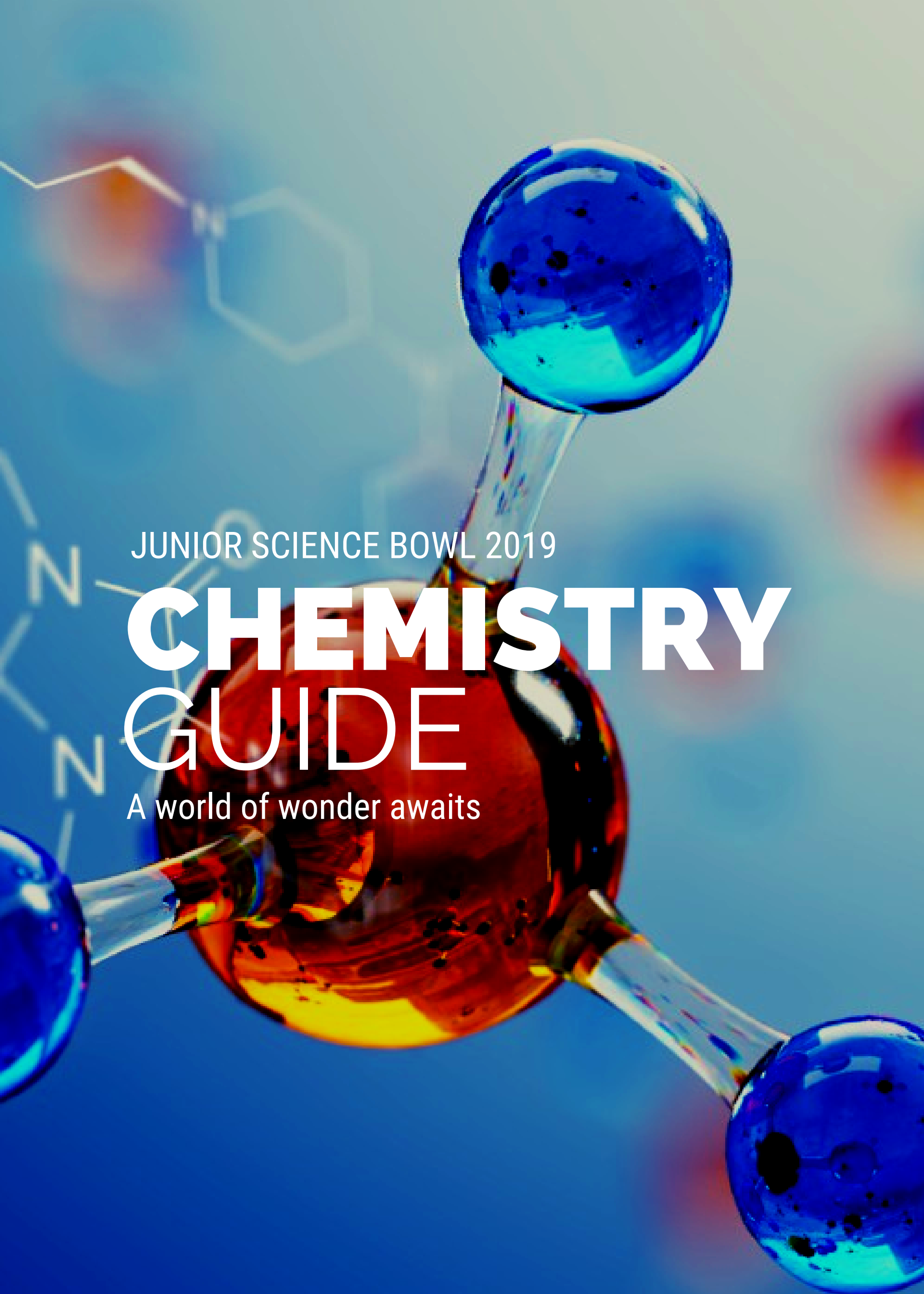


JUNIOR SCIENCE BOWL 2019

CHEMISTRY GUIDE

A world of wonder awaits

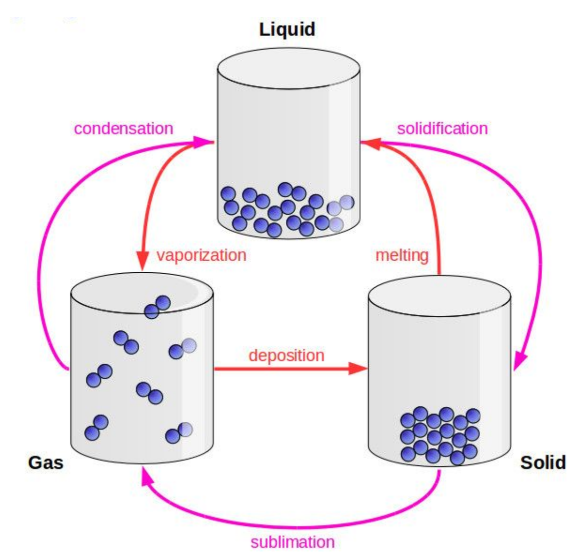
Introduction

Chemistry is defined as the study of matter; the building block of the universe. The interaction of matter's three different states, solid, liquid, and gas, is what allows everything around us to happen. Chemical reactions and the transfer of energy happens to each and every one of us every day of our lives. These reactions and transferals are what created and allow the universe to progress. Almost every aspect and activity in our lives can be traced back to chemistry.

Matter

Matter is consistently defined as anything taking up space. It exists in 3 different states solid, liquid, gas. We make the distinction between states of matter based on the strength between their particles which gives them their properties. In a lab environment we refer to different types of matter as **substances**

- **States of matter**
  - **Solid**
    Solids have nearly twice the attraction force between particles as the next strongest, liquid. Solids have a **definite shape and volume of the** particles have a tight unrelenting binding to each other
  - **Liquid**
    Liquids have far more space between their particles than solids do due to a much weaker attraction force; yet they have just enough attraction to maintain a definite volume. **Liquids have a definite volume**, but allowing them to take the shape of the container they are in
  - **Gas**
    Gas has by far the weakest attraction force between particles far less than liquid. This gives them **no definite shape** like a liquid but also **no definite volume**, the particles are so far gone from one another that they will completely fill the container they are put in



Conversions of matter

- **Solid to gas**
  Sublimation occurs when a solid absorbs so much heat it skips the intermediate liquid phase becoming a gas instantaneously. Snow and ice can sublime but only under extreme pressure in a 0 degree celsius environment
  Dry ice subliming in air depicted to the right.

- **Solid to liquid**
  Melting occurs when an object absorbs enough heat to undergo for tis particles to just barely separate from each other. Ice melts at 0 degrees celsius and above

- **Liquid to solid**
  Solidification, more commonly known as freezing occurs when the pressure of low temperatures push particles close enough to maintain attraction. Water freezes at 0 degrees celsius and below

- **Liquid to gas**
  Vaporization occurs when a liquid is exposed to so much heat the particles zoom past away from each other and collide rather than slide by each other becoming a gas not a liquid. Water evaporates at 100 degrees celsius

