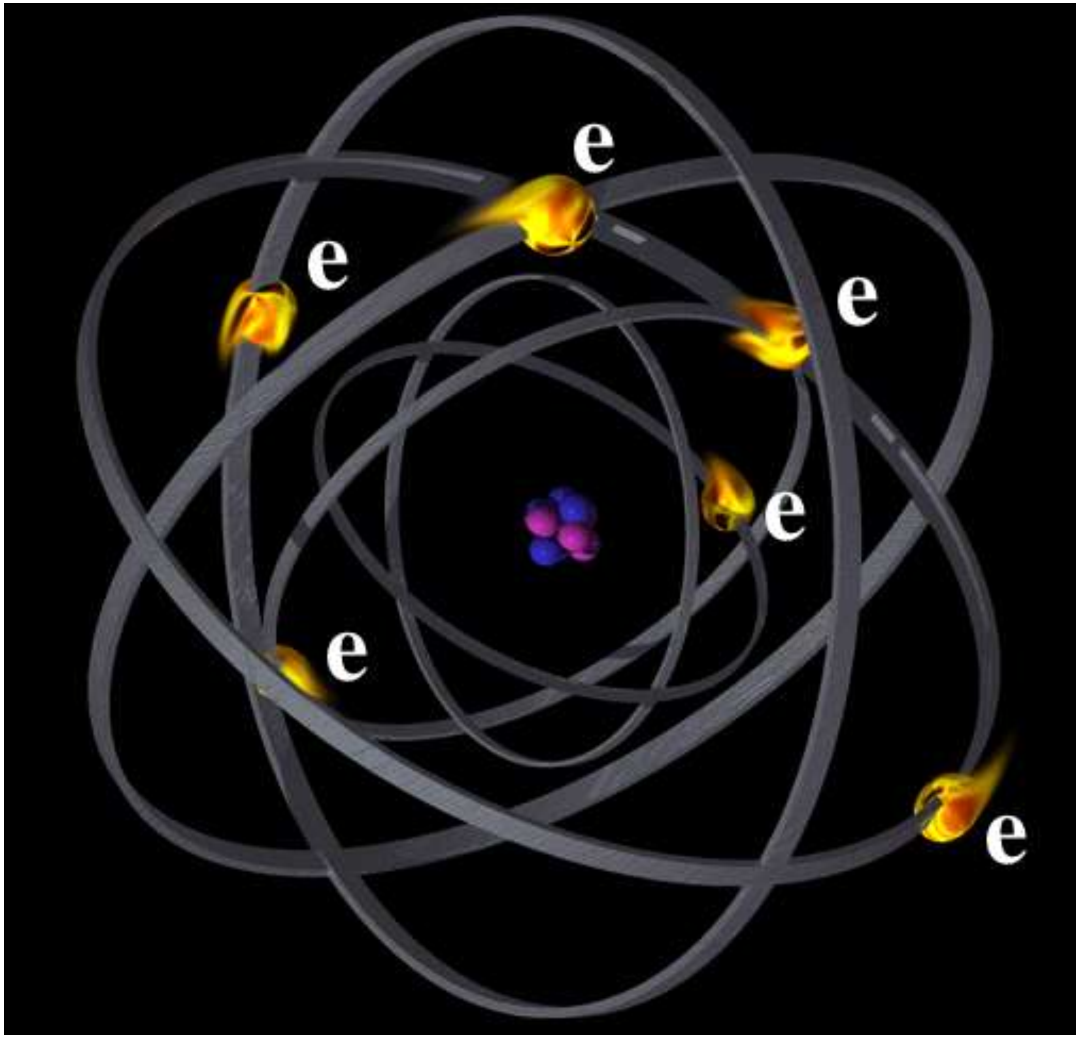
Section 3.1 – Matter, Elements, & Atoms



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What is Matter?

- Matter is anything that has volume and mass.
- Everything in the world is made up of matter.
- On Earth, matter usually occurs as a solid, a liquid, or a gas.

Elements

- All matter is composed of substances called elements.

- An element is a substance that cannot be broken down into simpler substances by physical or chemical means.

- There are 92 naturally occurring elements in the Earth and stars.

Elements and the Periodic Table

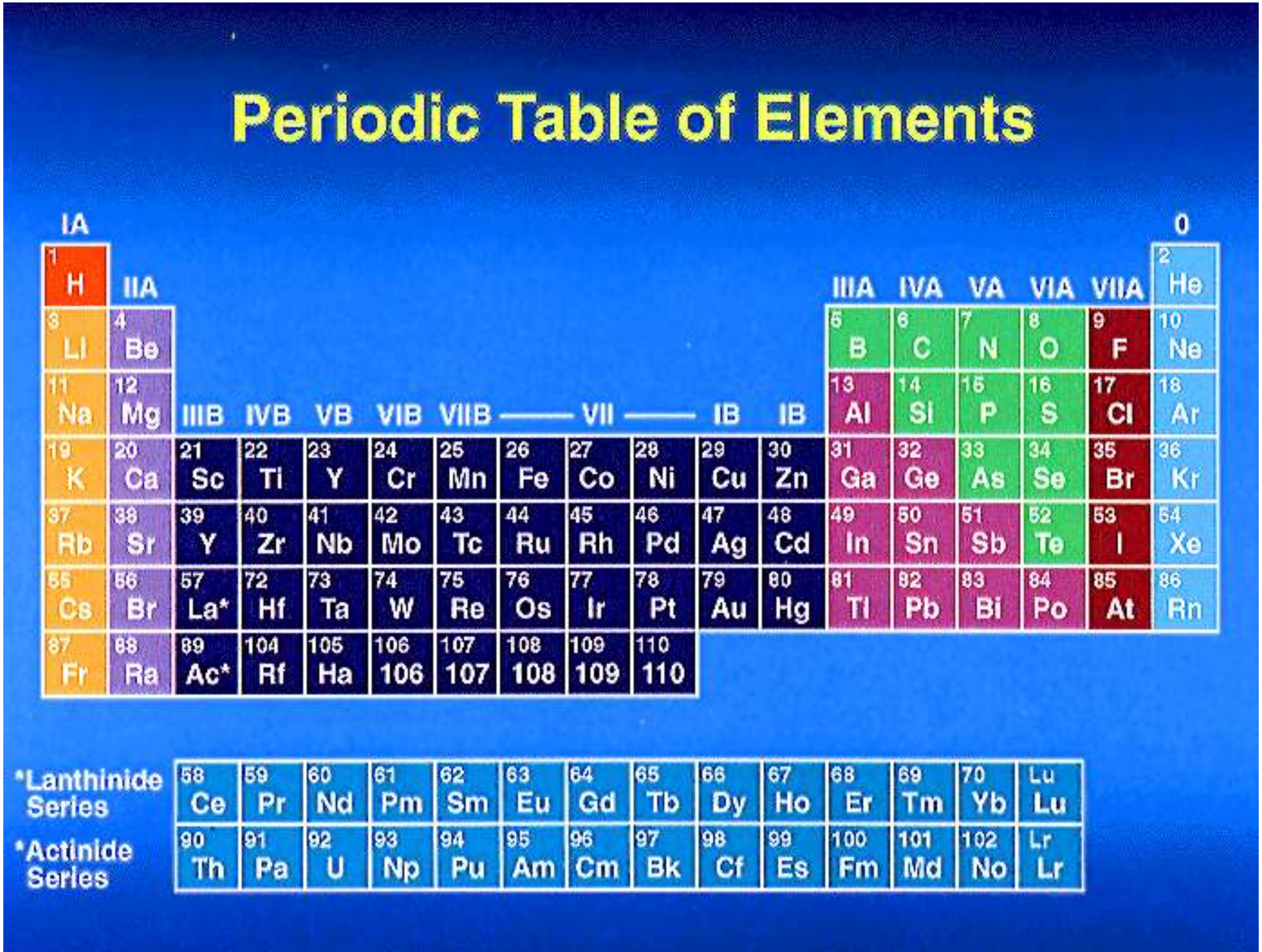
- Each element has a 1,2, or 3 letter chemical symbol.

