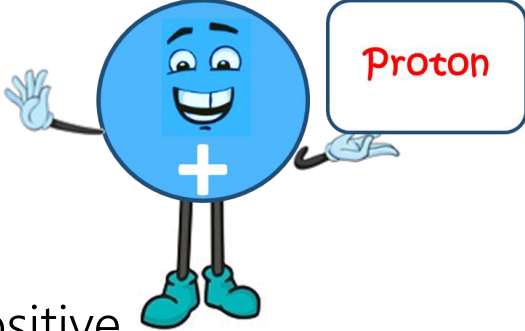
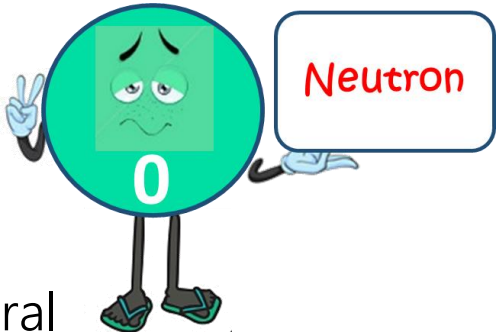
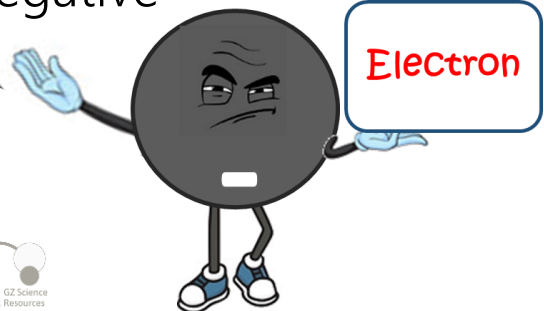
Atoms have equal number of protons and electrons

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.

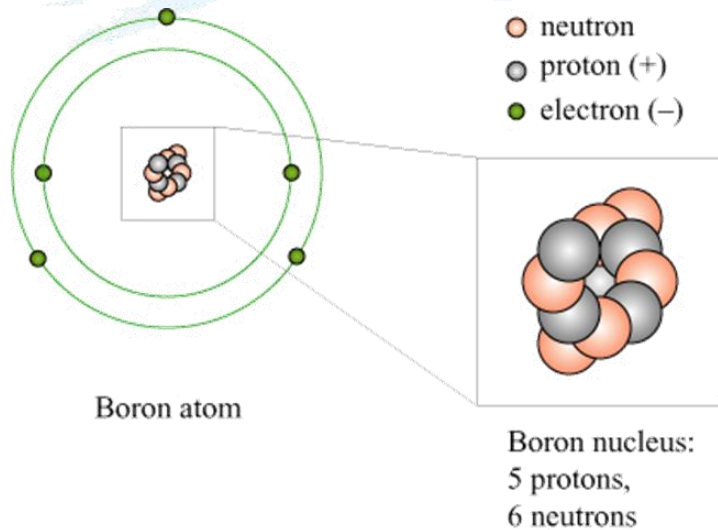
Summary

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

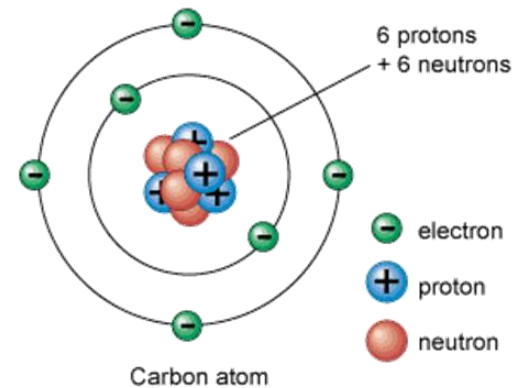


Subatomic particle	symbol	Mass compared to a proton	charge	location
 <p>positive</p>	p	1	+1	In the nucleus
 <p>neutral</p>	n	1	0	In the nucleus
 <p>negative</p>	e	1/1840	-1	Moving outside the nucleus

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.

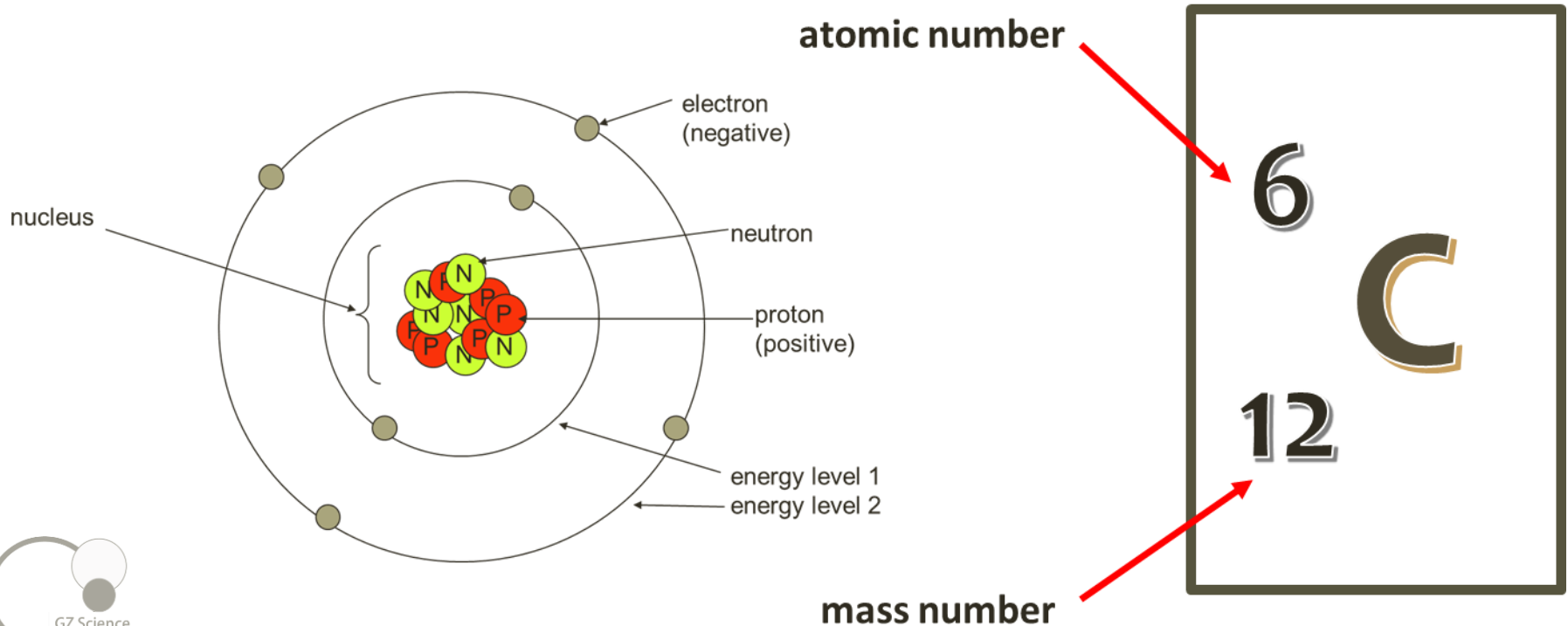
Atomic and Mass number

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:

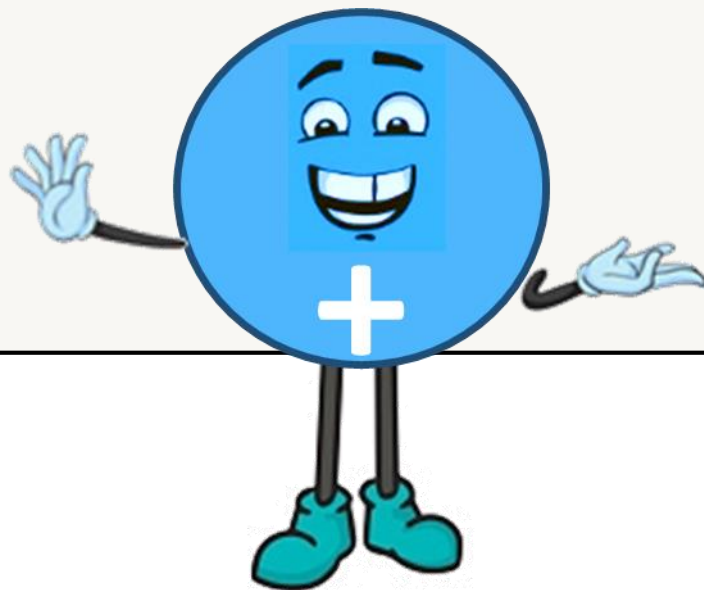
For an atom = atomic number

Number of electrons:

For an atom = atomic number

Number of neutrons:

For an atom = atomic mass - atomic number



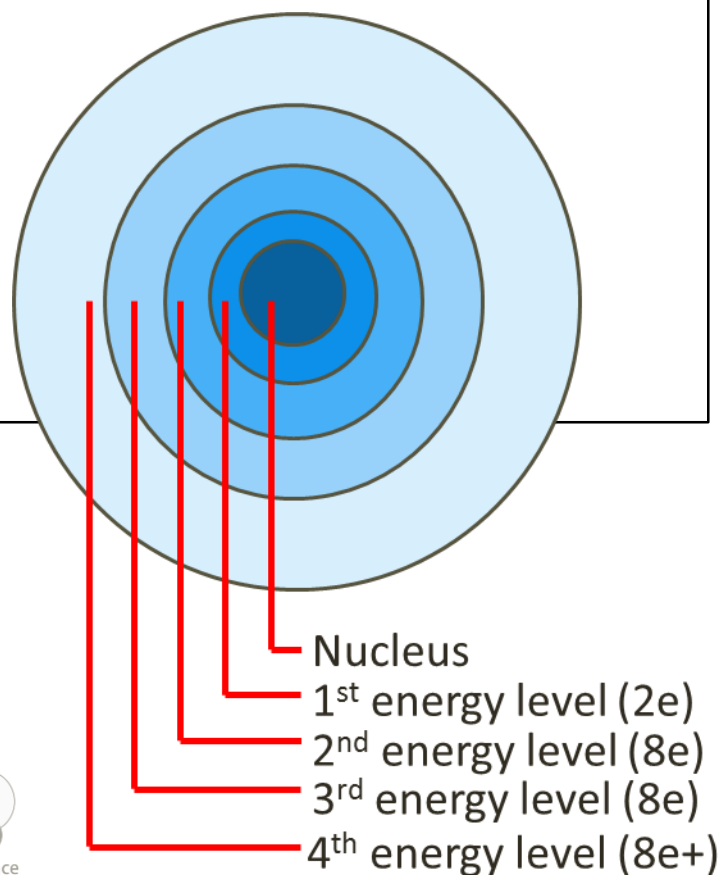
atom or ion	number of protons	Atomic number	number of electrons	number of neutrons	Mass number
carbon (C)	6	6	6	6	12
magnesium (Mg)	12	12	12	12	24
fluorine (F)	9	9	9	10	19

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 element's **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

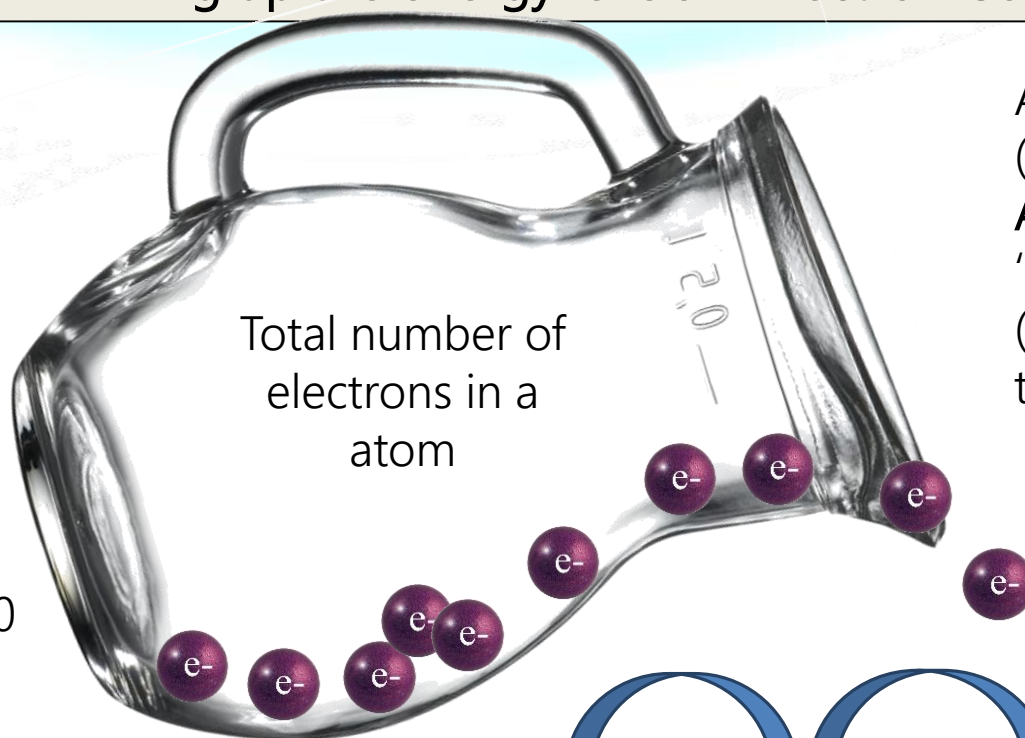
Atomic number

2, 8, 2

First EL, second EL, third EL

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

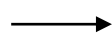
Filling up the energy levels - Electron Configuration



All of the electrons (determined by the **Atomic Number**) must be 'poured' into the glasses (energy levels) in order to their maximum fill

This jug represents Calcium (Ca) with 20 electrons. The EC will be 2,8,8,2

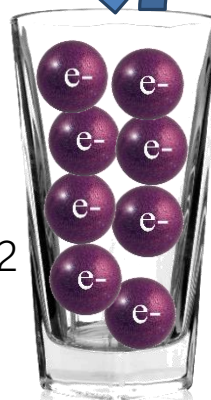
Energy levels



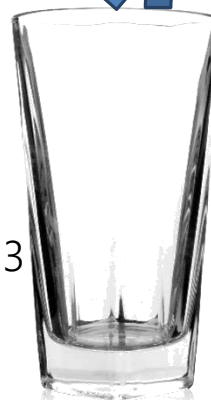
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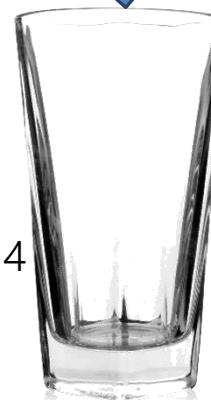
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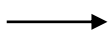
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4



Maximum fill



2 electrons

8 electrons

8 electrons

8 electrons

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.



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.