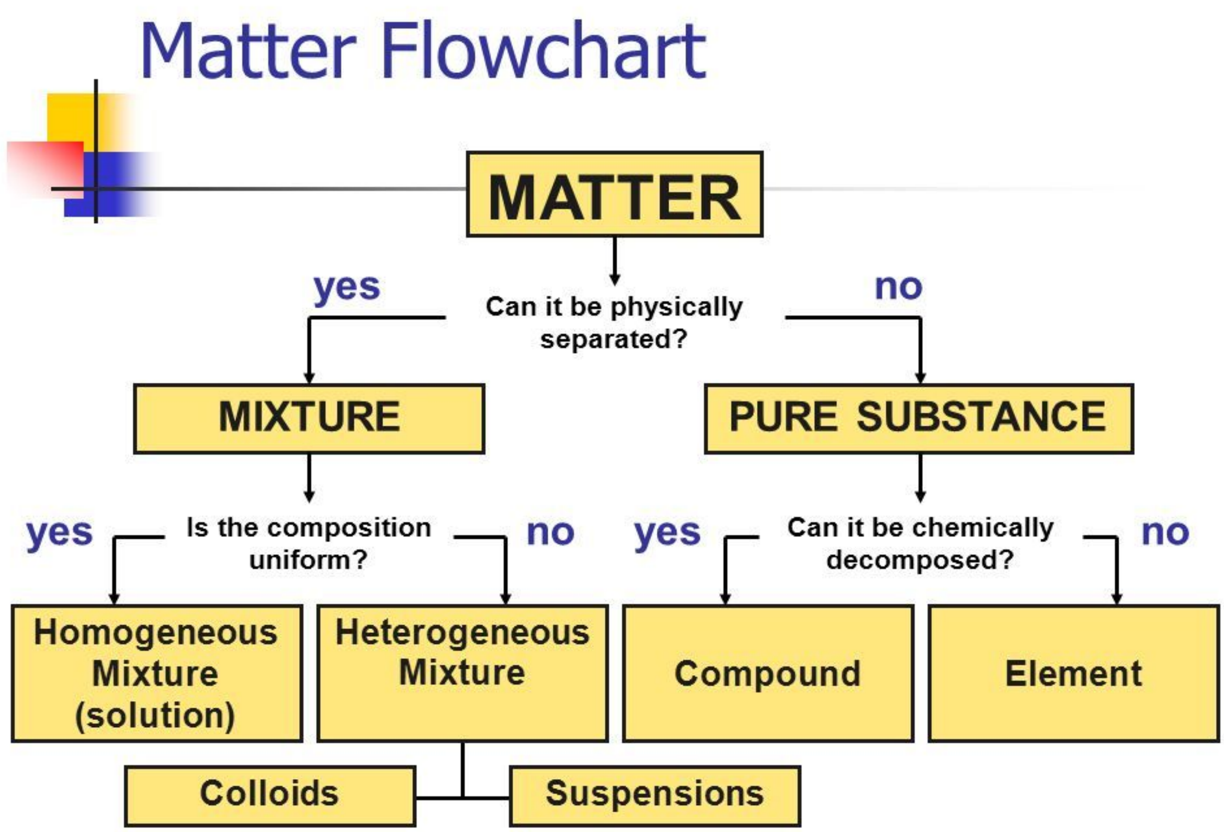
- **Gas to liquid**
  Condensation occurs when the high speed particles of a gas slowly have heat drawn out from them, slowing them down, increasing attraction and lowering space between particles creating a liquid. Water vapor condenses at any temperature between 0 and 100 degrees celsius given the pressure surrounding the gas