- You need to learn these! Quiz -

Elements and the Periodic Table

- All elements are classified and arranged according to their chemical properties on the periodic table.

The Periodic Table



Atoms

- Each element is made up of the same type of atoms.

- All atoms are made up of 3 subatomic particles.
  - Protons (+) in the nucleus
  - Neutrons (0) in the nucleus
  - Electrons (-) around the outside

- The amount and arrangement of these subatomic particles make each atom unique and give the elements their characteristics.

Tour of the Periodic Table

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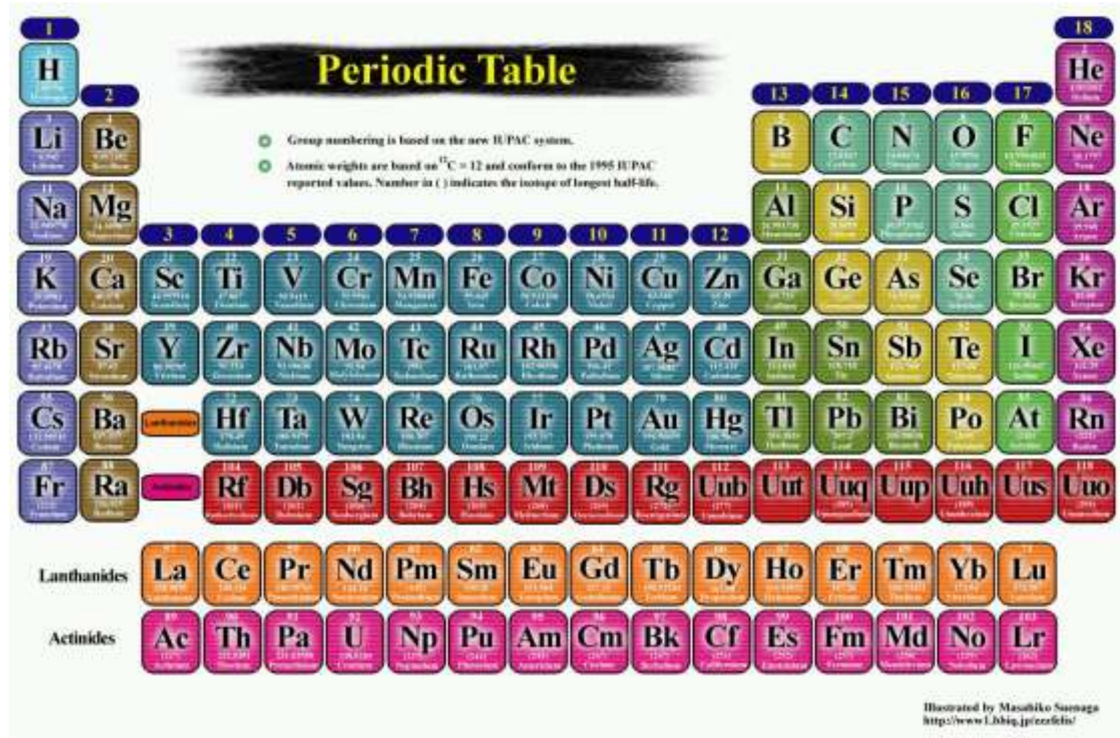
I am Dmitri Mendeleev!



I made the PERIODIC TABLE !

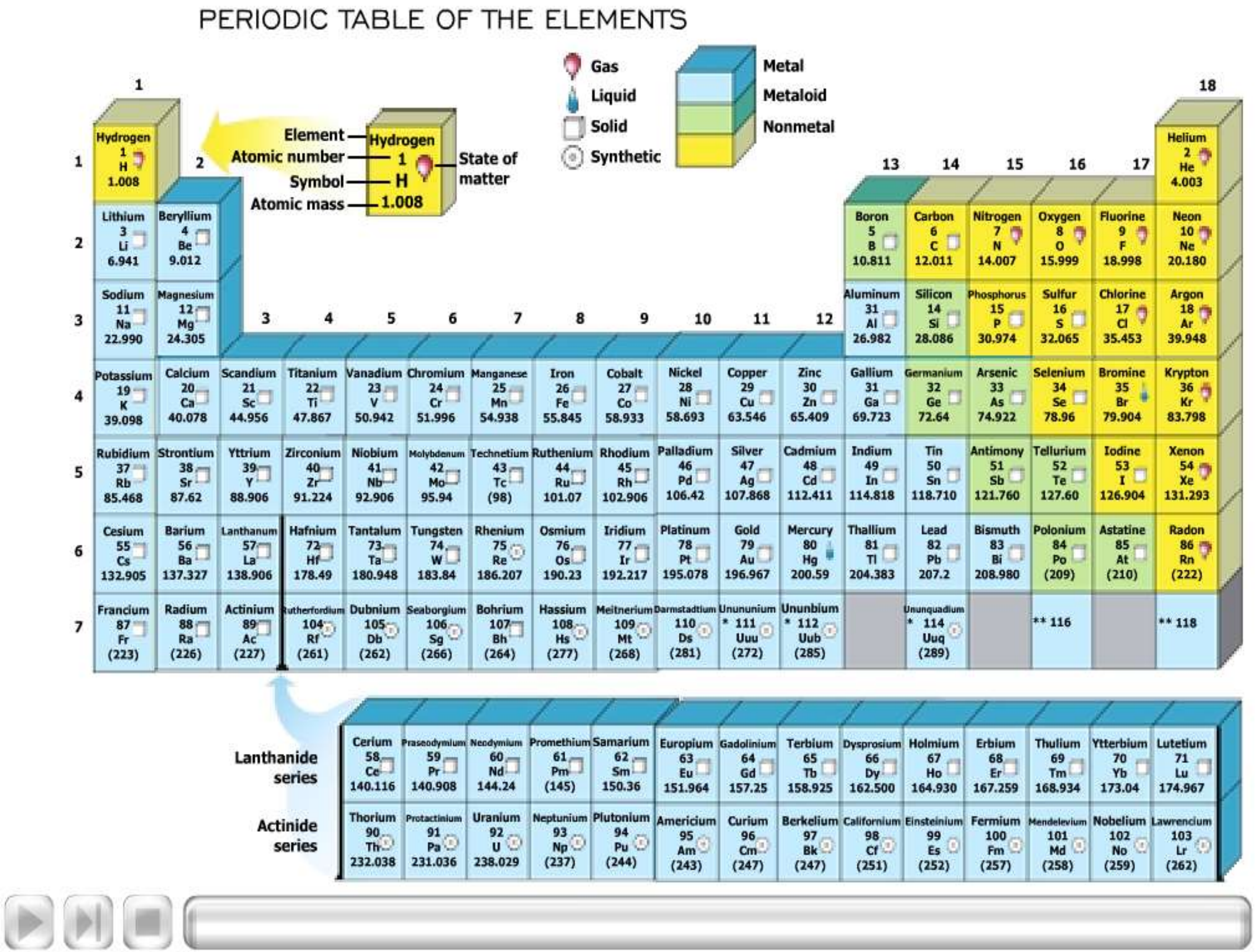
What is the PERIODIC TABLE?