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

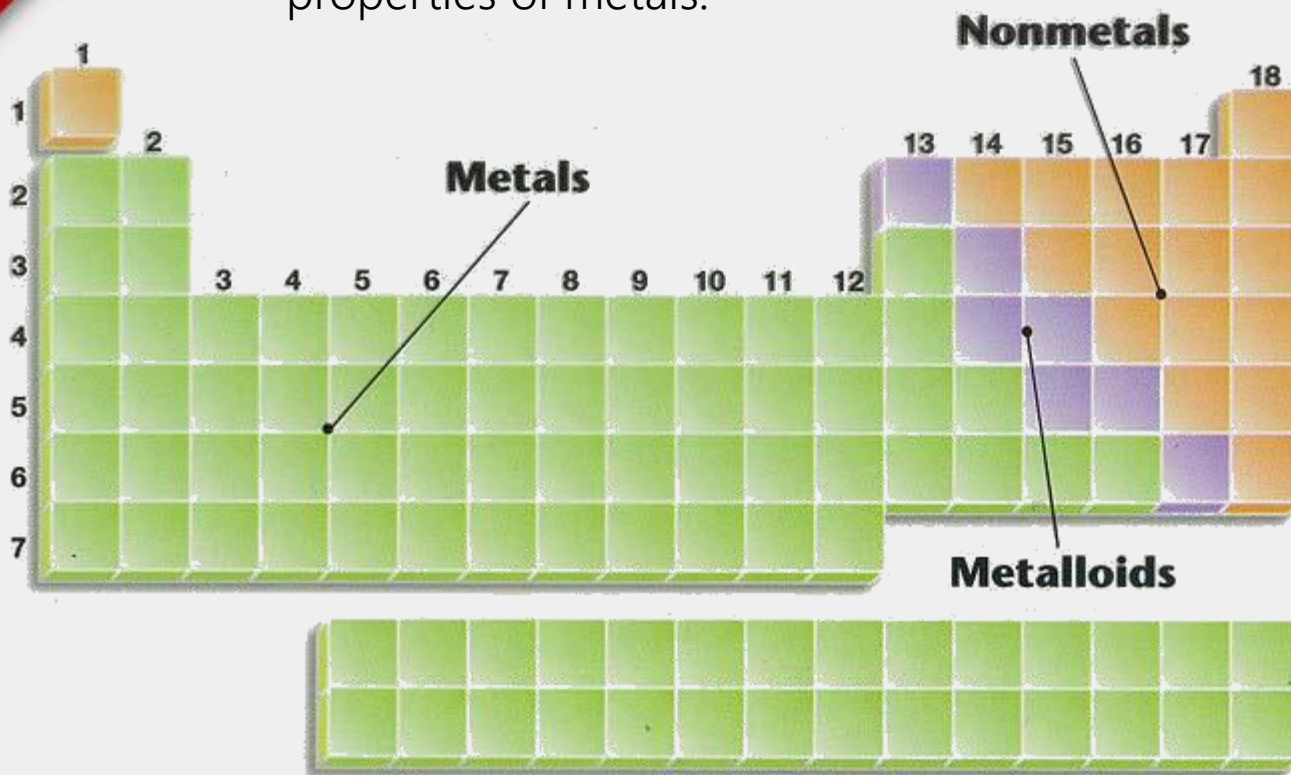
Series	Zero Group	Group I	Group II	Group III	Group IV	Group V	Group VI	Group VII	
0	x								
1		Hydrogen H—1.008							
2	Helium He—4.0	Lithium Li—7.03	Beryllium Be—9.1	Boron B—11.0	Carbon C—12.0	Nitrogen N—14.04	Oxygen O—16.00	Fluorine F—19.0	
3	Neon Ne—19.9	Sodium Na—23.05	Magnesium Mg—24.1	Aluminium Al—27.0	Silicon Si—28.4	Phosphorus P—31.0	Sulphur S—32.06	Chlorine Cl—35.45	
4	Argon Ar—36	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	
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
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	Cesium 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
11		Gold Au—197.2	Mercury Hg—200.0	Thallium Tl—204.1	Lead Pb—206.9	Bi-smuth Bi—208			
12			Radium Ra—224		Thorium Th—232		Uranium U—239		

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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 metalloids (e.g. boron and silicon), because they show some, but not all, of the properties of metals.

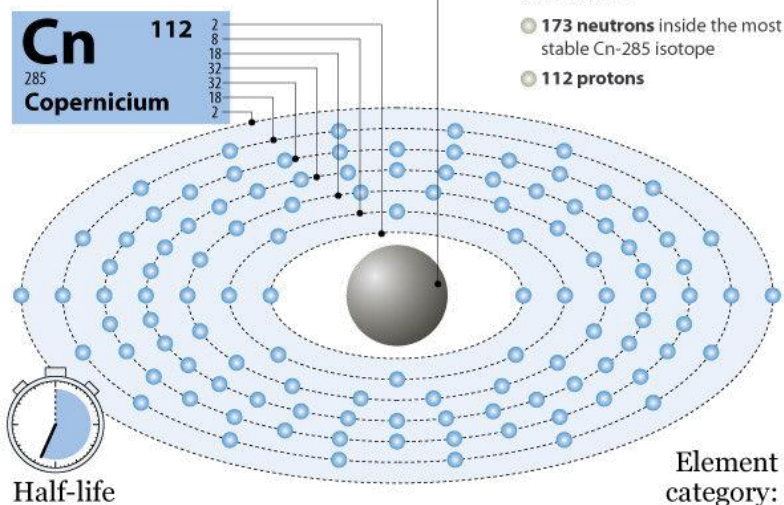


Elements are arranged on the periodic table according to their atomic number

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



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**

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



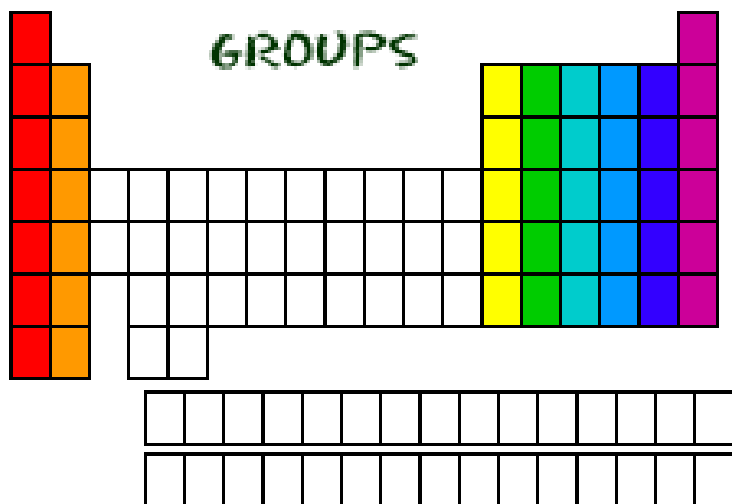
The International Union of Pure and Applied Chemistry (IUPAC) named the new element after **Nicolaus Copernicus** "to honor an outstanding scientist, who changed our view of the world."

Each element has an atomic number, which tells us how many protons are contained inside each atom's 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.

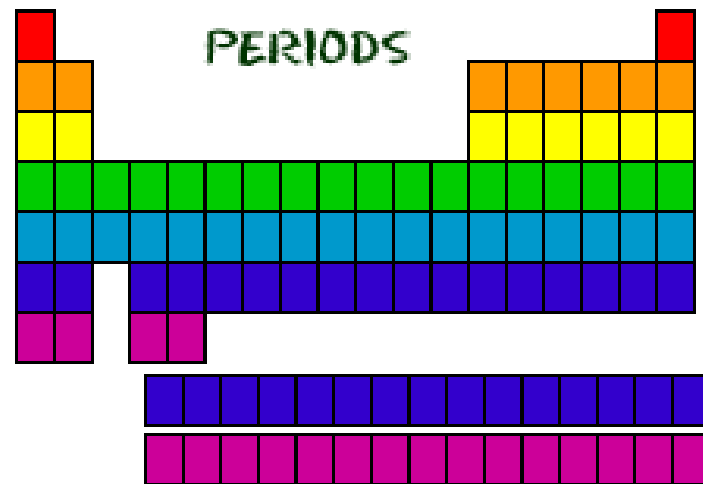
Groups are numbered vertical columns and periods are horizontal rows

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



1

1

H

Hydrogen

1.0

Atomic Number

Symbol

Name

Atomic mass

gas

liquid

solid

synthetic

Metals

Semi-Metals

Non-Metals

1

2

3

4

5

6

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8

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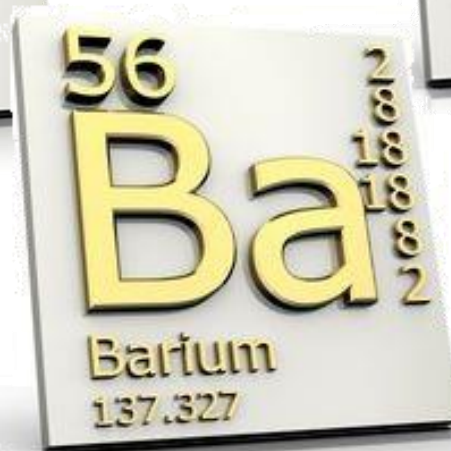
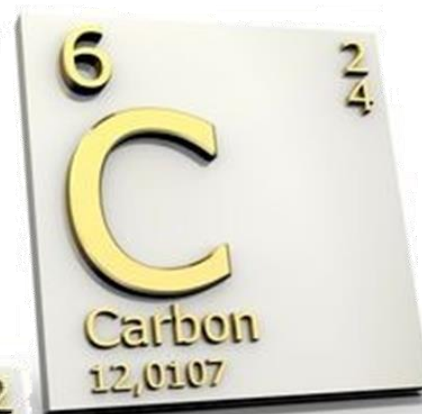
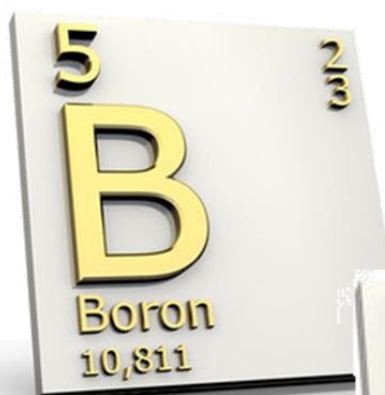
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Background Knowledge

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.



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

1st Shell	<div>H 1 </div>							<div>He 2 </div>
2nd Shell	<div>Li 3 </div>	<div>Be 4 </div>	<div>B 5 </div>	<div>C 6 </div>	<div>N 7 </div>	<div>O 8 </div>	<div>F 9 </div>	<div>Ne 10 </div>
3rd Shell	<div>Na 11 </div>	<div>Mg 12 </div>	<div>Al 13 </div>	<div>Si 14 </div>	<div>P 15 </div>	<div>S 16 </div>	<div>Cl 17 </div>	<div>Ar 18 </div>

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

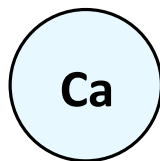
E

Extension

	1	2	3	4	5	6	7	8	9	10	11
1	H										
2	Li	Be									
3	Na	Mg									
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag
6	Cs	Ba	La-Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au
7	Fr	Ra	Ac-Lr	Rf	Db	Sg	Bh	Hs	Mt		

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



2, 8, 8, 2

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

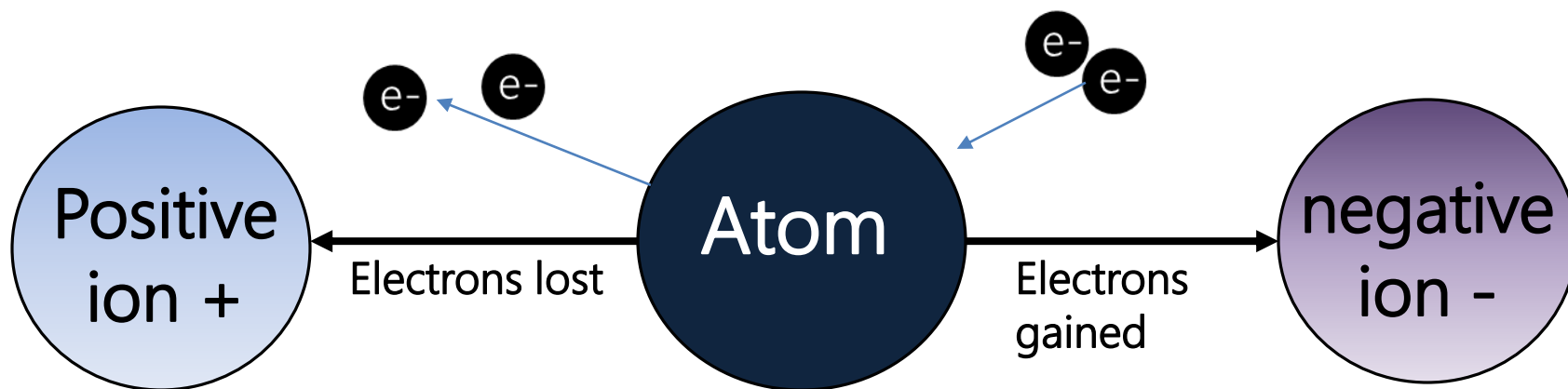
Step 3. backfill all energy levels with 8 electrons (2 in first) and add commas between each

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.

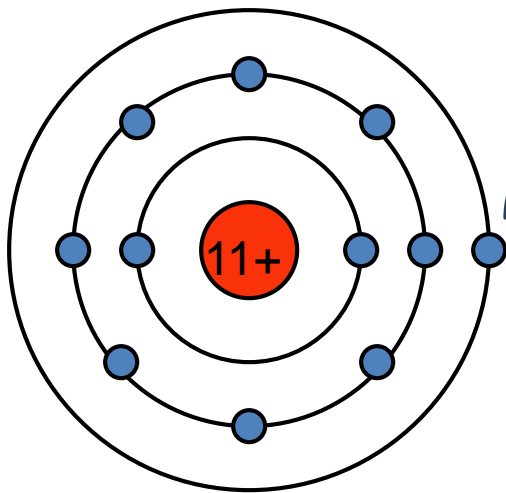
Elements can lose or gain electrons when they react with other chemicals to form ions and achieve stability.



Ions are formed by the gain or loss of electrons.

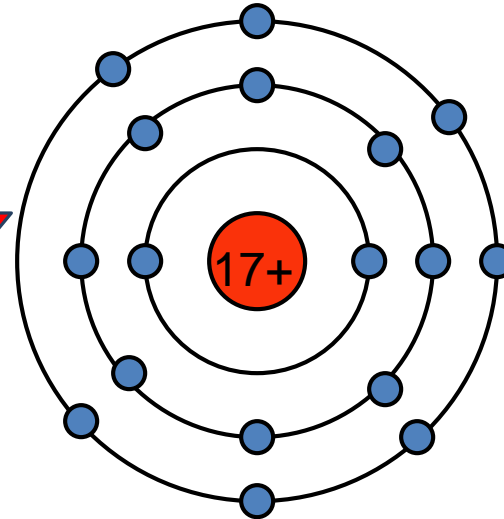
Ions are atoms or groups of atoms with electrical charges. Ions normally form in pairs of atoms when one or more electrons are passed between them. Depending on how many electrons are present in the outside energy level or how many are "missing" determines the total number of electrons transferred.

Sodium (Na)



Sodium now becomes the sodium ion Na^+

Chlorine (Cl)



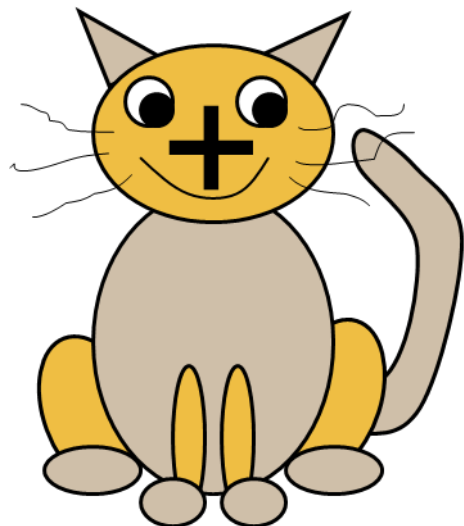
Chlorine now becomes the chloride ion Cl^-

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)

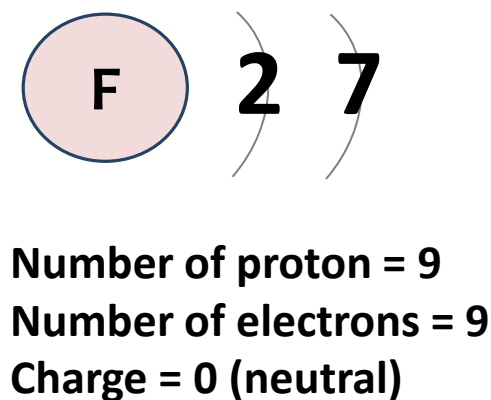


Non-Metals gain electrons to form Anions. They have 5-7 electrons in their outside energy level.