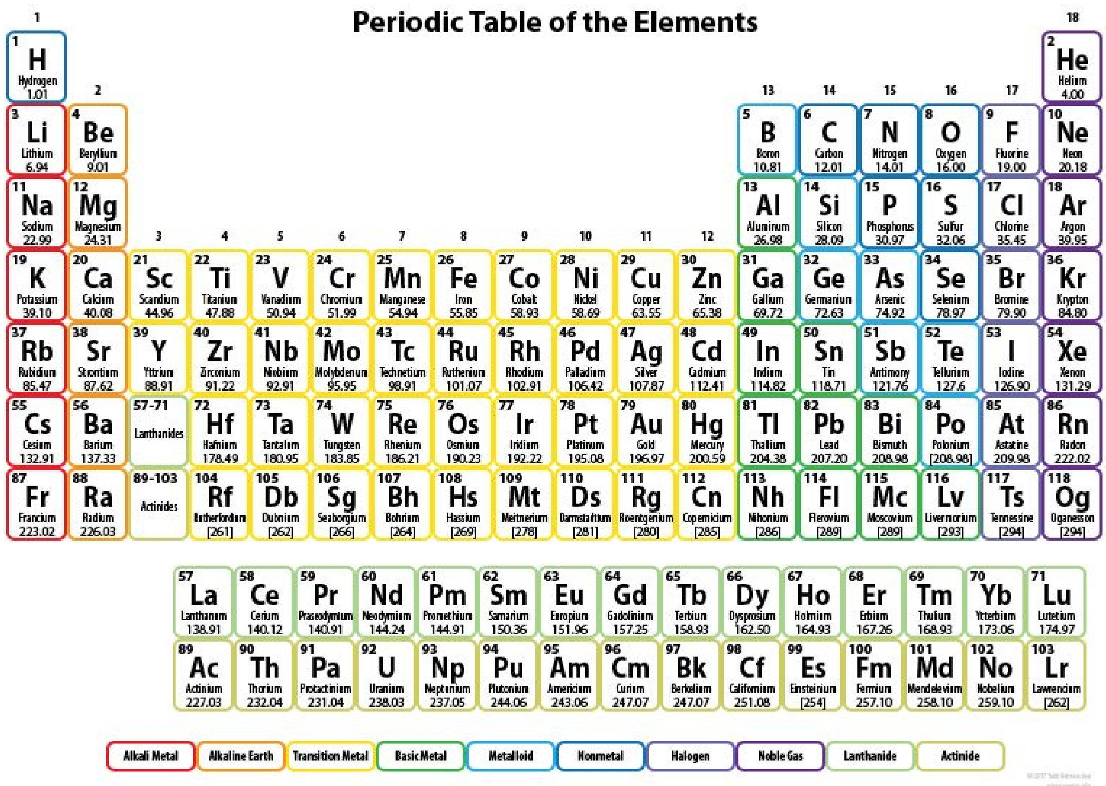
sciencebowl

- **Gas to solid**
  At very low pressures with an astounding pressure gas can simply turn to a solid through deposition; it would never become a liquid. Imagine water vapour in the air turning into a chunk of ice or snow and hitting the ground, sound familiar? Deposition is the chemical reaction taking place within a cloud

How else do we classify matter

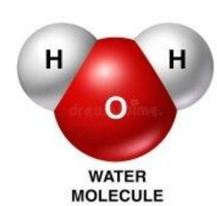
Solids, liquids, and gases all have different attractions between the particles that make them up, however we can also classify matter based on what particles they are made up of. Matters make up is also known as its **composition**





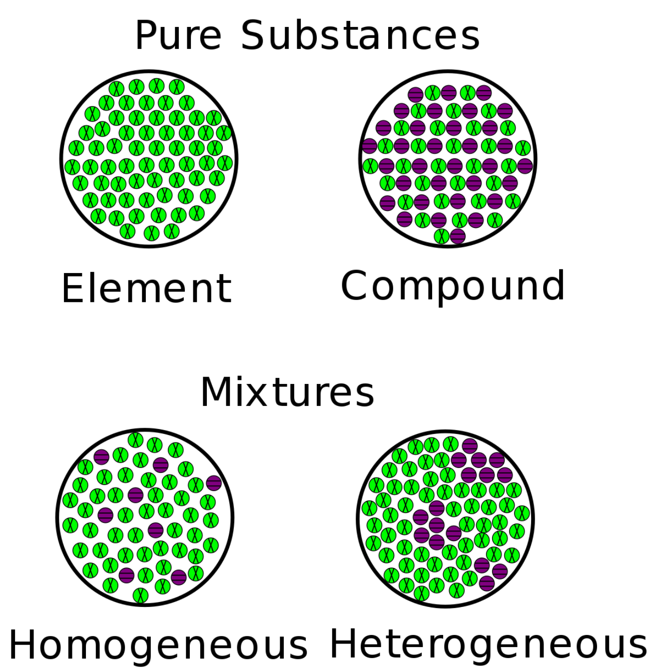
Matter that cannot be physically separated with any conventional methods means it is a pure substance. This means we can find every part that makes up the pure substance on a periodic table and that is its entire composition

Every part of a pure substance can be found above. These parts are more commonly known as elements and the thing above is commonly called the periodic table. **Elements** are as previously stated, the things making up the periodic table, and they are also particles making up pure substances. Any matter made up of one element is classified as an element, anyobject made up of two or more particles is a **compound**. A block of gold would be an element since all particles in a solid are the same type, a gold particle. Water is a compound since it is made up of two types of elements and nothing else, hydrogen and oxygen. The image on the right shows a water particle (more professionally known as a molecule) containing one oxygen and two hydrogen atoms. These three atoms are physically



attached to each other they are bonded. Atoms of elements from the periodic table bond and give us compounds. Another example would eb sodium chloride, table salt, which has one sodium and one chlorine particle physically connected together. A mixture has particles not attached to each other.