- Shows all known elements in the universe.
- Organizes the elements by chemical properties.

How do you use the Periodic Table to determine what type of substance the element is?

The metals, non-metals, & metalloids are organized in certain places on the Periodic Table.

Color the nonmetals yellow **Color the metalloids green** **Color the metals blue**



What makes an element a nonmetal?

- Poor conductors of heat & electricity
- Dull and brittle
- Less dense than metals
- Lower melting/boiling points than metals

What makes an element a metal?

- Good conductor of heat & electricity
- Shiny, malleable
- More dense than nonmetals
- High boiling points & melting points

What makes an element a metalloid?

- Their properties are in between that of a metal & nonmetal

  - Semi-conductors

  - Some look like metals; some do not

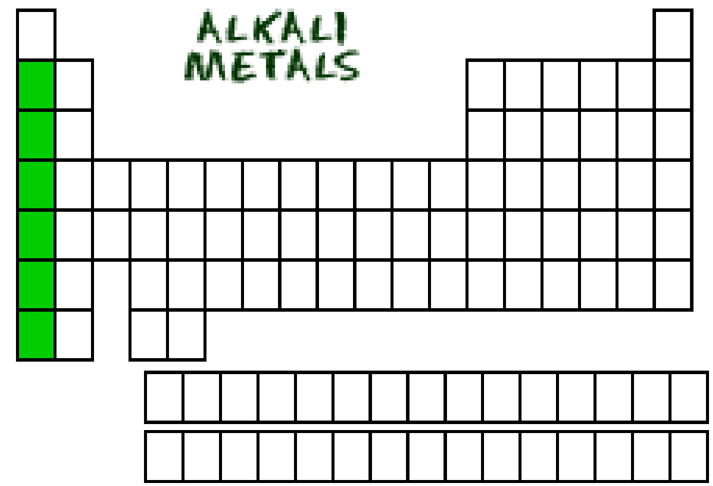
What do the different columns mean?

The Columns are Groups or Families

- Elements with similar chemical properties
- Some groups have special names

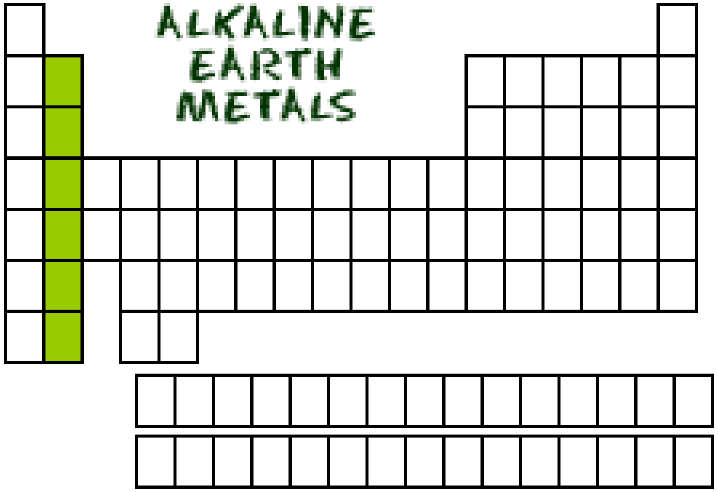
The Alkali Metals
Group 1

- Very reactive
- Cause explosions when mixed with water
- Metals
- Shiny
- Light weight



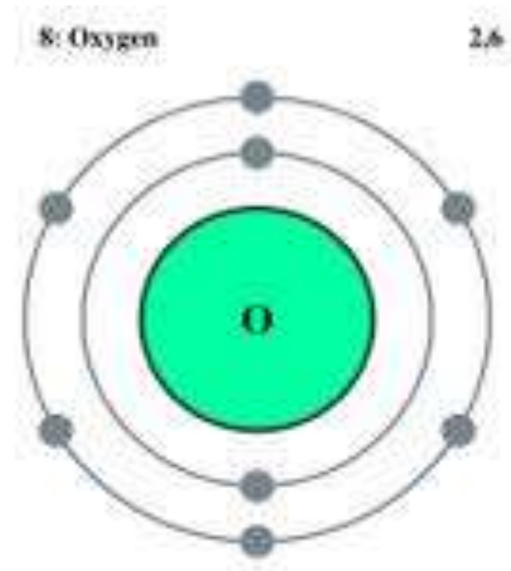
The Alkaline Earth Metals
Group 2

- Reactive, but not quite as much as Group 1
- Metals
- Shiny
- Light weight



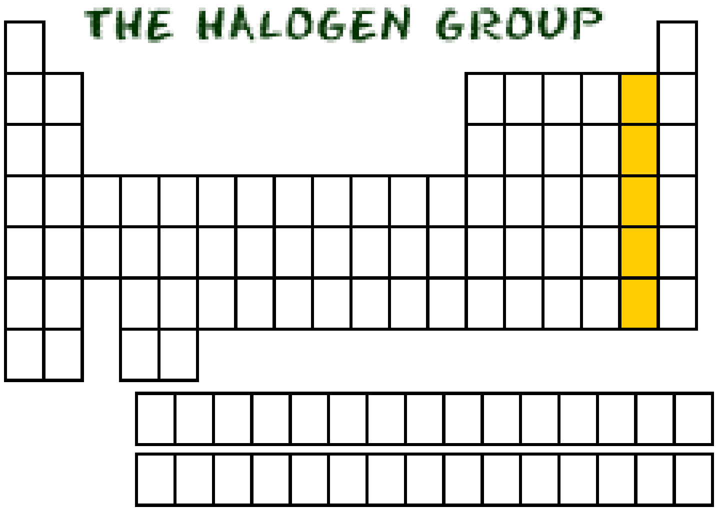
The Alkaline Chalcogens
Group 16

- A.K.A. -the oxygen family
- Mix of metals & metalloids
- Many are found in minerals



The Halogens
Group 17

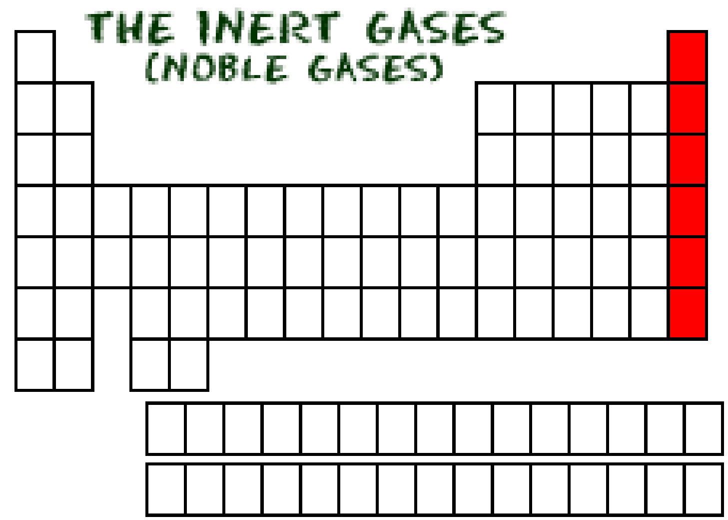
- Often bond with metals from Group 1
- Very reactive
- Often form salts