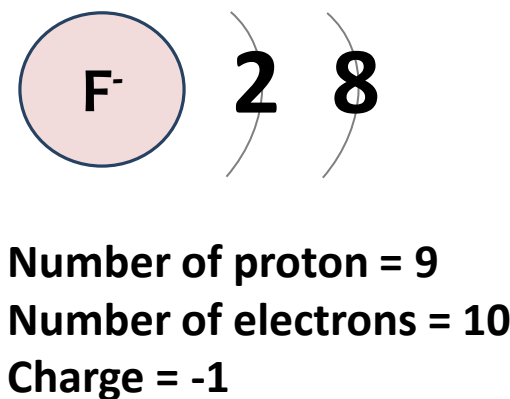
The number of protons compared to electrons determines the charge

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
Mg²⁺	12	12	10	2,8



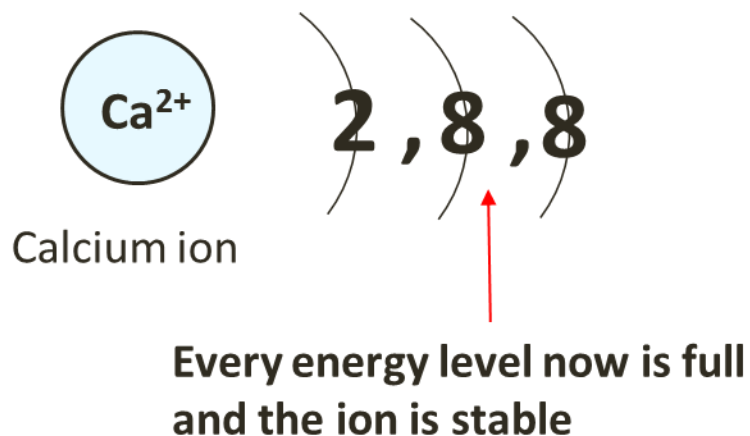
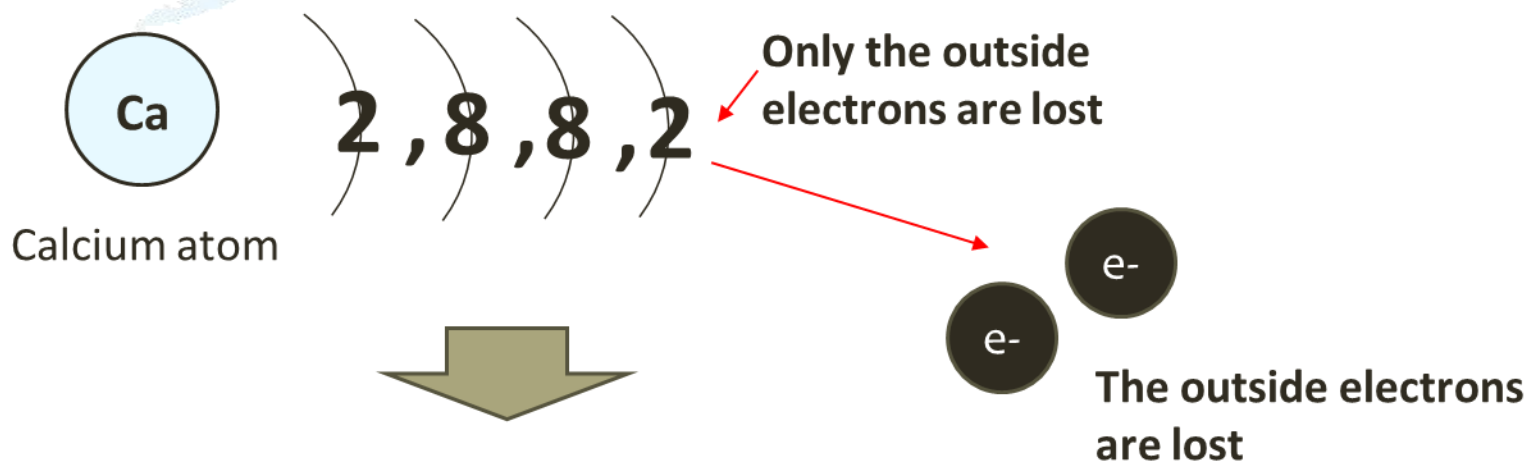
One electron is
gained by the
atom



Electron arrangement of positive ions (metals)

E

Extension



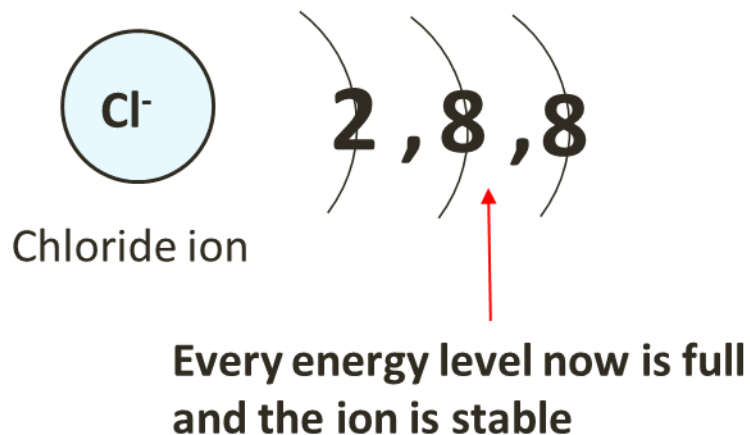
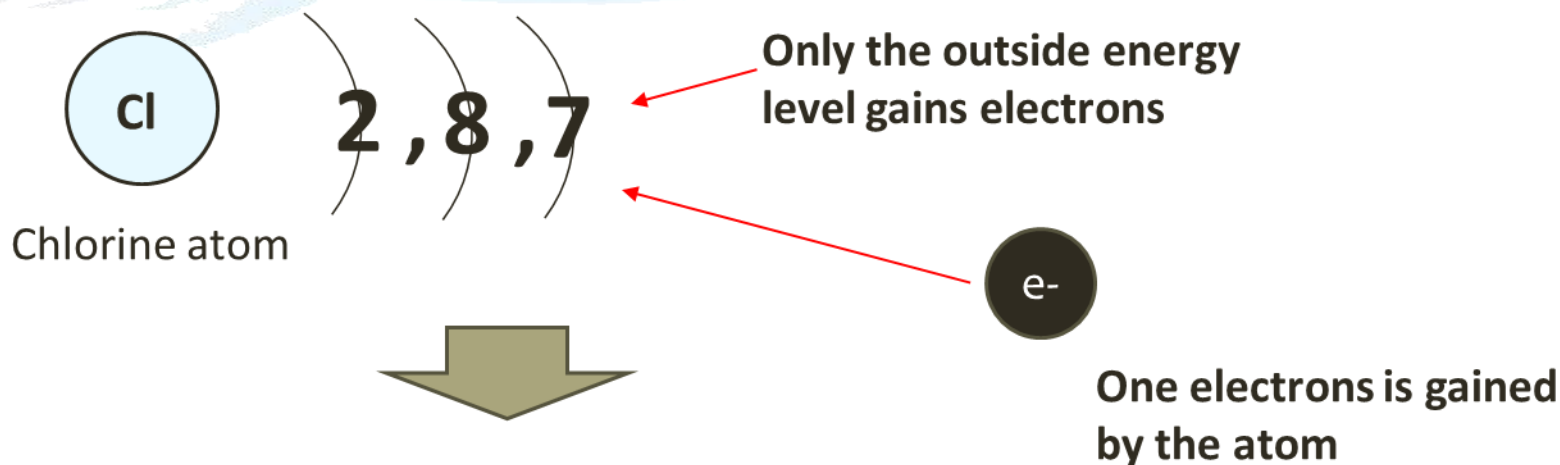
The Ca atom has 20 protons and 20 electrons so has no charge. It is neutral.

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

Electron arrangement of negative ions (non-metals)

E

Extension



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

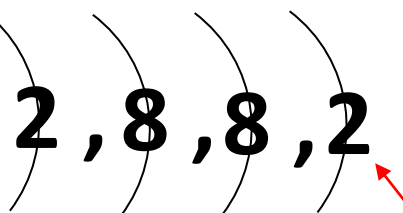
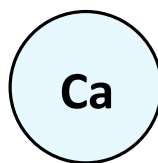


	1	2	3	4	5	6	7	8	9	10	11
1	H										
2	Li	Be									
3	Na	Mg									
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag
6	Cs	Ba	La-Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au
7	Fr	Ra	Ac-Lr	Rf	Db	Sg	Bh	Hs	Mt		

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



Periodic Table of the Elements

Atomic Number | Name | Symbol | Atomic mass

Metals | Semi-Metals | Non-Metals

gas
liquid
solid
synthetic

Group

Period

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1.0	2 He Helium 4.0																
3 Li Lithium 6.9	4 Be Beryllium 9.0																
5 Na Sodium 23.0	6 Mg Magnesium 24.3																
7 K Potassium 39.1	8 Ca Calcium 40.1																
9 Rb Rubidium 85.5	10 Sr Strontium 87.6																
11 Cs Caesium 133	12 Ba Barium 137																
13 Fr Francium 223	14 Ra Radium 226																
15 La Lanthanum 139	16 Ce Cerium 140	17 Pr Praseodymium 141	18 Nd Neodymium 144	19 Pm Promethium 147	20 Sm Samarium 150	21 Eu Europium 152	22 Gd Gadolinium 157	23 Tb Terbium 159	24 Dy Dysprosium 163	25 Ho Holmium 165	26 Er Erbium 167	27 Tm Thulium 169	28 Yb Ytterbium 173	29 Lu Lutetium 175			
30 Ac Actinium 227	31 Th Thorium 232	32 Pa Protactinium 231	33 U Uranium 238	34 Np Neptunium 237	35 Pu Plutonium 239	36 Am Americium 241	37 Cm Curium 247	38 Bk Berkelium 249	39 Cf Californium 251	40 Es Einsteinium 254	41 Fm Fermium 257	42 Md Mendelevium 258	43 No Nobelium 259	44 Lr Lawrencium 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

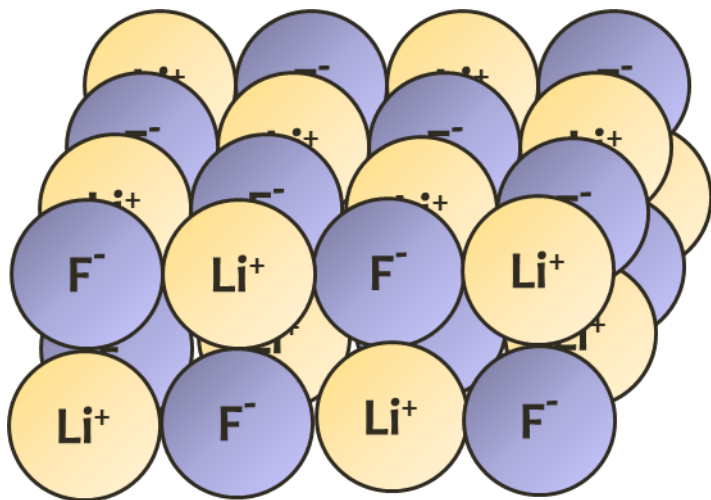
Compounds

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.

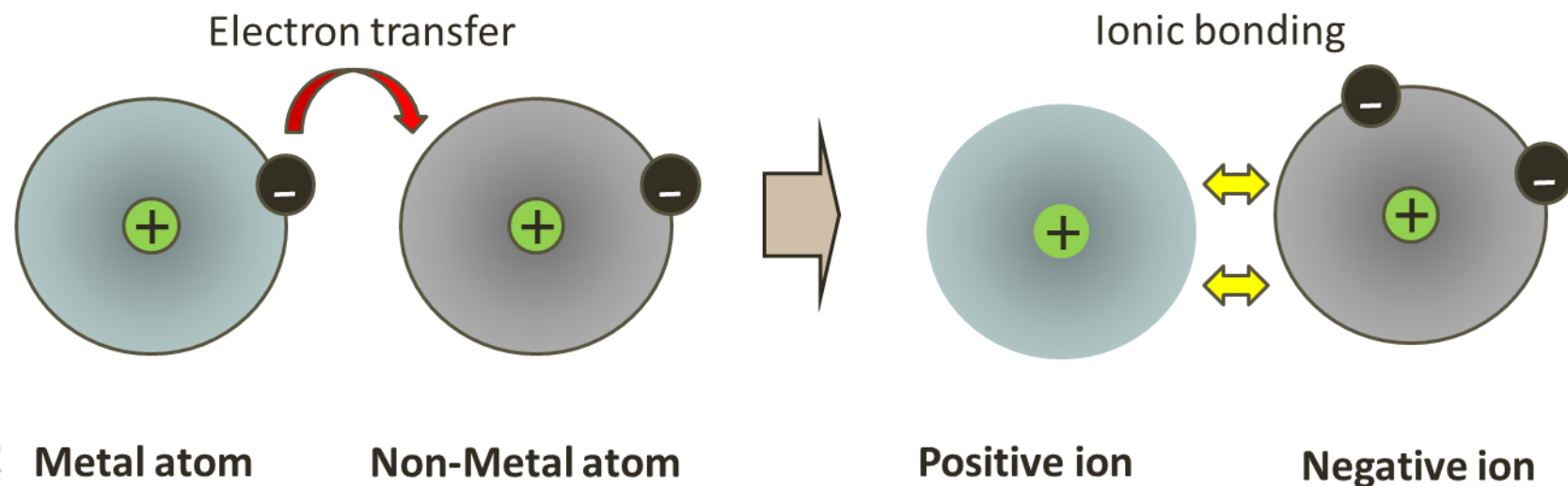
Anions and Cations have a strong electrostatic attraction for each other so they bond together as a compound.

Ionic Bonding



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^-		
Oxide	O^{2-}		

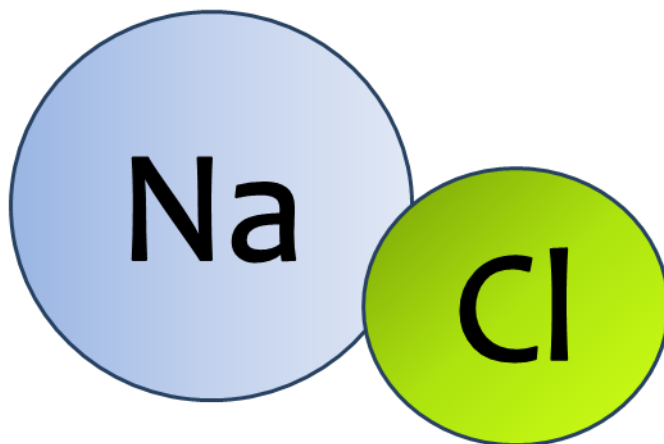
Yellow Shaded ions will be more commonly used in class

Naming a compound



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.

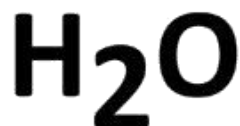
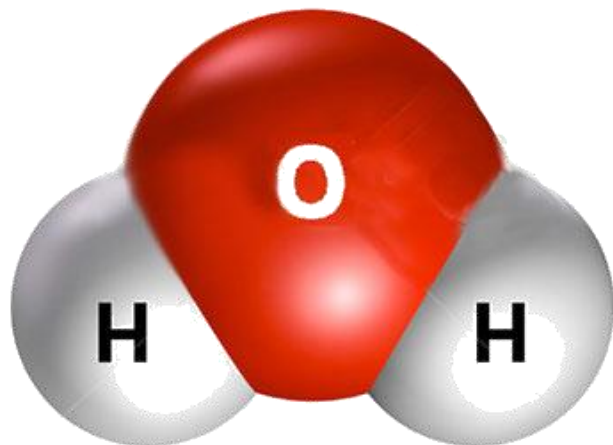
Sodium chloride (NaCl)



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.