Mixtures are things containing multiple particles of different elements and compounds that aren't bonded or attached to one another. **Homogenous mixtures** are mixtures that look uniform, as though they contain one part only, when in reality they are a mixture, containing multiple parts. Homogeneous mixtures cannot be filtered into their seperate parts. Examples include, salt water, vinegar, corn oil, steel, and air as well, since the air we breathe as oxygen as well as unbonded argon helium, hydrogen, and nitrogen.**Suspensions** are mixtures that look different, as in, you are able to see the different parts making up the mixture. Examples include, trail mix, oil in water, sandy water; anything that has visibly different parts and can be filtered. A **colloid** is a heterogeneous mixture that looks uniform and might seem like a homogeneous mixture. An example includes milk; milk looks uniform, but put it under a microscope and you can calcium and fat particles unbonded



Properties of Matter

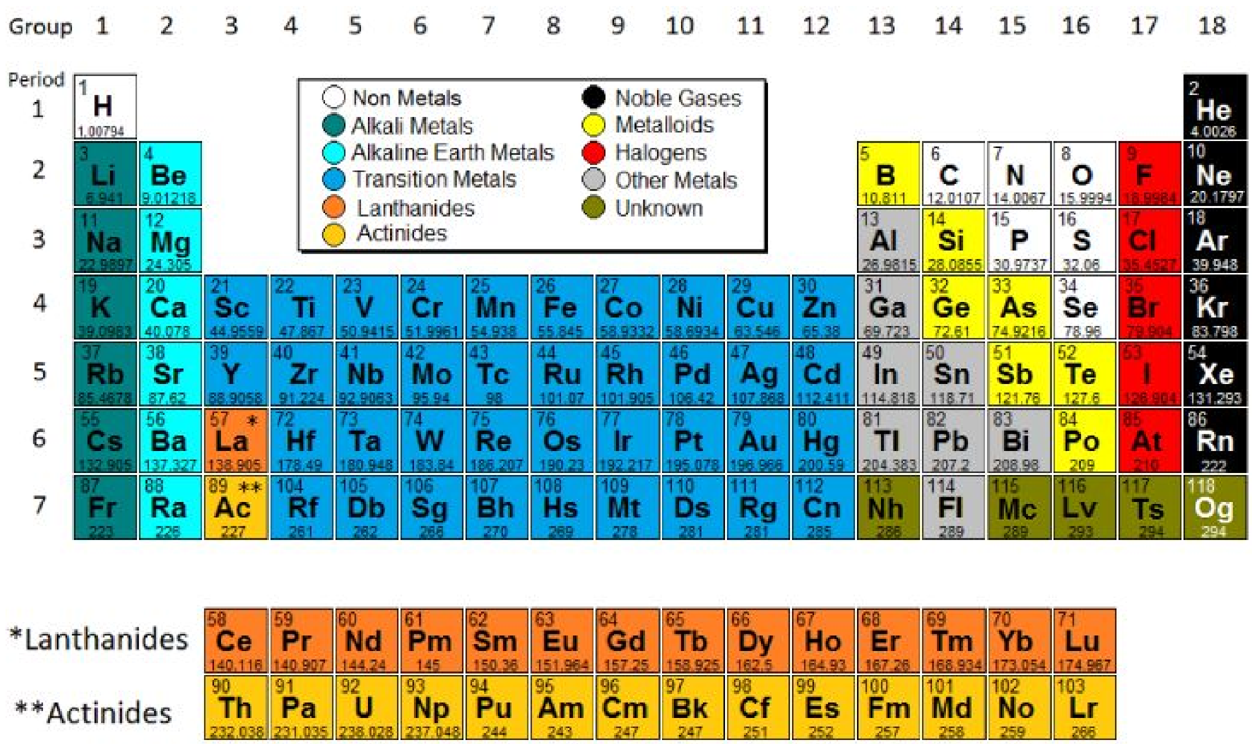
Finally, our last classification of matter, properties. There are two types of properties of matter, physical, and chemical

- **Physical** properties regard a substance's composition (what the matter is made of). These can be recorded without altering the matter in anyway. In other words, I don't need to change the substance's composition to measure these things. Physical properties include, boiling point, melting point, malleability, ductility, color, state, solubility, crystal formation, conductivity, and magnetism
- **Chemical** properties regard a substances reactivity to other substances. To measure and observe these properties i would need to alter the substances composition. Examples of this include, a substance's ability to burn, flash point, behaviour in air, reaction in water, reaction with acids, reaction to heat, and reaction to red/blue litmus
- All of these properties are derived from **empirical observations,** date found from observations and experiments. These observations are either **qualitative,** meaning they are about a substance's quality and are found with the five senses, or they are **quantitative** meaning the observation can be assigned a number value. Example of both include, color, taste, length, height, area, sound it makes, weight. Anything u can see, taste, touch, hear or smell is an empirical observation. An example of an observation that isn't empirical is "each particle of the water had three atoms, two hydrogen, one oxygen". An excellent inference, not an observation, because you cant see how many atoms that water has.