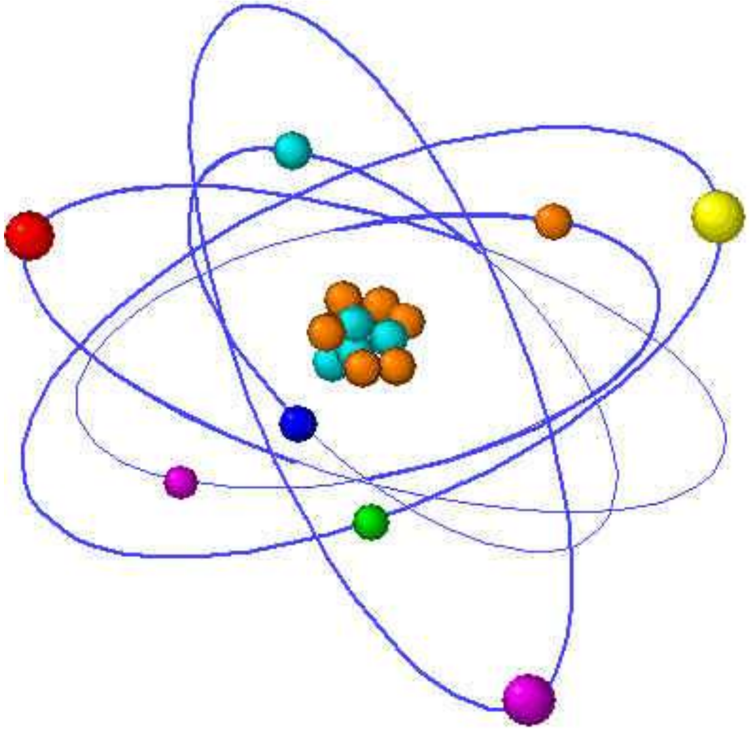
The Inert (Noble) Gases
Group 18

- Rarely react

- As you move down the column, the gases become more rare



Section 3.1 – Atoms & Elements
How to Determine the Structure of Atoms



- Recall that the electrons of the atom is what gives the atom its chemical properties

- The structure of the atom refers to the three subatomic particles – protons, neutrons, & electrons.

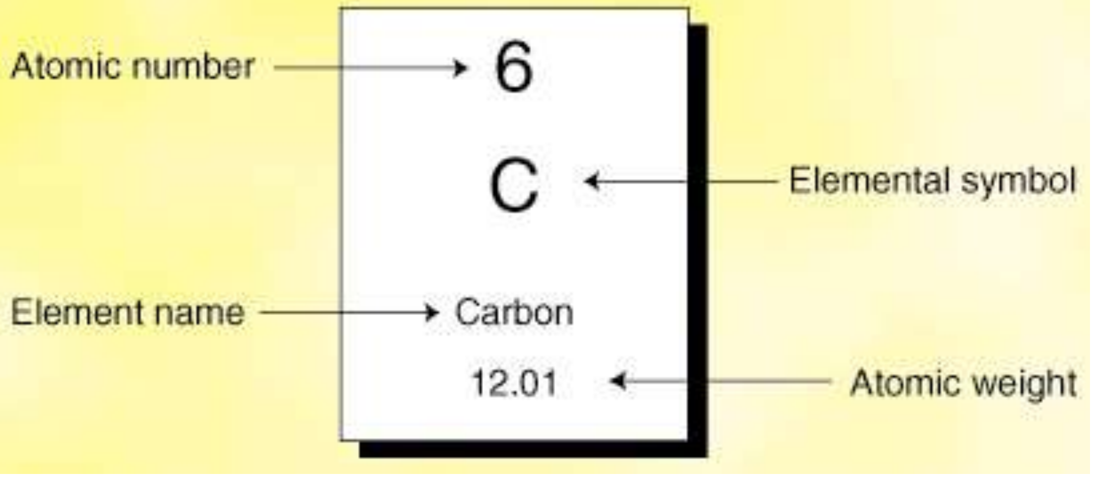
Determining the Structure of Atoms

Steps:

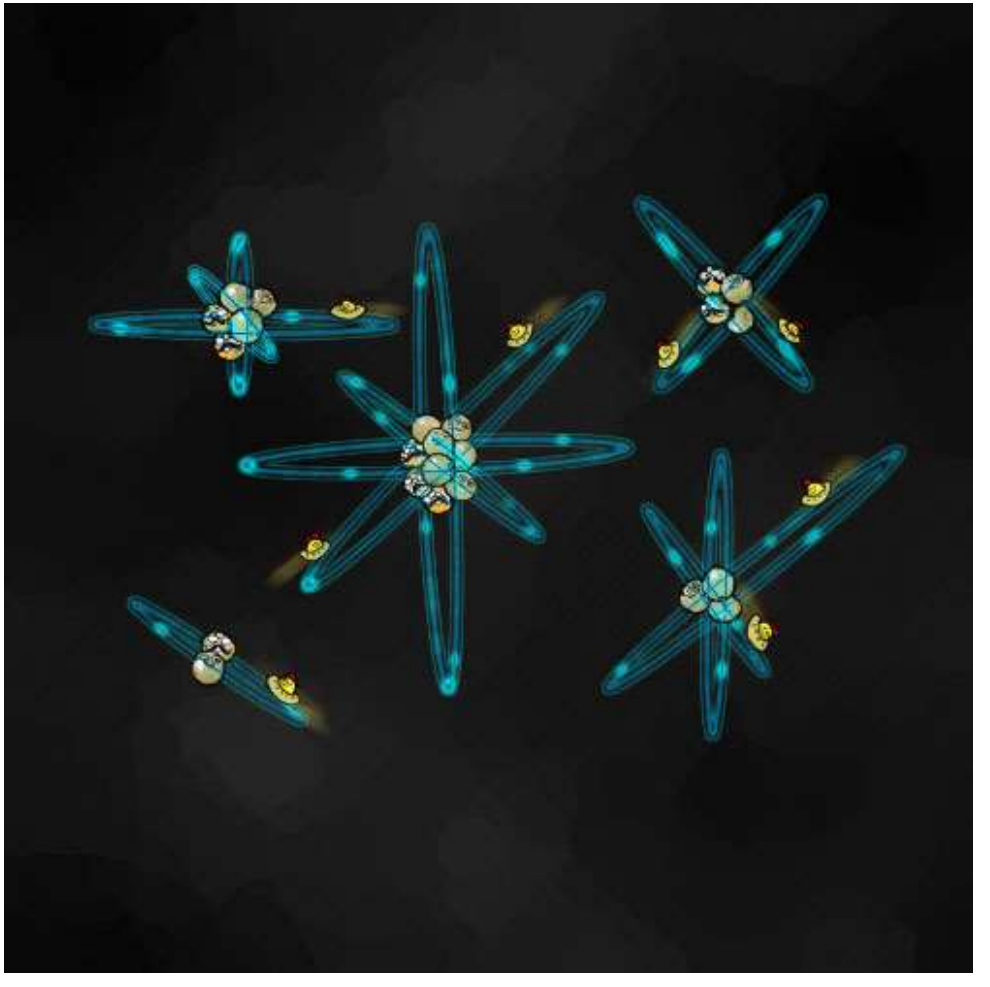
1. Use the atomic number to determine the number of protons and electrons in a neutral atom.
2. Use the atomic mass and the atomic number to determine the number of neutrons.
3. Make adjustments to numbers if dealing with an isotope or ion.