We can draw a compound to show what type of atoms (or ions) are present and in what ratio. A simpler method is to write a chemical formula.

WATER MOLECULE

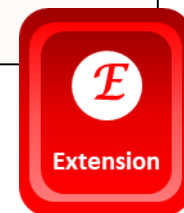


This formula for water (H_2O) tells us that there are 2 Hydrogen atoms and 1 Oxygen atom in a molecule of water

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.



2 Mg
atoms

4 N
atoms

12 O
atoms

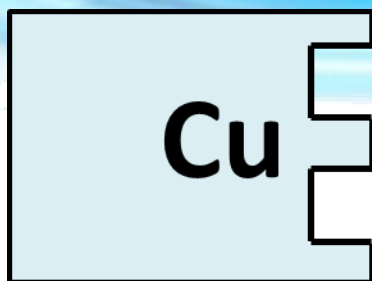


A number in front of the compound tells you how many molecules there are.

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



Copper

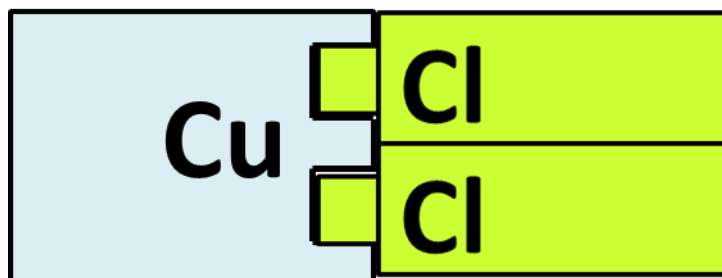
Copper forms a positive copper ion of Cu^{2+} . It loses 2 electrons – shown by the 2 “missing spaces” in the shape



Chloride

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

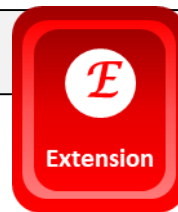
If we want to form a balanced ionic compound then each space in the positive ion must be filled by a tab from the negative ion. In this case 2 chloride ions are needed for each copper ion to form copper chloride.




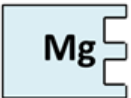
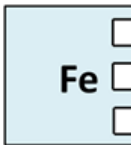


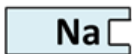
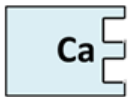
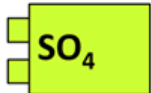
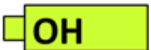

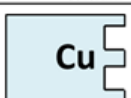
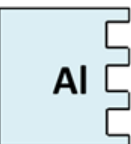
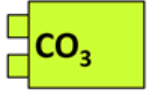
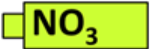
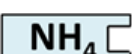
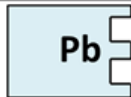
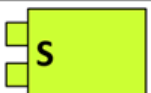

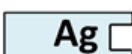
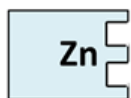



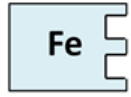
Copper Chloride

Copper chloride has a formula of CuCl_2

Chemical reactions



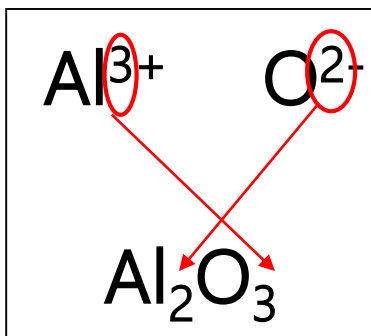
When products are made in a reaction the name of it is often a combination of the names of the chemicals it is formed from. For example MgCl_2 is called magnesium chloride

Cation			Anion	
1+	2+	3+	2-	1-
 Hydrogen	 Magnesium	 Iron (III)	 Oxide	 Chloride
 Sodium	 Calcium		 Sulfate	 Hydroxide
 Potassium	 Copper	 Aluminium	 Carbonate	 Nitrate
 Ammonium	 Lead		 Sulfide	 Hydrogen Carbonate
 Silver	 Zinc	 Iron (II)		 fluoride
 Lithium	 Iron (I)			

Cross and Drop method for balancing ionic compounds

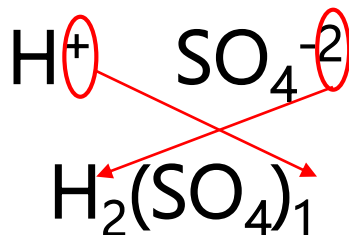


1. Write down the ions (with charges) that react to form the compound.
Cation comes before Anion.



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



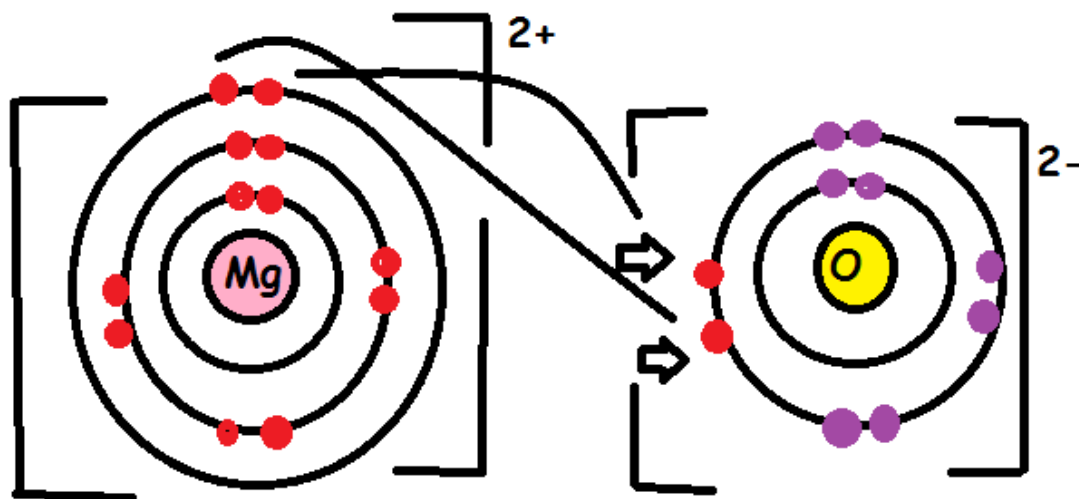
Charged ions make neutral Ionic Compounds



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 .



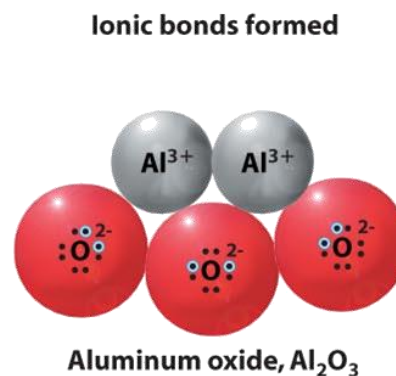
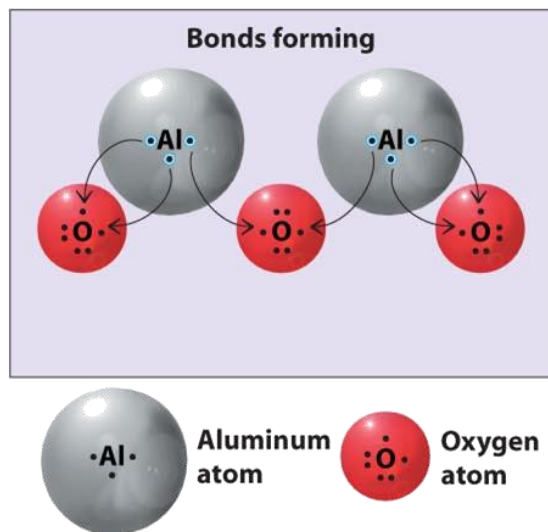
Charged ions make neutral Ionic Compounds



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.



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.



Testing 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.

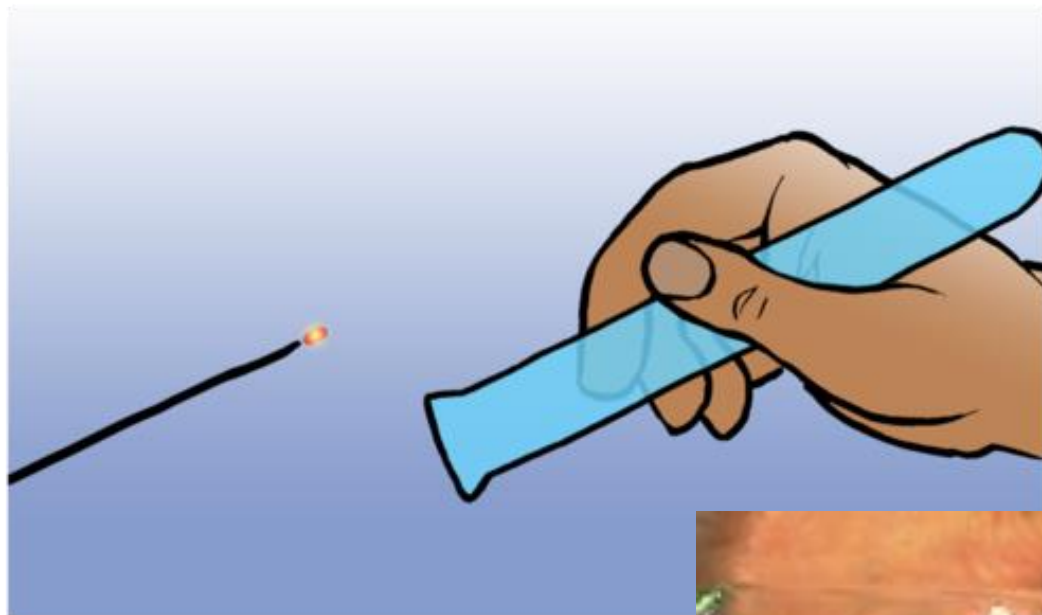


Oxygen gas is a molecule formed from two bonded oxygen atoms



Oxygen in the air combines with iron to form rust.

Testing for Oxygen gas

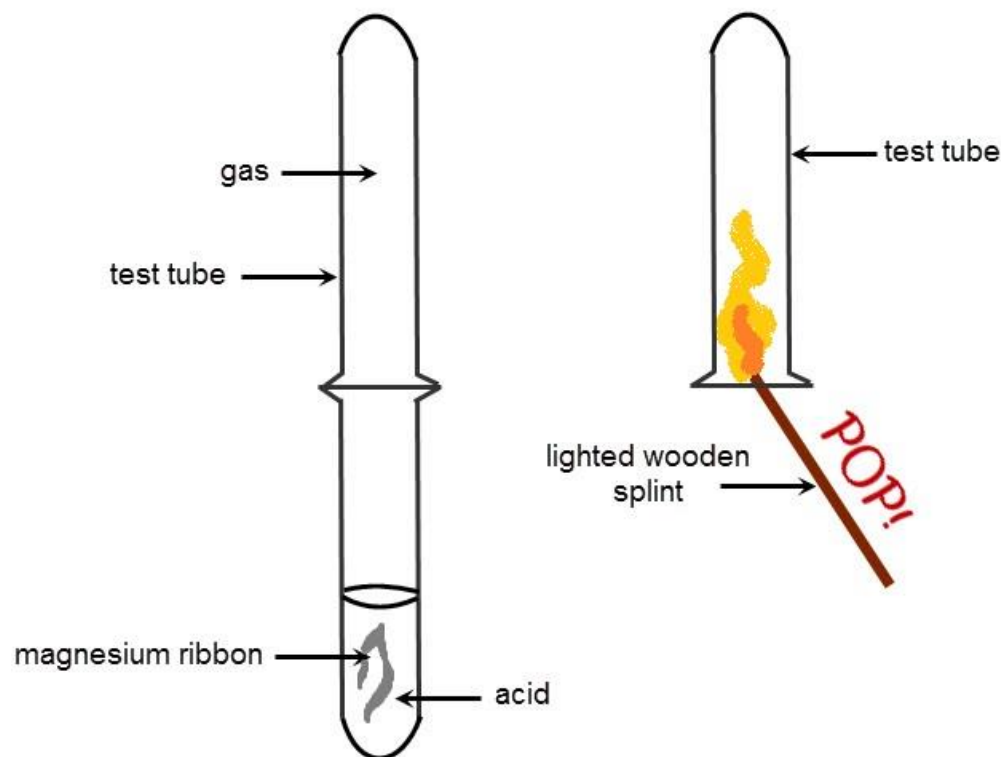


All types of combustion (burning) need oxygen. By supplying pure oxygen the glowing splint begins to combust at a faster rate, which we see as flames.



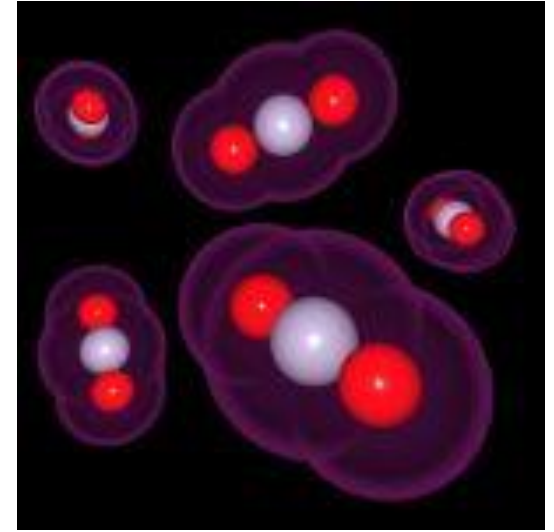
Testing for Hydrogen gas

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.



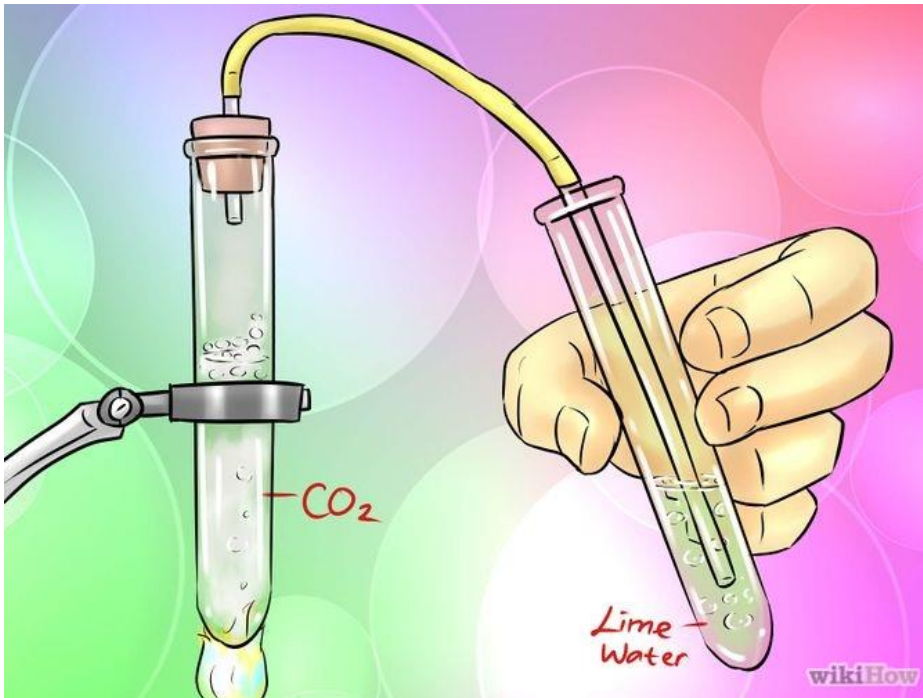
Testing for Carbon Dioxide gas

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 CO₂ gas into the leaf

Testing for Carbon Dioxide gas

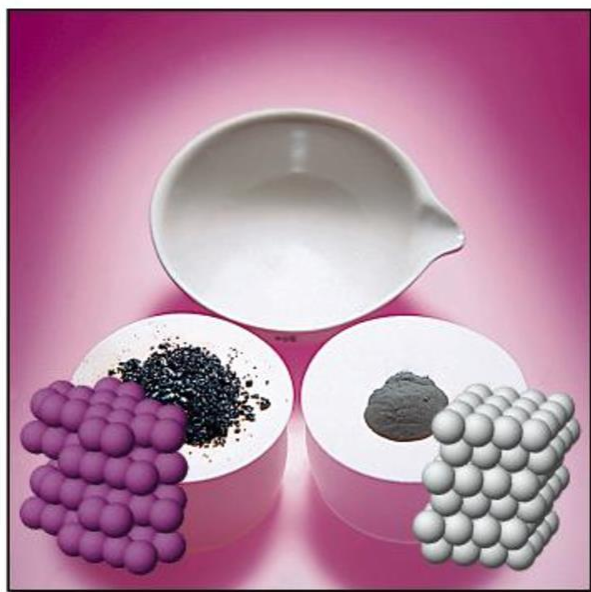


Carbon Dioxide is a colourless gas and limewater is a solution of calcium hydroxide in water which is also colourless. The carbon dioxide gas reacts with the limewater and changes it into calcium carbonate which is not soluble (can not dissolve) in water and appears as a milky white colour.