Chemical reactions

- Almost every single process or action in the entire universe (even the bing bang) is either a chemical reaction, or requires a chemical reaction take place. Even you reading this page is a chemical reaction of your body expending protein to move your eyes
- Whenever a substance changes into another substance, a chemical reaction occurs.
- There are five pieces of evidence for a chemical reaction
    - Change in odor (scent of something burning)
    - Change in color (food coloring)
    - Change in temperature
        - Endothermic absorbs heat (baking cookies)

        - Exothermic releases heat (the big bang)
    - Formation of gas (smoke)
    - Formation of precipitate (bubbles)
- Physical changes regard changes to physical properties and chemical changes regard changes or chemical properties
- If two or more of the five pieces of evidence are present after a test on substance, a chemical reaction has occurred as opposed to a physical one

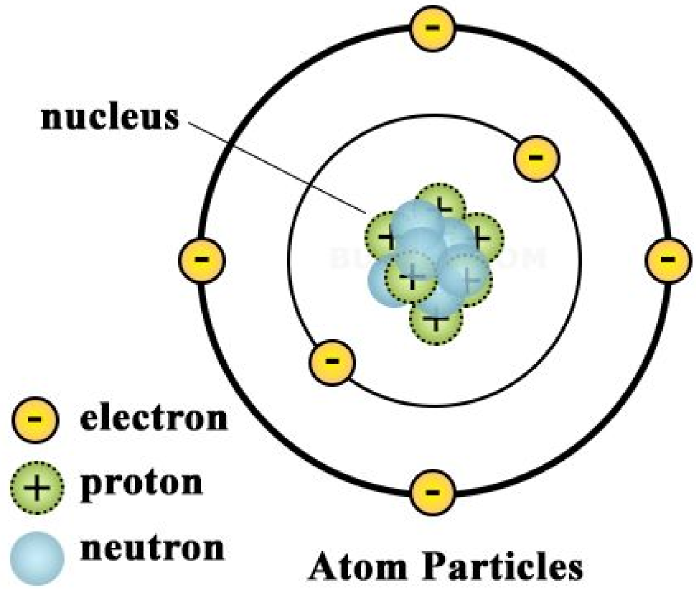


The Periodic table of Elements

The periodic table is a record of physical and chemical properties of all matter in the universe. It is remarkably simple to interpret its layout, this layout is known as periodicity.

- First off, u may have noticed this copy of the table is color coded, this is in order to explain families of elements in the table. We will be looking at the 4 major families.
    - **Alkali metals (turquoise)-** Going left to right, the first family are the alkali metals, they are soft, shiny, silver metals and dangerously reactive with water (as in if you throw sodium in a lake it explodes)
    - **Alkali Earth Metals (light blue)-** The second family are also shiny and silver but not as soft

    - **Halogens (red)-** highly poisonous on its own, also forms salts readily with alkali metals
    - **Noble gases (black)-** full valence shell makes them highly unreactive
- Columns as we've stated are families, and every element in that column have similar chemical and physical properties. Another thing they have in common, is their valence electrons.
- In case you aren't familiar, every atom in the universe is made up of protons neutrons and electrons. These subatomic particles are present in every atom of every element.