Example

- Draw the carbon atom.
  - Atomic number = # of protons & electrons in an atom of a particular element
  - Atomic weight = Mass of protons + neutrons



Electrons!



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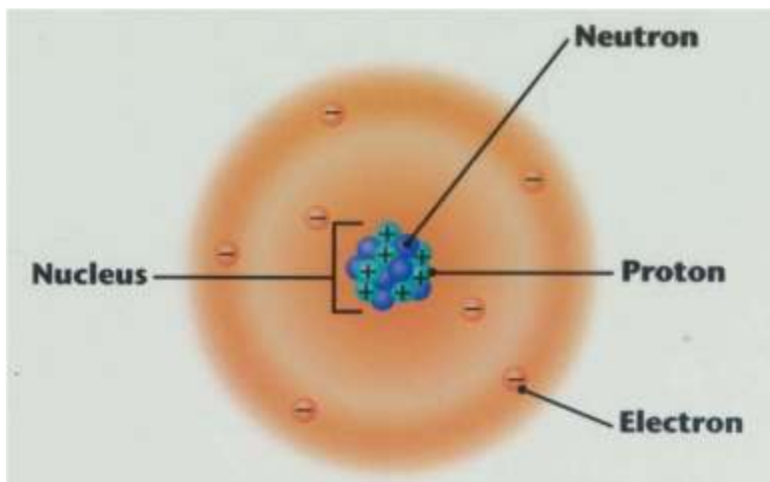
Where are electrons located?

- The exact location of an electron cannot be determined, but the general area it is located in can be estimated. This is called an energy level.



How do you know where the electrons are located?

- Each energy level can only hold a certain number of electrons.

  - The first level can only hold 2.
  - The second level can only hold 8.
  - The third level can only hold 18.
  - The fourth level can only hold 32.

Heisenberg
Uncertainty Principle

Valence Electrons

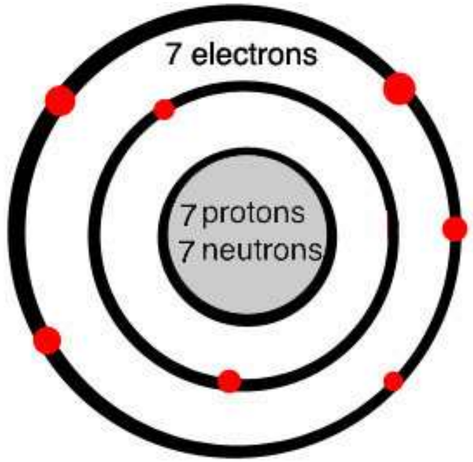
- The outermost energy level that an atom contains is the called the valence.
  - The amount of electrons in this level determine the atom’s chemical behavior.
  - All elements in the same family have the same number of valence electrons!

Drawing Atomic Structures

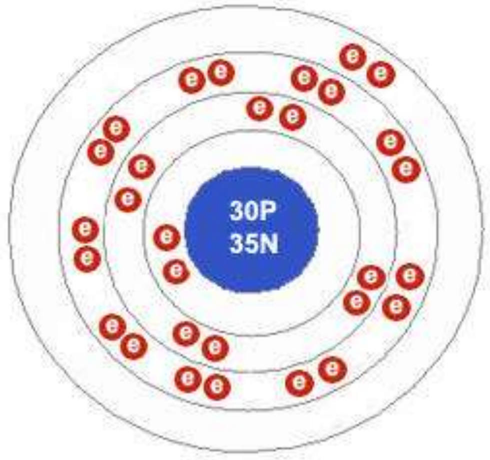
1. Determine the number of protons, electrons, and neutrons in the atom. Record this on your paper.
2. Draw the nucleus and place the protons and neutrons in the nucleus.
3. Place electrons into their proper energy levels. You must fill an energy level completely before you can begin a new one!

Let’s Practice!

- Draw the structure of N.



- Draw the structure of Zn.

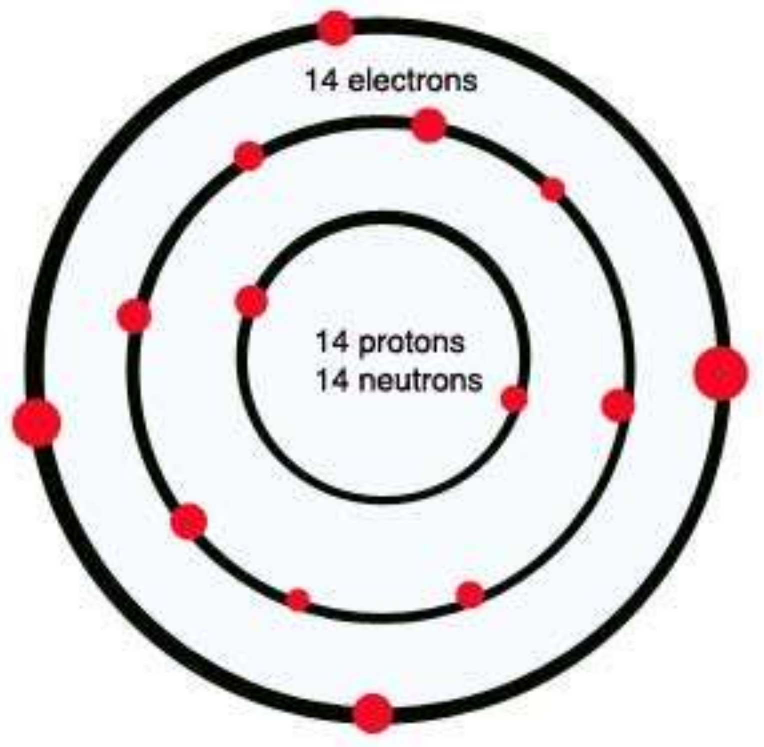


Valence Electrons and Stability

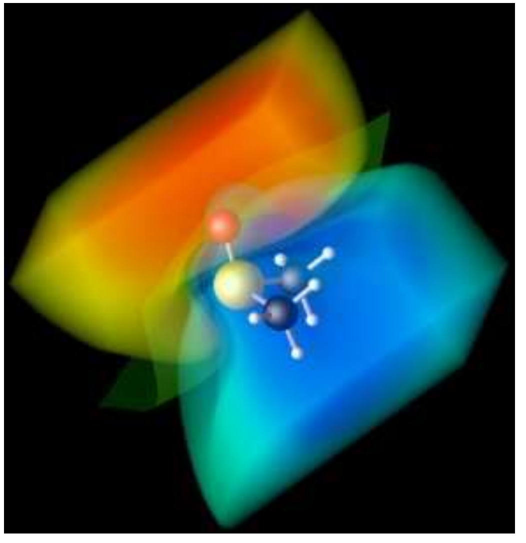
- To be considered “stable” an electron must have a full outer valence.
  - For the first level, 2 is considered a full valence.
  - For all other levels, 8 is considered a full valence.
- If an atom is not stable, it will combine with other atoms to become stable.