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.

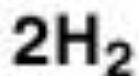


Reactants join together to form new products during chemical reactions

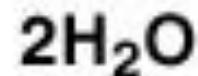
The atoms present in the **reactants** rearrange themselves in different combinations and form new bonds. The new combinations of atoms are called **products** and can either be single atoms or molecules.

Reactants

Products



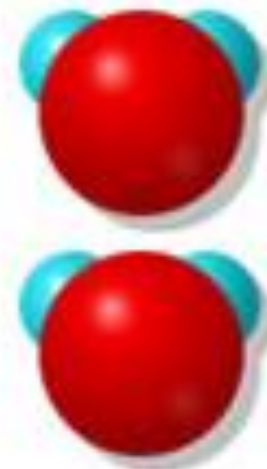
+



4.07.18 15:04:53



+



2 hydrogen molecules + 1 oxygen molecule yields 2 water molecules

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 \rightarrow water + carbon dioxide

Add
chemicals
with a +

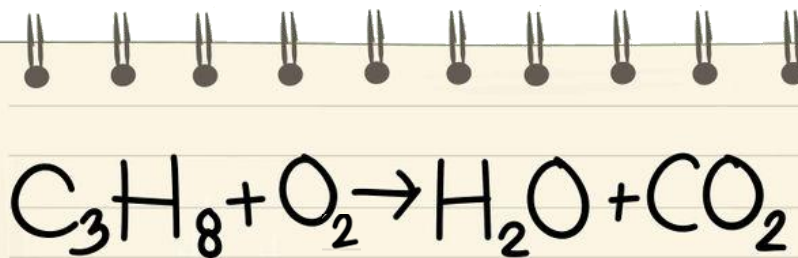
Show reactants turning
into products with a \rightarrow

Writing symbol equations



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)

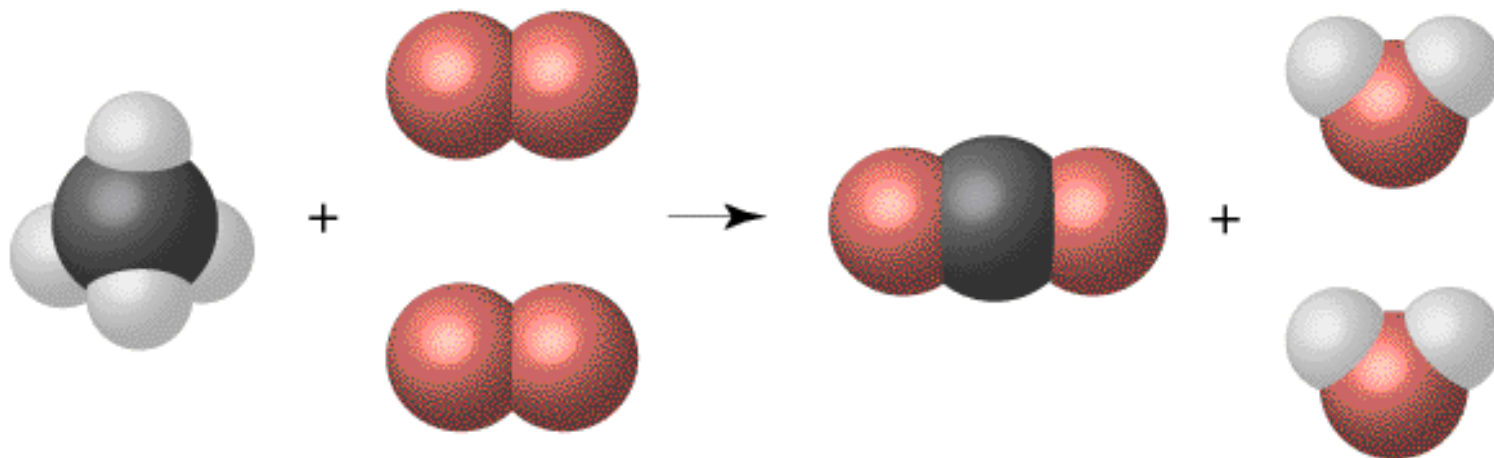
You will need to use ion charts to write the formula for compounds made of ions.

Balancing Chemical equations

E

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

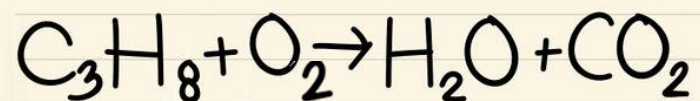
Two water
molecules



Balancing Chemical equations

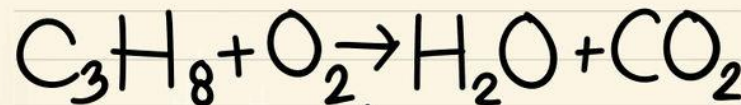


1. To balance an equation first write down the equation



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



$$\text{C} = 3$$

$$\text{H} = 8$$

$$\text{O} = 2$$

$$\text{C} = 1$$

$$\text{H} = 2$$

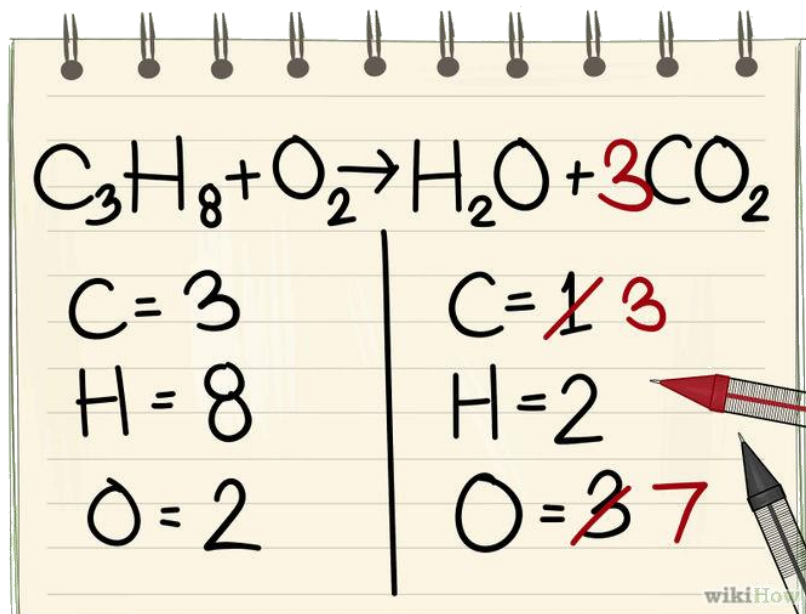
$$\text{O} = 3$$

Balancing Chemical equations

E

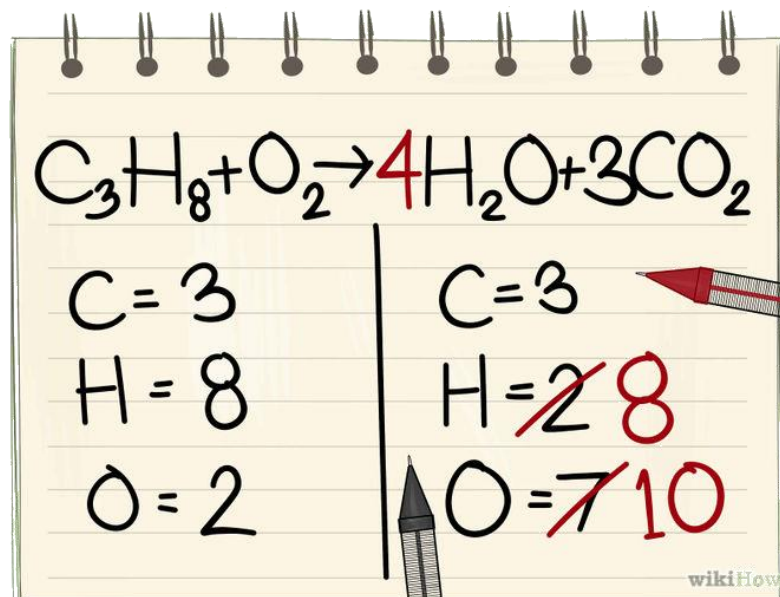
Extension

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



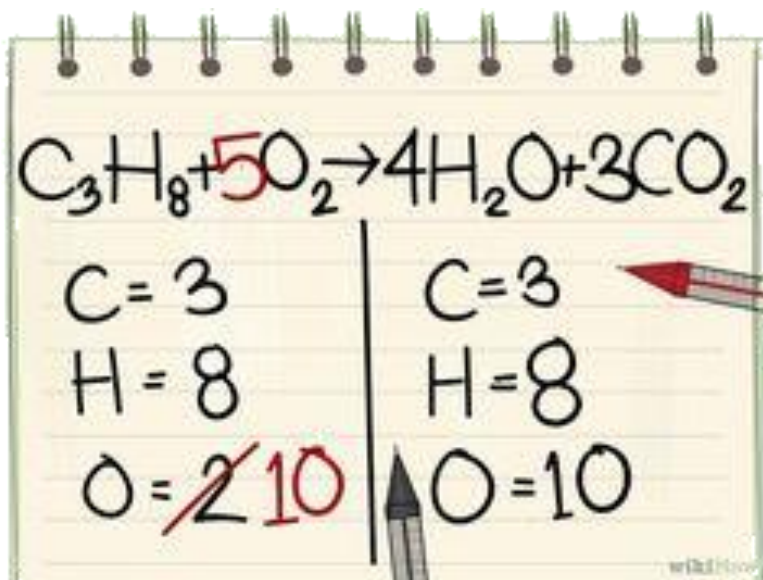
Balancing Chemical equations

E

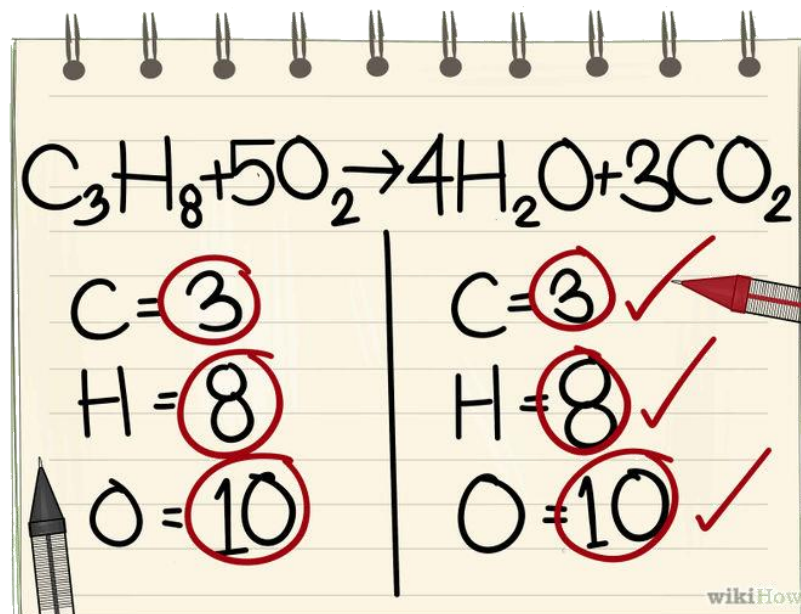
Extension

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!**




Acids – their characteristics



Acids are a family of substances which all show **acidic characteristics** or properties. These properties relate to how the acids react with other chemicals.

They have a **sour taste** and react with metals. Acids can be found in nature and called **organic acids** or manufactured in the laboratory and called **mineral acids**.



Common acids - names and formula

Name	Chemical formula
hydrochloric acid	HCl
sulfuric acid	H ₂ SO ₄
nitric acid	HNO ₃
ethanoic acid	CH ₃ COOH

Acids react with most metals to form hydrogen gas

Taste sour (like lemons)

Frequently feel "sticky"

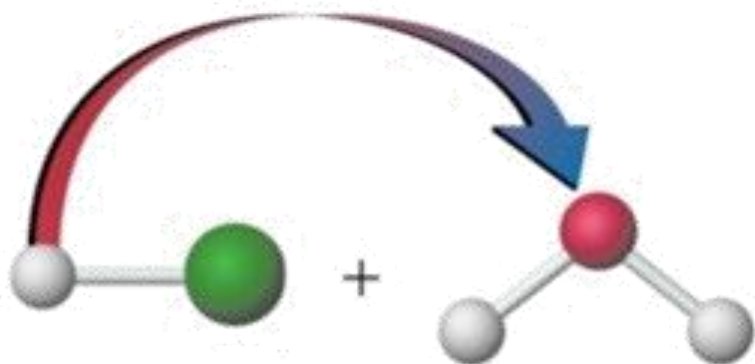
Usually gases or liquids

You need to learn these acids and their formula

Defining an Acid

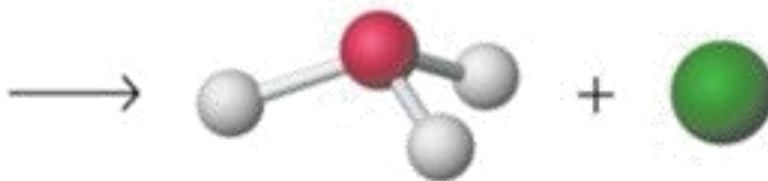
All acids contain hydrogen. When an acid reacts it gives away its **Hydrogen ion** (H^+), which is really just a proton, and the electron remains behind.

Before the reaction



Acid giving
its
hydrogen
ion (H^+) in
a reaction

After the reaction



Acid with the
hydrogen ion
removed

Bases – their characteristics



Bases are a family of Chemicals that have hydroxide ions present (OH^-). They have opposite properties from acids.

Common Household bases include floor clearers and antacid tablets to fix indigestion. A Base that dissolve into water is called an **alkali**.



SCIENCEPHOTOLIBRARY

Common bases - names and formula



Name	Chemical formula
sodium hydroxide (OH)	NaOH
calcium carbonate (CO_3)	CaCO_3
magnesium oxide (O)	MgO
potassium hydrogen carbonate (HCO_3)	KHCO_3

Feel "slippery". (because your skin dissolves a little when you touch them.)