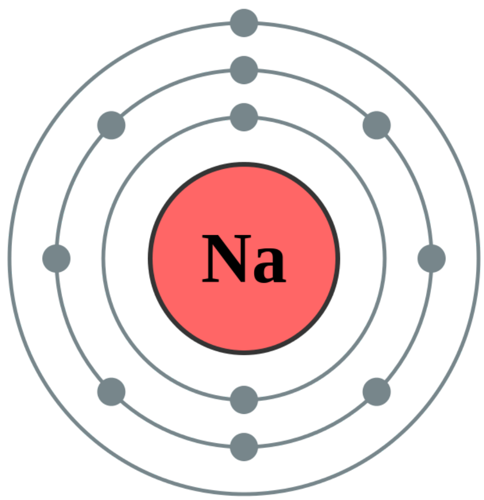
    - A proton is a positively charged particle
    - A neutron has no charge (think neutral)
    - And an electron has a negative charge
    - The neutron and proton are the centre of a tom and are called the nucleus. This is the densest heaviest part of the atom
    - The electrons orbit the outside of an atom and have next to know weight. Electrons are similar to our hair, the outermost part of our body covering it almost entirely, yet it weighs essentially nothing at all
- Additionally atoms can gain and lose electrons, this will be the final topic you will learn from this guide.

Ions

An ion is a charged atom by definition. This is to say it has either a negative or positive charge. All atoms are neutral in charge, for example, a sodium atom has an atomic number of 11. This means it has 11 electrons and 11 protons. That rule applies for every element on the table. Oxygen has 8 protons 8 electrons, fluorine has 9 and 9 etc. however, every atom can lose and gain electrons, this is how ions are created. Atoms that lose electrons and have more protons have a positive charge, and atoms that gain electrons and have less protons have a negative charge

- cations give away electrons and become more positive and are metals
- Anions gain electrons to become more negative and are non metals

So how do we know which atoms give up electrons and which ones gain electrons? We know based on what the periodic table tells us.certain atoms have a tendency to give up electrons and certain atoms like to gain them. Additionally where do cations give away electrons? And where do anions get additional ones from? Well from each other. Before getting into that lets look at valence electrons and shells.

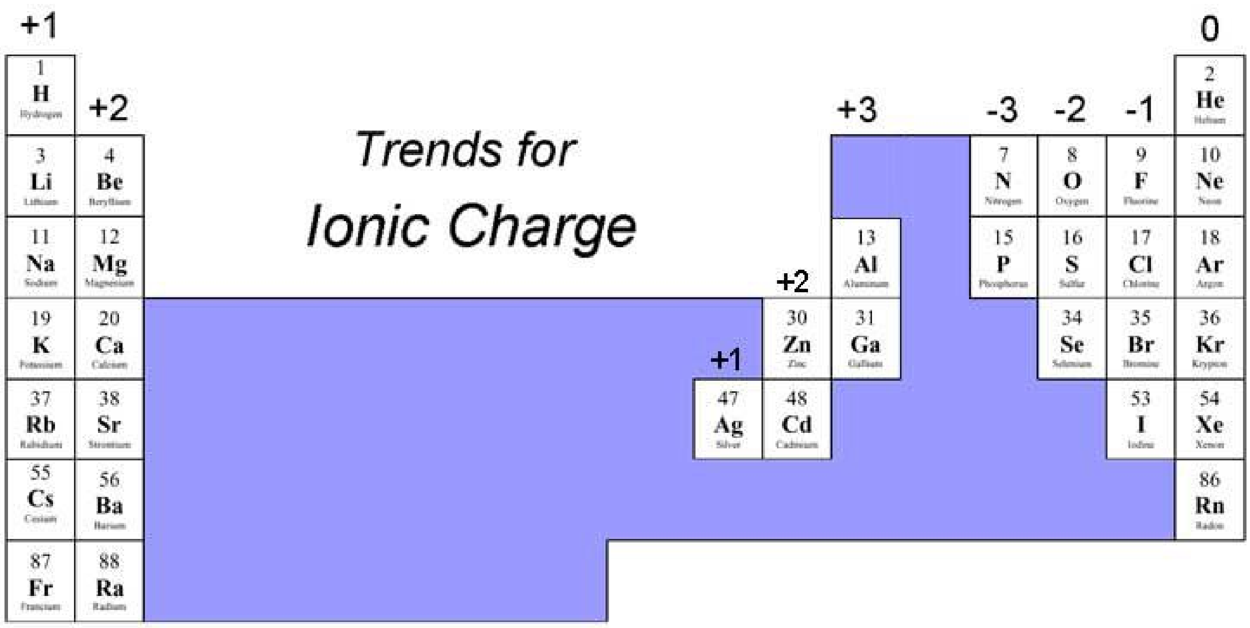


This is a lewis dot diagram of a sodium atom (not an ion). It has 11 electrons for 11 protons to make that neutral charge. You may have noticed the electrons are spread into different levels. 3 levels to be exact. If you'll look at the periodic table a few pages ago, Na is on the third row of the periodic table, coincidence? Not at all. Rows are called periods on the table just as columns are families. Every element in the same row has the same number of levels to hold electrons. We commonly call these levels electron shells. And each electron shell has a certain maximum capacity of electrons before moving to another level.