Determining Stability

- Draw the structure of Si below. Then determine if it is stable or unstable based on its valence.



How to Determine the Atomic Structure of Isotopes and Ions



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Class Notes

What Is An Isotope?

- *Isotope* – atoms of the same element with different atomic masses

- All atoms of the same element MUST have the same number of protons, however, the number of neutrons may vary.

An Example - Chlorine

- All chlorine atoms must have 17 protons, but chlorine atoms can have 18 or 20 neutrons.

- These are cal 37.

Protons - 17	Protons - 17
Electrons – 17	Electrons – 17
Neutrons – 18	Neutrons – 20

How Do You Know Which Isotope You Have?

- The number at the end of the isotope name is the mass of the isotope.
  - Remember this is equal to the number of protons + neutrons in the atom.

- The mass number you see on the periodic table is actually the average of the mass numbers of the isotopes of an atom.
  - This is why it appears as a decimal!

Steps to Determining the Atomic Structure of an Isotope

1. Use the atomic number to determine the number of protons and electrons in a neutral atom.

2. Use the atomic mass that is attached to the isotope name to determine the number of neutrons in the isotope of the atom.

Let’s Practice!

Determine the atomic structure of Carbon-14.

- Protons: ? (use the atomic number)
- Electrons: ? (use the atomic number)
- Neutrons: ? (use isotope mass – atomic number)

Radioactive Isotopes

- The nuclei of some isotopes are unstable and tend to break down. When they do, the isotope emits energy in the form of radiation.

- There are different types of radioactive decay:
  - A nucleus can lose protons and neutrons.
  - A proton can change to a neutron.
  - A neutron can change to a proton.

- When you change the number of protons in an atom, you change the element!
  - Example: polonium-218 will decay over time to become bismuth-214

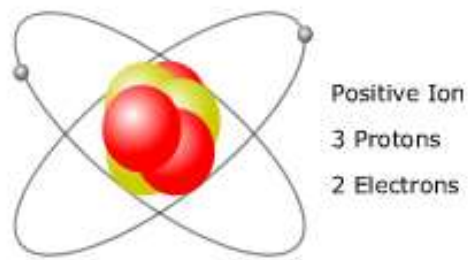
What Is An Ion?

- *Ion* – An atom that has gained or lost an electron or electrons

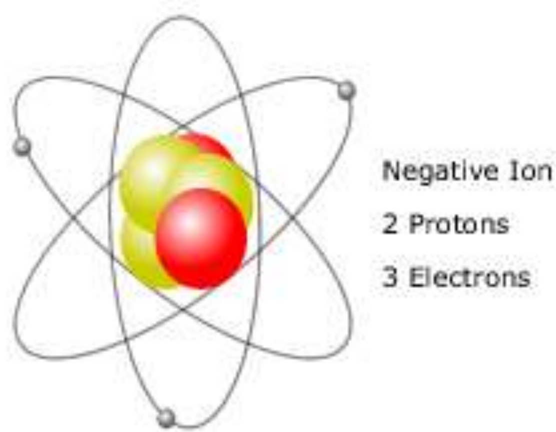
- Why do they do this?
  - To become stable….more on this later.

How Do You Determine the Charge on an Ion?

- Atoms that lose electrons will have a positive char
  - Example:



- Atoms that gain electrons will have a negative char
  - Example: Cl^-



Steps to Determining the Atomic Structure of an Ion

1. Use the atomic number to determine the number of protons and electrons in a neutral atom.

2. Use the (atomic mass – atomic number) to determine the number of neutrons.

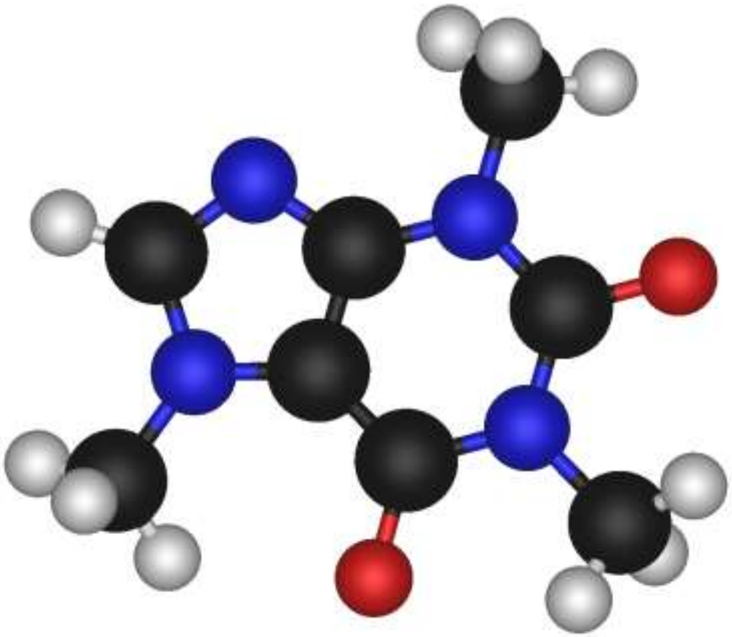
3. Adjust the electron number to make the ion.
   - If an ion is negative, add electrons.
   - If an ion is positive, subtract electrons.

Let's Practice

Determine the atomic structure of Na+.

- Protons: ? (use the atomic number)
- Electrons: ? (use the atomic number, the adjust for charge)
- Neutrons: ? (use atomic mass – atomic number)

Compounds and Bonding



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Class Notes

Objectives:

- Describe the three chemical bonds that unite atoms to form compounds

- Identify components of a chemical equation

What if a substance is not an element?

- Not everything in the world is an element.

- Some substances are made up of two or more elements.

  – Some common examples of these are table salt, water, and sugar.

Compounds

- *Compounds* – substance composed of two or more atoms chemically combined

- Compounds have different properties from the individual elements that make them.
  - Example: Water is made up of two gases (hydrogen and oxygen), yet water is a liquid!