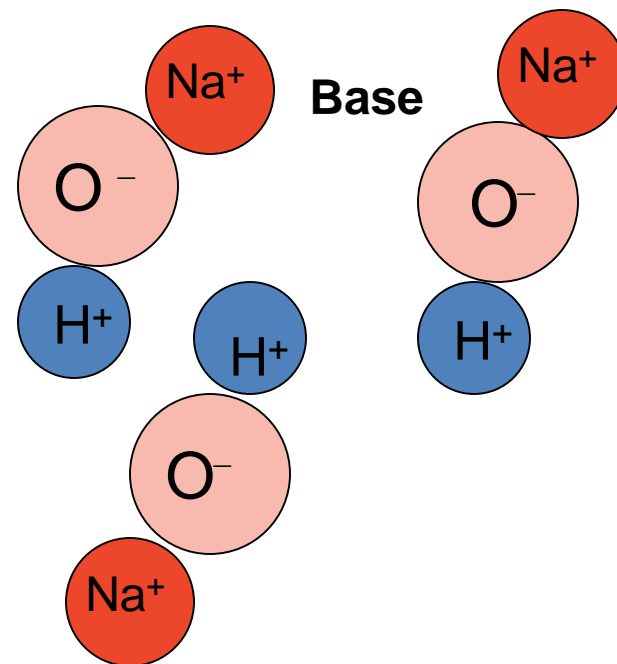
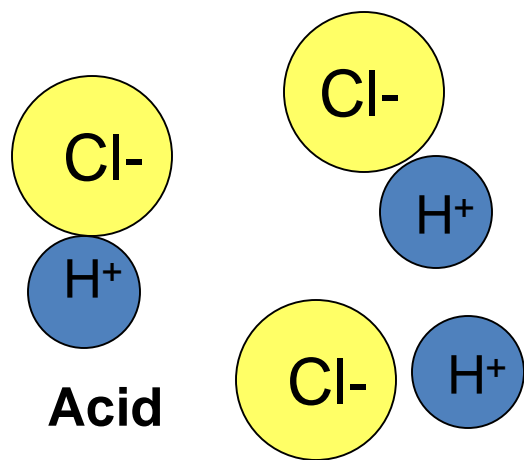
Taste bitter (like baking soda)

React with oils and greases (used as cleaners)

Frequently solids

Acid and Base definition

An **acid** is a molecule or ion that gives away a hydrogen ion (proton, H^+), and a **base** can contain a hydroxide ion (OH^-)



What is an Alkali

A base that dissolves in water and **produces a OH^- ion** (hydroxide) is known as an **alkali**. The solution it creates with water is known as alkaline.

Common alkalis are sodium hydroxide (NaOH) and potassium hydroxide (KOH)

The concentration of H^+ and OH^- ions in a solution determine how acidic or basic it is.

High H^+ concentration and low OH^- concentration mean the solution is acidic.

Low H^+ concentration and high OH^- concentration mean the solution is basic.

When the concentration of H^+ ions and OH^- ions are equal then the solution is said to be **neutral**, neither acidic or basic.



Corrosive

Indicators determine whether substances are acid, base or neutral.



Indicators can be used to determine the pH of a solution by the colour change.

An indicator is a large organic molecule that works like a "colour dye". They respond to a change in the hydrogen ion concentration. Most of the indicators are themselves weak acids.

The most common indicator is found on **litmus paper**. It turns/remains red for acid and turns/remains blue for a base.

Universal Indicator, which is a solution of a mixture of indicators that provide a full range of colours for the pH scale.

Red and Blue Litmus paper works as an indicator

Added to...	Blue Litmus	Red litmus
Acid solution	Turns red	Stays red
Base solution	Stays blue	Turns blue
Neutral solution	Stays blue	Stays red

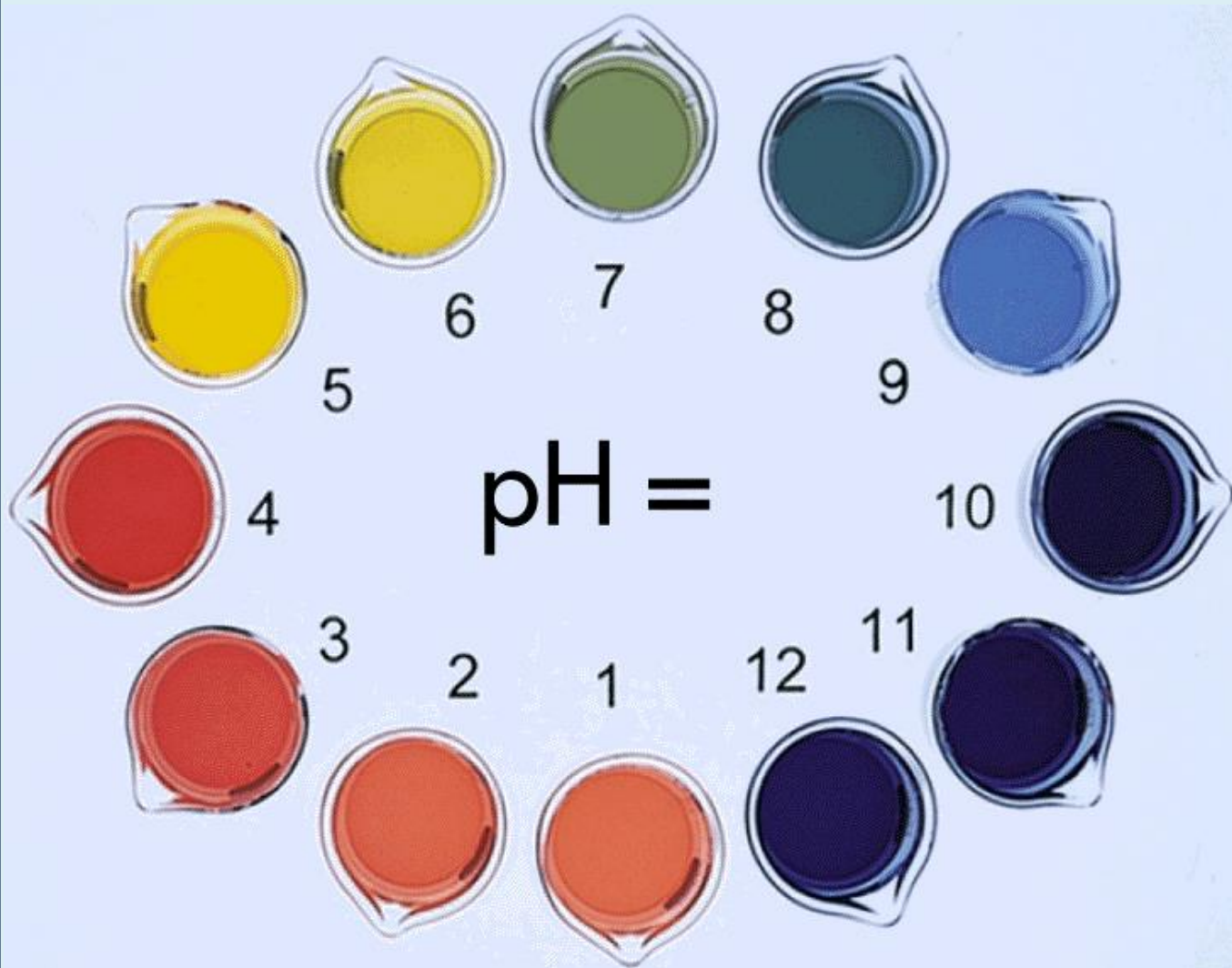


Blue litmus paper turning red in acid



Red litmus paper turning blue in base

Universal Indicator is used to give the strength of the acid or base

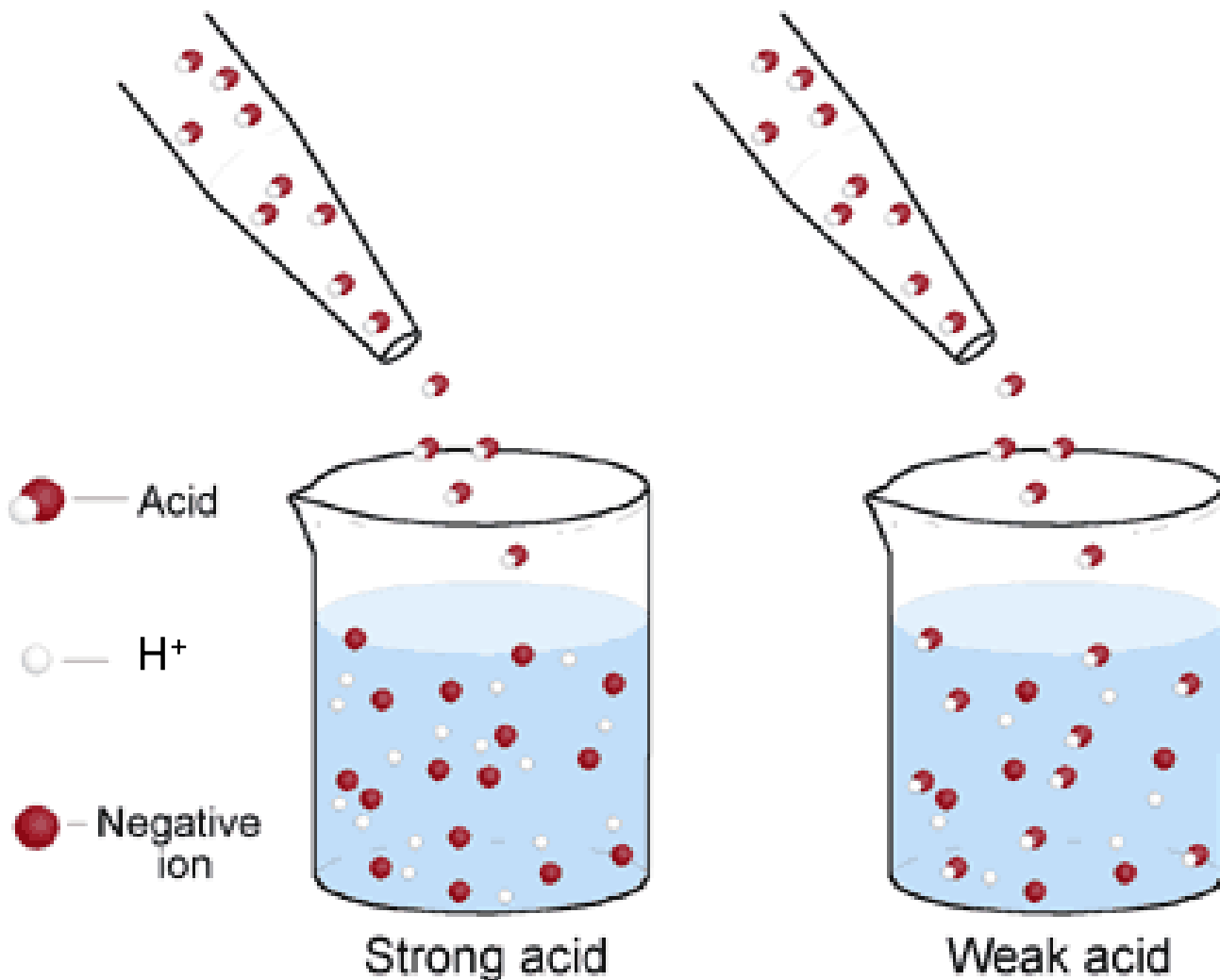


The Universal Indicator is similar to the Litmus paper, in that the acids turn the indicator mostly red and the bases turn the indicator mostly blue. It does have an advantage over the litmus paper as it shows neutral by having a green colour and has different colours for weak acids and weak bases.

The difference between strong and weak acids and bases

E

Extension



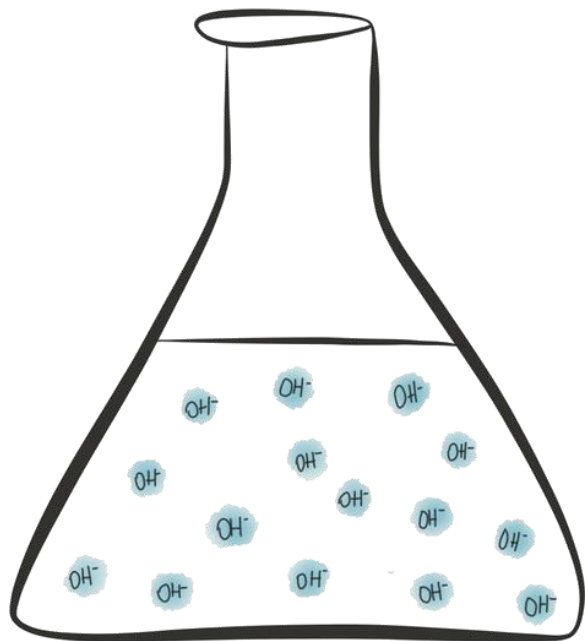
You can define acids and bases as being "strong" or "weak". **Strong acids** are compounds release a large amount of H⁺ ions. A **weak acid** releases much less H⁺ ions

Strong and weak bases

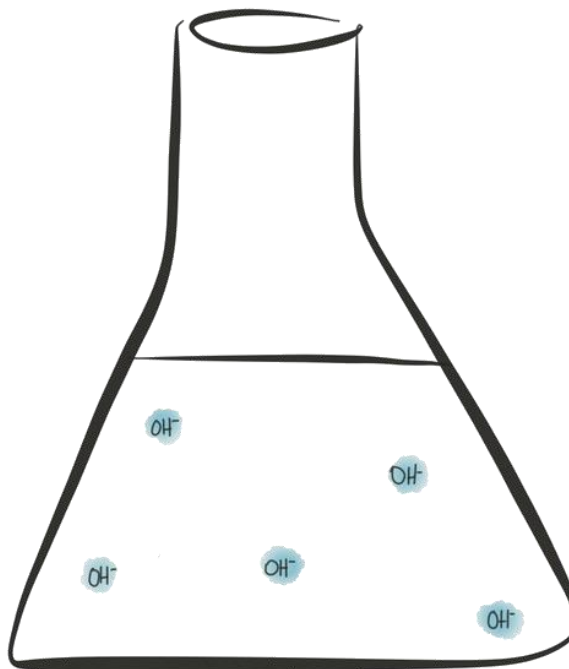
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Extension

Strong base



Weak base



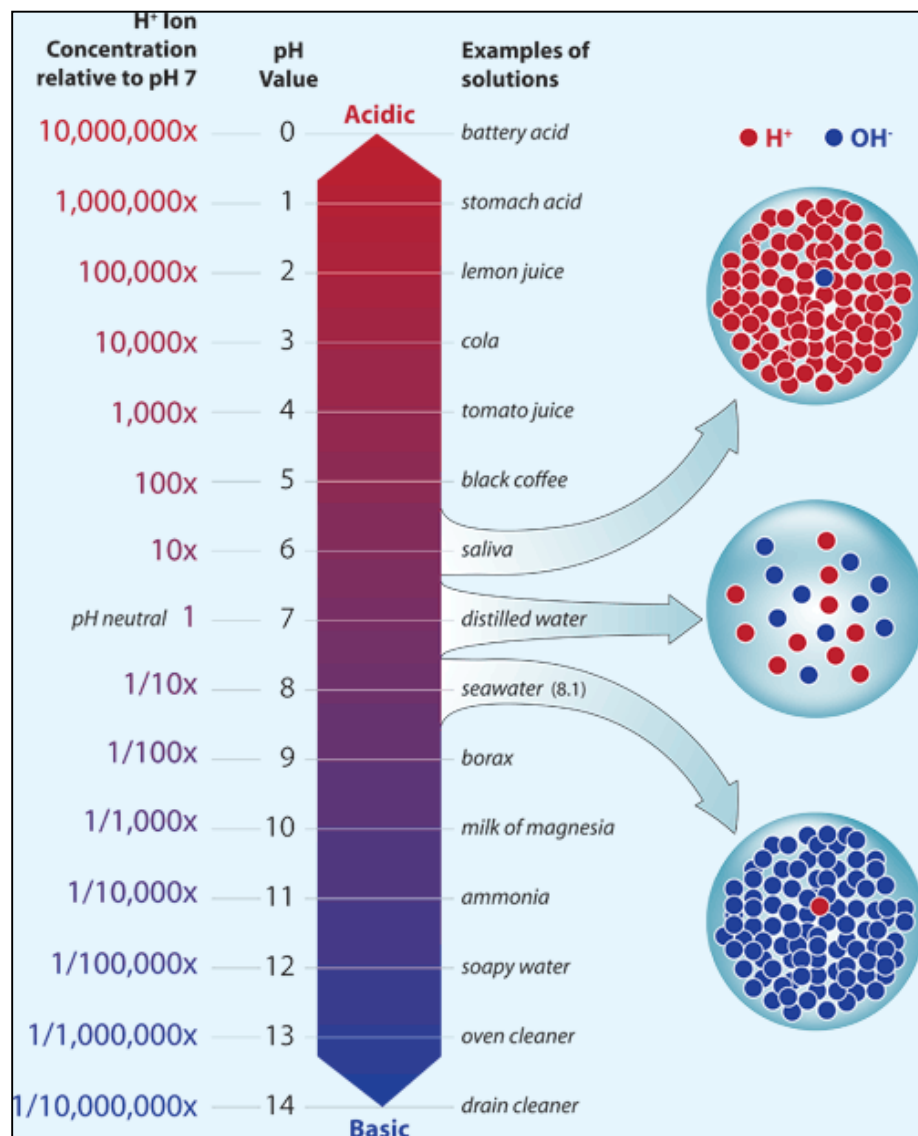
You can define bases as being "strong" or "weak". **Strong bases** are compounds where they release a large amount of OH^- ions.