- The first level closest to the middle or (nucleus) of the atom can hold 2 electrons
- The second level holds 8
- The third level holds 8 as well
- The fourth level with 18
- And every level afterwards holds 18 as well

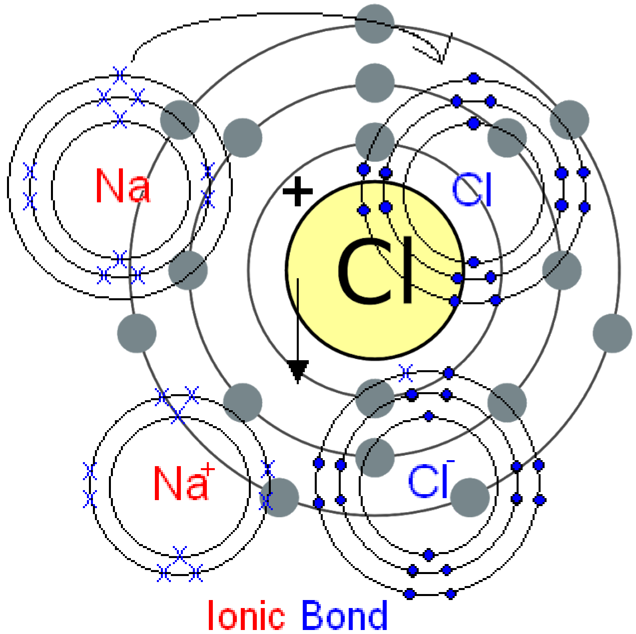
Next up, you may have noticed that there is only one electron on sodiums outermost shell. That shell is known as its valence shell. And that electron is its valence electron. Every atom wants to have a full valence shell and will either lose or gain electrons to do that. Imagine if the sodium atom picture above lost an atom, it outermost one. That third level would cease to exist and its second level is already full with 8 electrons so the sodium ion would have achieved stasis.

Just like how the rows tell us the number of electron shells all elements in that row have, the columns tell us the number of valence electrons every element in that family has. Sodium has one but so do all the other alkali metals. Observe the image below.



- Alkalis have one valence electron
- Alkali earths have two
- Halogens have 8 -1 so 7
- And the noble gases have a full shell
- Additionally, metals closer to the bottom like francium are more likely to give away electrons than sodium due to having a weaker grasp on electrons, the opposite is true for non metals

Let's look at one more example. Chlorine has three levels as it is in the same period as sodium, and has 7 valence electrons because it is in the 17th row. Would it be easier for chlorine to lose 7 electrons or gain one to have a full outermost shell? Obviously gain one which is why it is likely to bond with any atom with one valence electron.



Ionic compounds

Now that you know how and why anions and cations give away electrons, let's look at the bonding process. Ionic bonds occur when electrons are transferred from one atom to another, they require on cation and one anion, or in other words one metal and one non metal. Additionally all ionic compounds are always always neutral, there is never an exception to this rule. Which means that the charges of the ions must balance.

For an example let's look at aluminum chloride,

- Aluminum has a 3+ charge
- Chlorine has a -1 charge
- Tis means if we wanted to bond chlorine with aluminum, we would need not one chlorine atom, but 3
- 3 x (-1)= -3 and obviously negative three counteracts aluminums positive three making it neutral
- We would write this symbolically as $AlCl_3$ (three chlorines so we write it as a subscript at the bottom of the chlorine symbol)

sciencebowl

Naming ionic compounds

We name ionic compounds simply by writing the metal or cation first, then nonmetal or anion second (think left to right just as the elements appear on the periodic table)
However we simply change the ending of the non metal to -ide

1. Find the cation (sodium)
2. Find anion (chlorine)
3. Right out in proper order (sodium chlorine)
4. Change ending to ide (sodium chloride)