Chemical Formulas

- ***Chemical formulas* – represent compounds**
  - *Example*: H_2O
    - Each element is represented by its symbol
    - Subscripts tell you how many atoms of that element are in the compound

Example Compounds and Formulas

Table Salt
NaCl

Sugar
C6H12O6

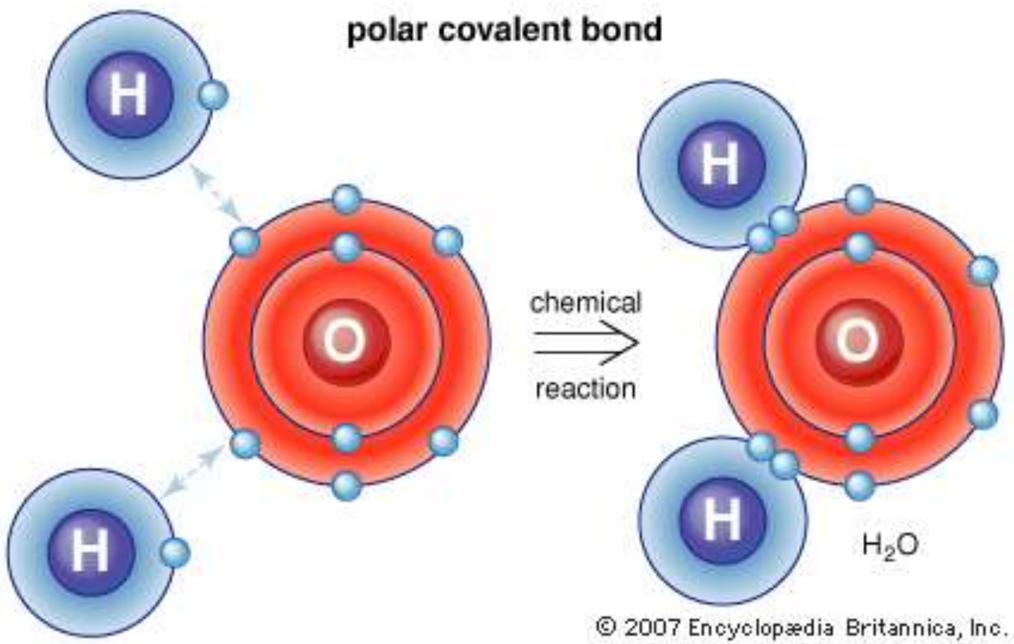
Chemical Bonds

- Remember that an atom is stable when its valence is full.
- When an atom does not have a full valence it can create one by joining with other atoms to make a chemical bond.
- Chemical bonds are what holds compounds together.

Covalent Bonds

- *Covalent bonds* – bond created when two atoms share electrons
- Atoms that are held together by covalent bonds are called molecules.
- The overall charge of a molecule is always zero.
- Covalent compounds –
  - generally have a lower melting point than ionic compounds.
  - Many are not water soluble, (sugar is)

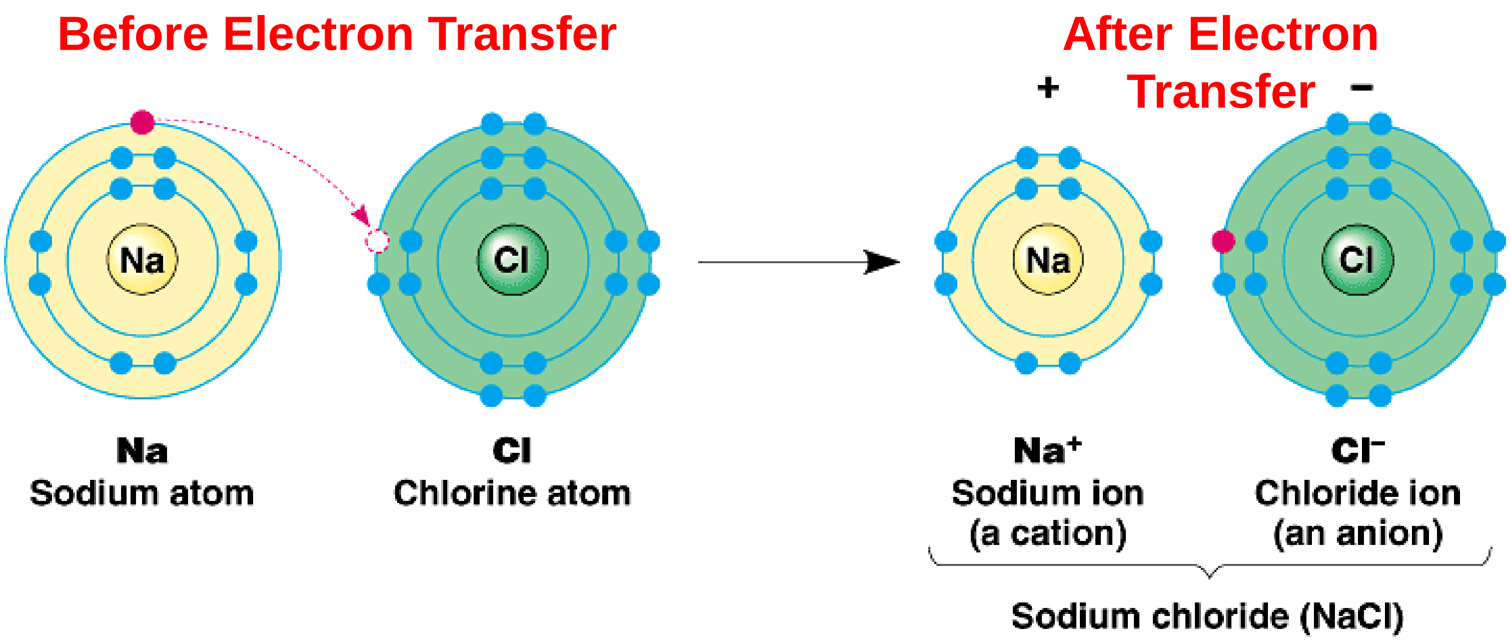
Example Covalent Bond
Water (H_2O)



Ionic Bonds

- *Ionic bond* – bond held together by the attraction between ions of opposite charge
- Compounds that held together by ionic bonds are called ionic compounds.
- Ionic compounds –
  - tend to be brittle
  - often have a high melting point
  - in a solid state at room temperature

Example Ionic Bond
Table Salt (NaCl)



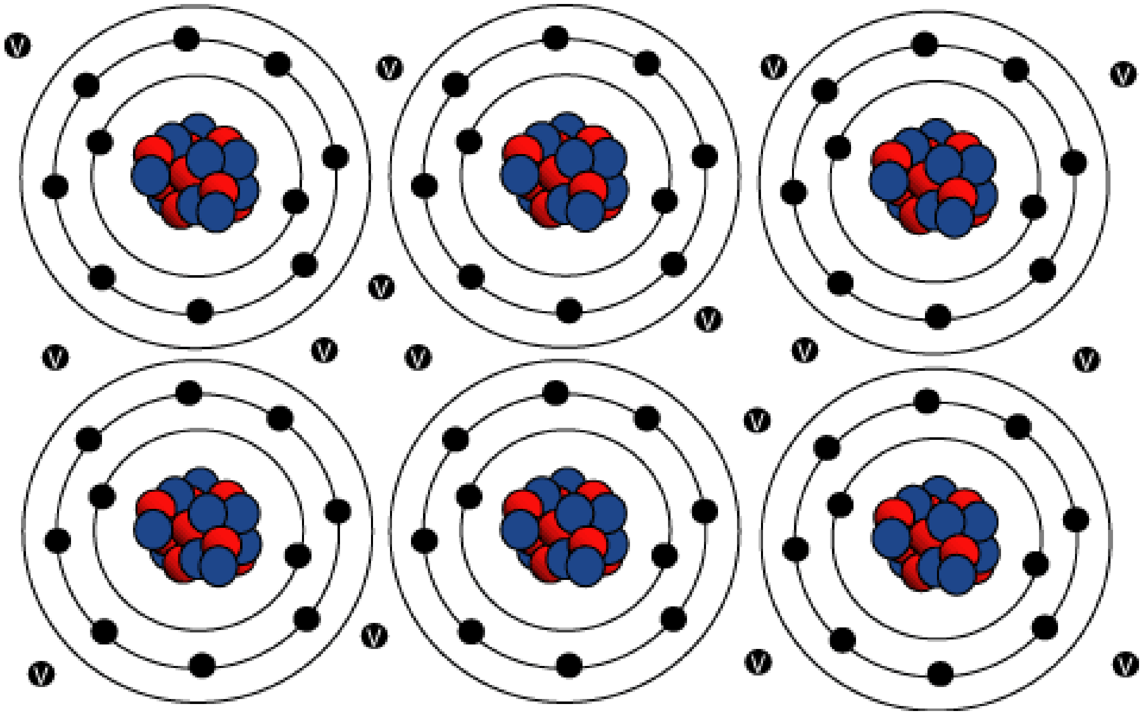
Metallic Bonds

- *Metallic bonds* – type of bond created when the valence electrons are shared by all atoms

- Allows metals to conduct electricity because the electrons move freely.