A **weak base** is a compound where there are much less OH^- ions released. Most weak base molecules remain unreacted.

E

Extension

The pH scale measures level of acidity and alkalinity

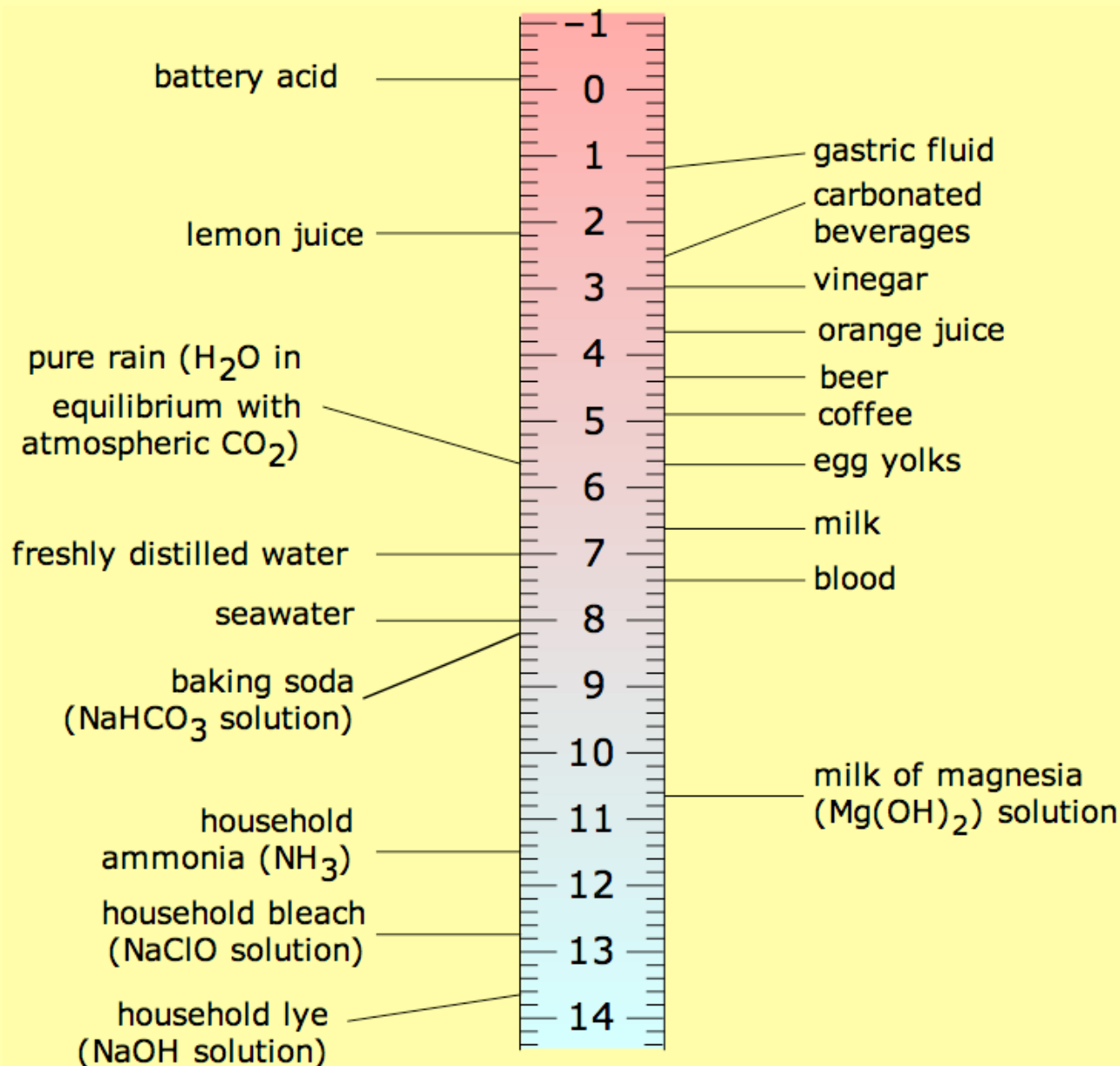


The **pH scale** measures how acidic or alkaline a substance is. Substances with a pH of 7 are **neutral**, substances with a pH greater than 7 are **alkaline** (or 'basic') and substances with a pH lower than 7 are **acidic**. Remember alkalis are 'bases' that are soluble in water. (All alkalis are bases but not all bases are alkalis.) The pH of a substance is determined by the concentration of hydrogen ions. The higher the concentration of hydrogen ions the lower the pH.

The pH of common acidic, alkaline and neutral substances.

E

Extension



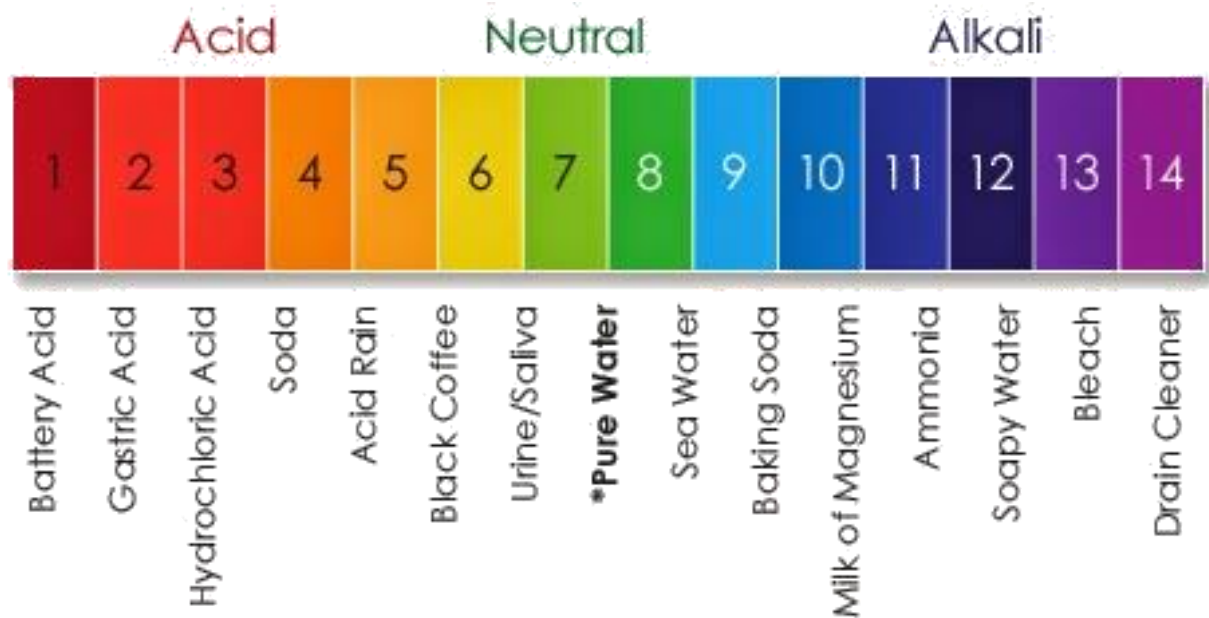
Pure water is **neutral**. But when chemicals are mixed with water, the mixture can become either acidic or basic. Examples of acidic substances are vinegar and lemon juice. Lye, milk of magnesia, and ammonia are examples of basic substances

The pH scale.

- Acids have a pH less than 7

Neutral substances have a pH of 7

Alkalis have pH values greater than 7



The pH scale is **logarithmic** and as a result, each whole pH value below 7 is ten times more acidic than the next higher value. For example, pH 4 is ten times more acidic than pH 5 and 100 times more acidic than pH 6.

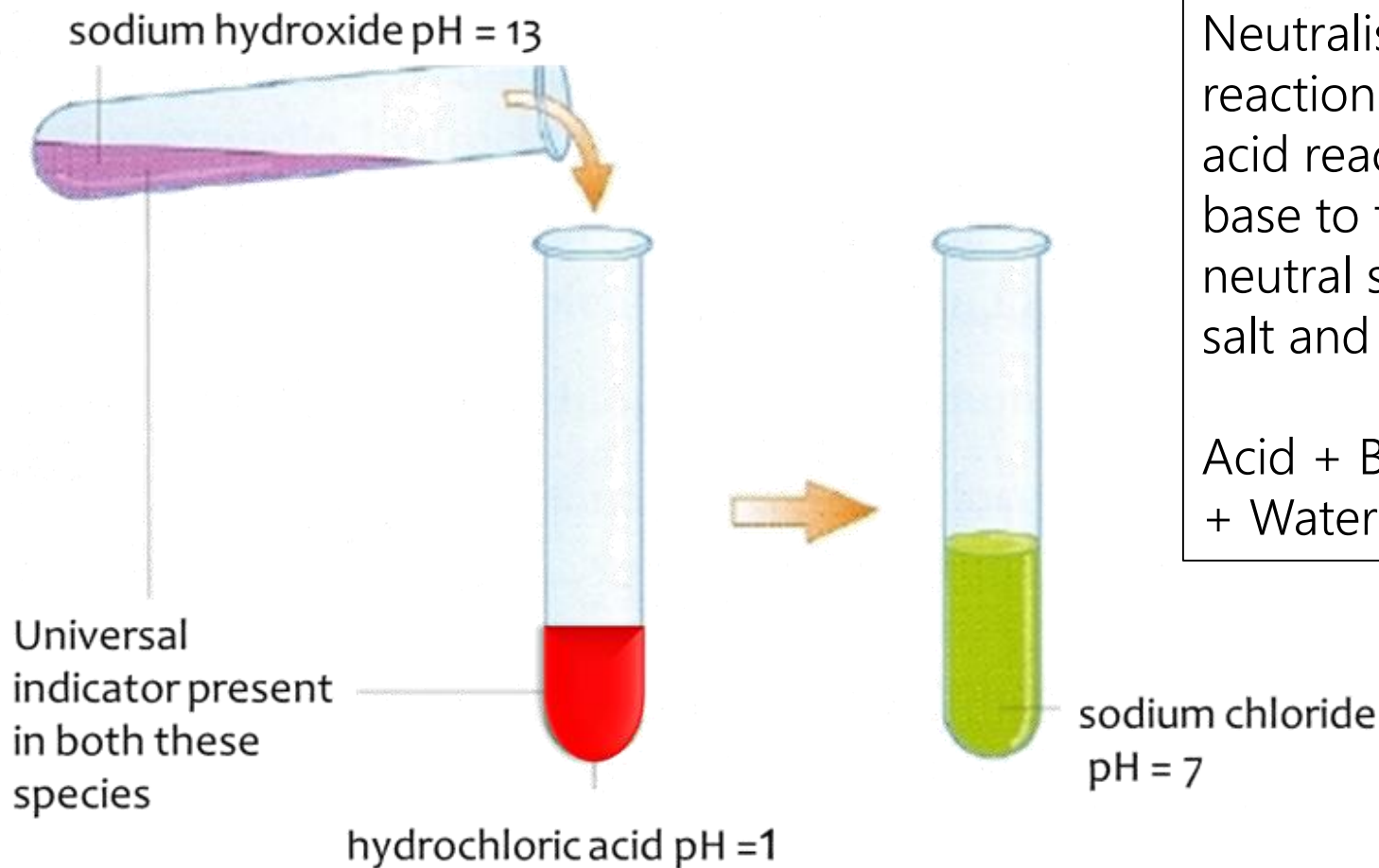
Putting it all together



Blue litmus														
Red litmus														
Universal indicator														
pH	1 - 2		3 - 6			7	8 - 12			13 - 14				
description	Strong Acids Readily donate all their protons when dissolved		Weak Acids donate only a small proportion of protons			Neutral solution		Weak Bases Accept only a small proportion of protons			Strong Bases Readily accept protons			
H ₃ O ⁺ / OH ⁻ concentration	Concentration of H ⁺ ions is greater than that of OH ⁻ ions					Concentration of H ⁺ ions is the same as that of OH ⁻ ions					Concentration of H ⁺ ions is less than that of OH ⁻ ions			



During neutralisation reactions acids combine with bases to form a salt and water



Neutralisation is a reaction where an acid reacts with a base to form a neutral solution of a salt and water.



During neutralisation reactions hydrogen ions combine with hydroxide ions to form water molecules.



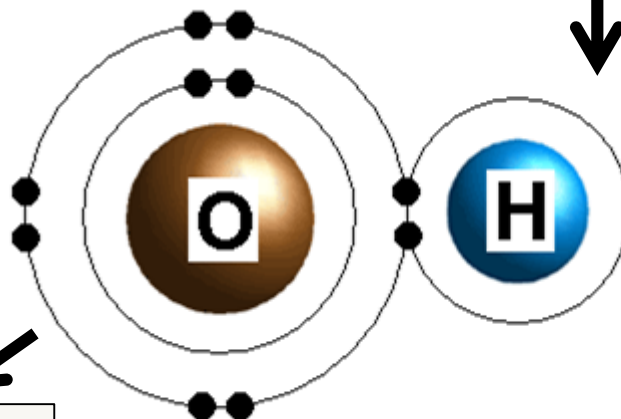
From an acid

Hydrogen ion
1 proton
0 electrons
= +1 charge

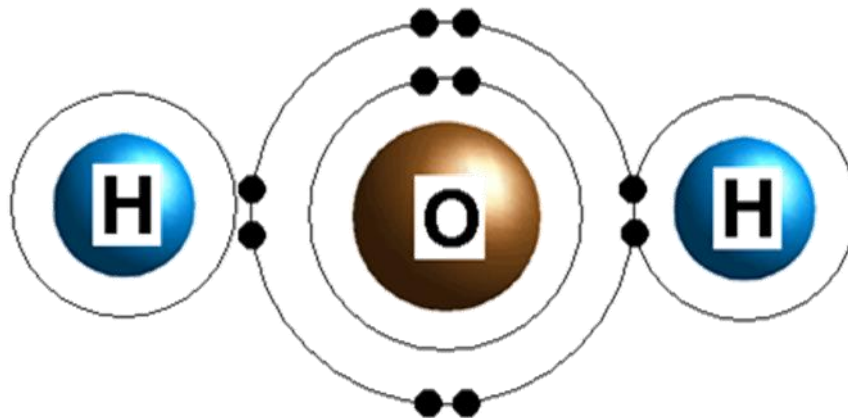


From a base

Hydroxide:
9 protons
10 electrons
= -1 charge



Neutralisation



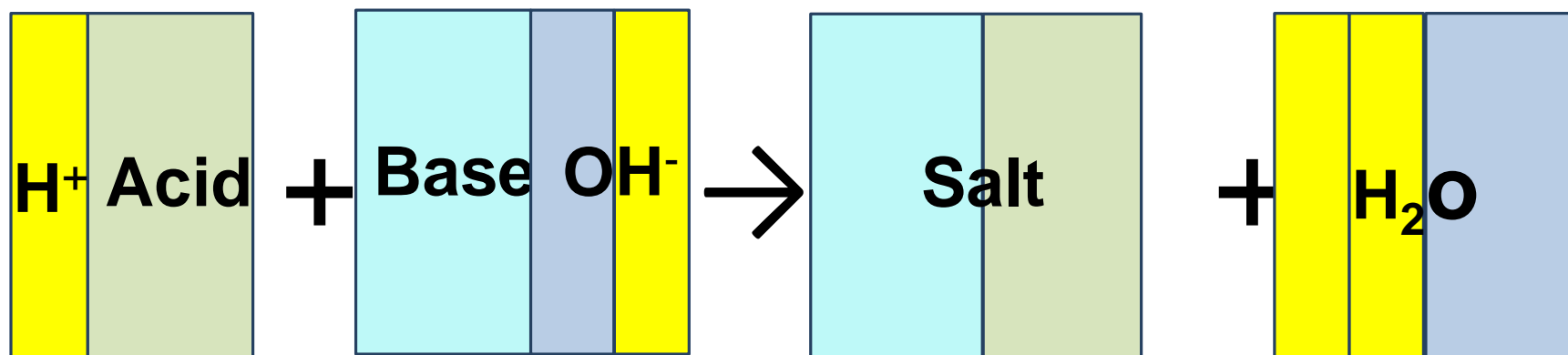
Water
10 protons
10 electrons
= 0 charge

Balanced equations for salt formation

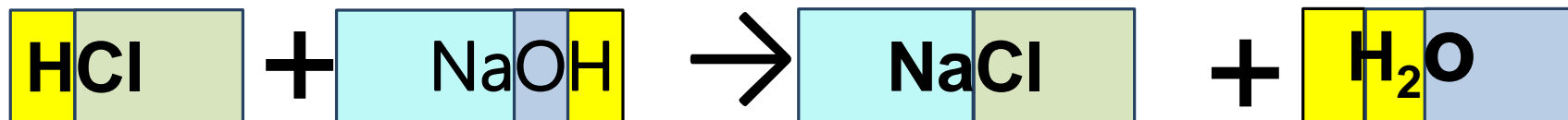
E

Extension

Bases **neutralise** acids and a salt and water are formed



Example



Hydrochloric
Acid

+

Sodium
Hydroxide

→

Sodium
Chloride

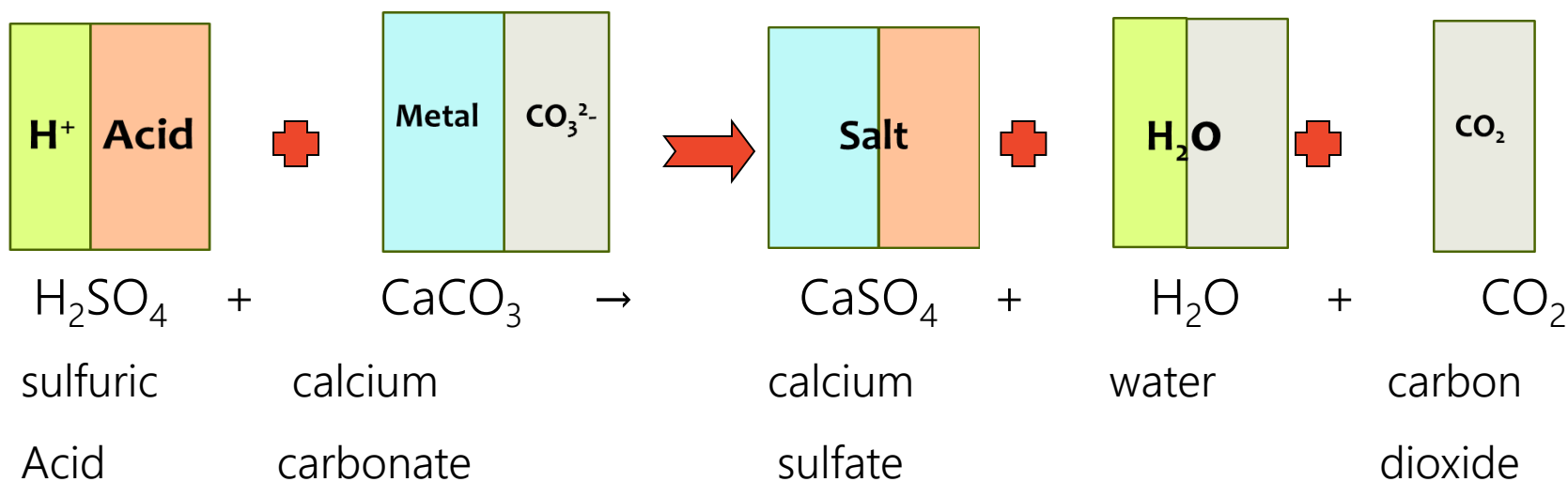
+

Water

Metal carbonates form salts , water and carbon dioxide gas when reacting with acid



Acids react with Carbonates to give a salt and water and carbon dioxide.

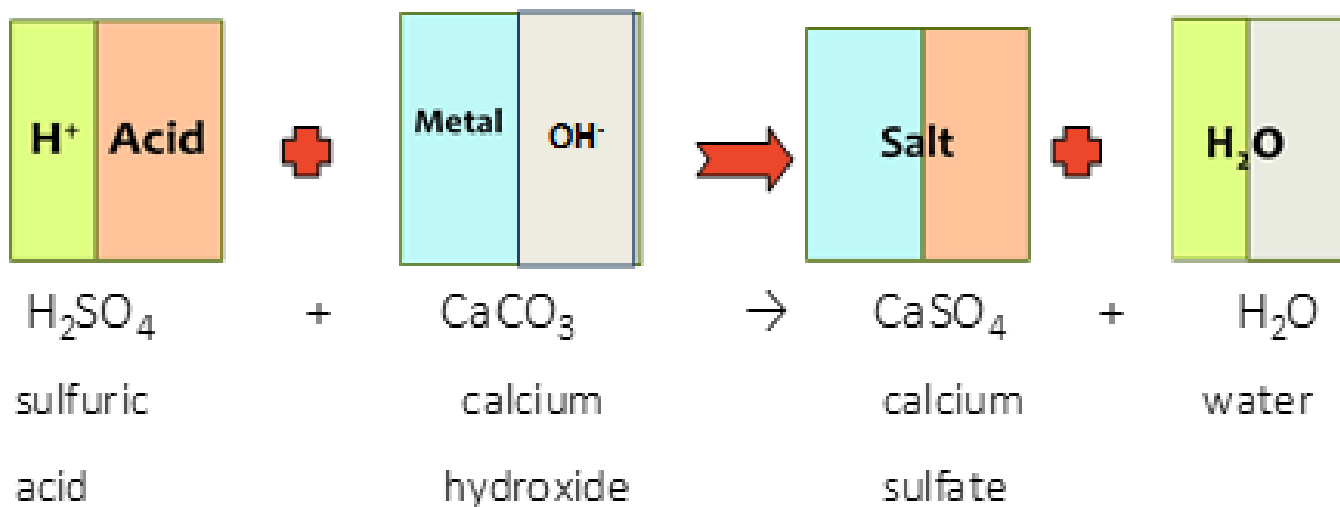


We can test to see if carbon dioxide has formed by bubbling the gas into another test tube filled with lime water. The lime water will turn cloudy if the gas is carbon dioxide.

Metal hydroxides form salts and water when reacting with acid



Acids react with hydroxides to give a salt and water.



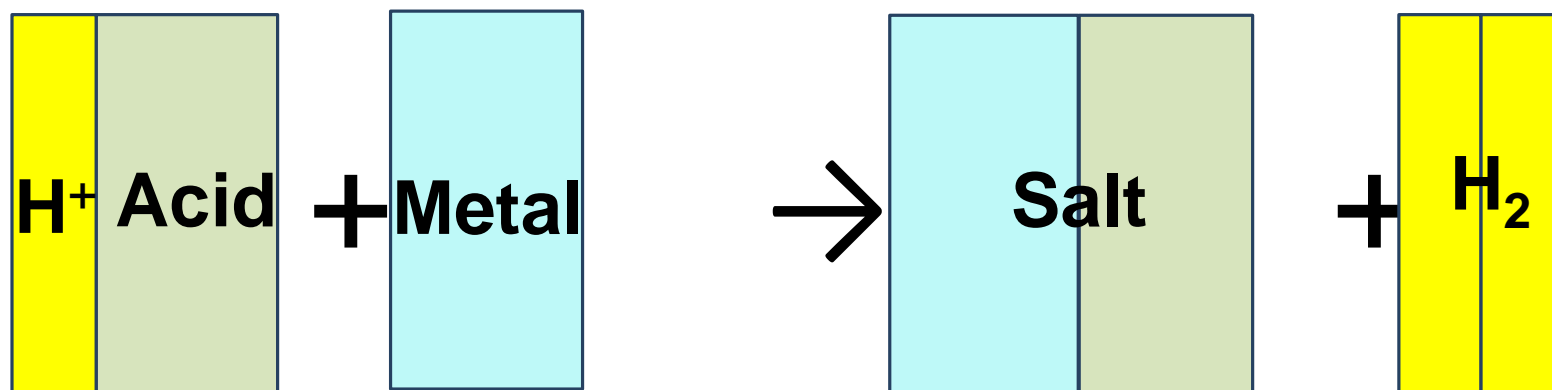
We can test to see if a solution has been neutralized (all of the acids and base has reacted to form salt and water) by testing with universal indicator which will turn green.

Acids react with metals to form a salt and hydrogen gas

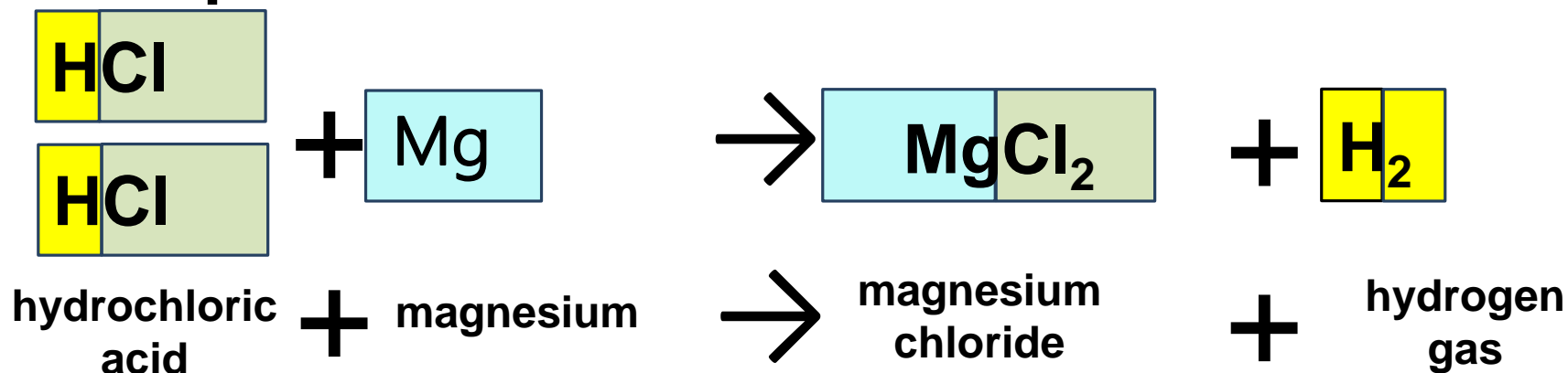
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Extension

Metals react with acids to form a salt and hydrogen gas



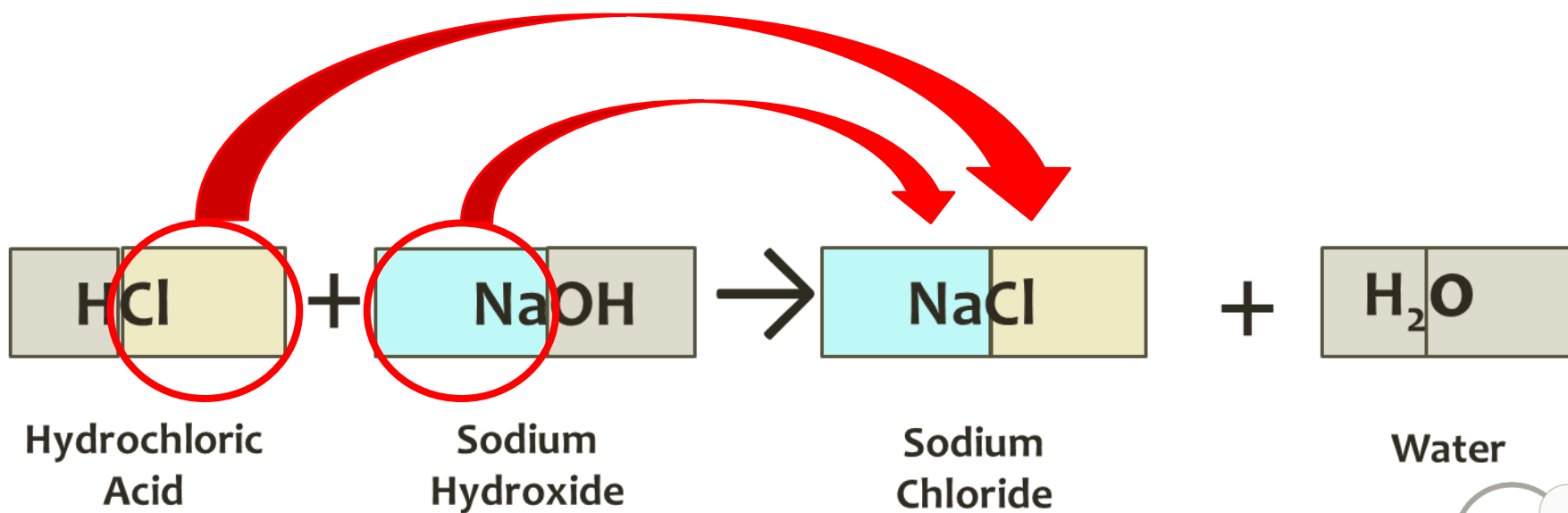
Example



Names of salts

When salts are formed the name depends upon the acid reacted and the metal that forms part of the base compound.

Name of acid	Name of salt formed
Hydrochloric acid	chloride
Sulfuric acid	sulfate
Nitric acid	nitrate



Acid reactions summary



1. Acid and Base

General equation acid + base → salt + water

Word equation nitric acid + copper oxide → copper nitrate + water

Formula equation $2\text{HNO}_3 + \text{CuO} \rightarrow \text{Cu}(\text{NO}_3)_2 + \text{H}_2\text{O}$

2. Acid and Metal Carbonate

General equation acid + metal carbonate → salt + water + carbon dioxide

Word equation hydrochloric acid + magnesium carbonate → magnesium chloride + water + carbon dioxide

Formula equation $2\text{HCl} + \text{MgCO}_3 \rightarrow \text{MgCl}_2 + \text{H}_2\text{O} + \text{CO}_2$

3. Acid and metal

General equation acid + metal → salt + hydrogen gas

Word equation nitric acid + copper → copper nitrate + hydrogen gas

Formula equation $2\text{HNO}_3 + \text{Cu} \rightarrow \text{Cu}(\text{NO}_3)_2 + \text{H}_2$