- Also explains why metals are malleable because when a force is applied, the electrons simply move past each other.

Example Metallic Bond Aluminum



Chemical Reactions

- *Chemical reaction* – the process in which bonds are made or broken

- Chemical reactions are represented by chemical equations.

- The number of electrons must be equal on both sides of the equation because matter cannot be created nor destroyed.

Example Reaction

$H_2 + O_2 \rightarrow H_2O$

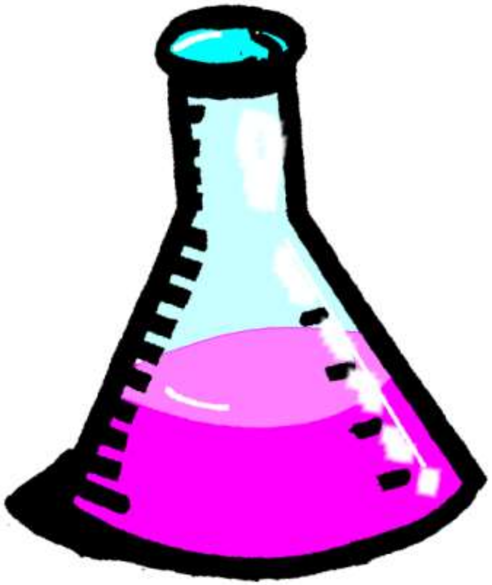
This equation is not balanced, because you cannot lose an oxygen atom!

$2\ H_2 + O_2 \rightarrow 2\ H_2O$

4 H atoms + 2 O atoms **yields** 4 H atoms & 2 O atoms as 2 water molecules.

reactants **product**

Mixtures and Solutions



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Class Notes

Mixtures

- *Mixture* – combination of two or more components that retain their identities
  - *This means they are NOT chemically combined!*

- Examples: sand, soil, lemonade, air

Heterogeneous vs. Homogeneous Mixtures

- *Heterogeneous mixture* – a mixture whose components are easily recognizable

- Examples – sand, soil, a salad

Heterogeneous vs. Homogeneous Mixtures

- *Homogeneous mixture* – Another term is **solution**; the different components cannot be distinguished

- Examples – lemonade, milk, air, fog

More on Solutions…

- Solutions can be solid, liquid, or gas
  - – Example liquid – salt water
  - – Example gas – air
  - – Example solid – bronze, brass

Solutions as Acids and Bases

- *Acids* – solution containing a substance that produces hydrogen ions in water

- Examples – sulfuric acid, citric acid, milk, rainfall in PA

Solutions as Acids and Bases

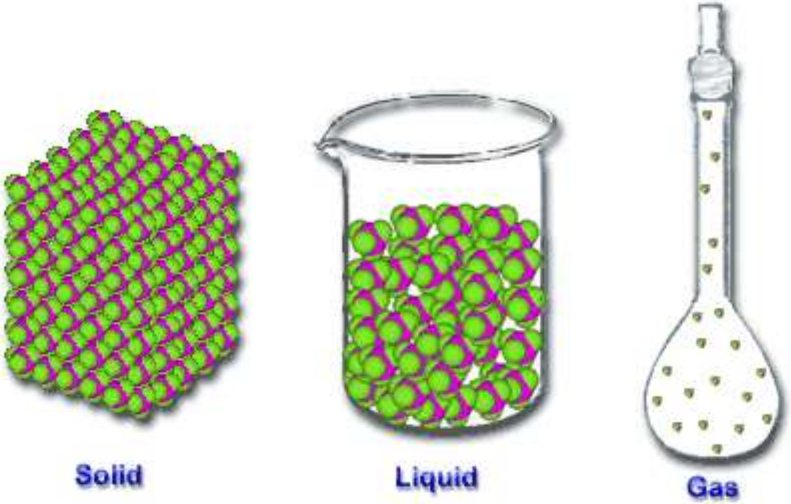
- *pH scale* – measures the amount of hydrogen ions in a solution
  - *Tells if something is an acid or a base*

- On the pH scale, 7 is considered neutral
- Anything below 7 is an acid
- Anything above 7 is a base

Solutions as Acids and Bases

- *Base* – substance that produces hydroxide ions in water
- Examples – sodium hydroxide, antacids, ammonia, shampoos, soaps

States of Matter



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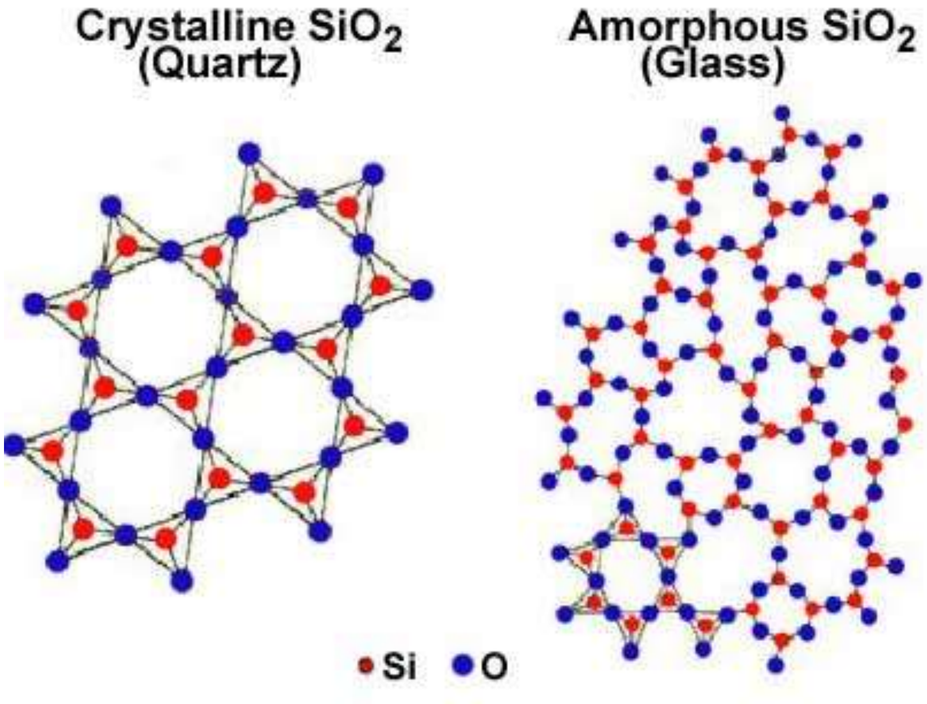
Solids

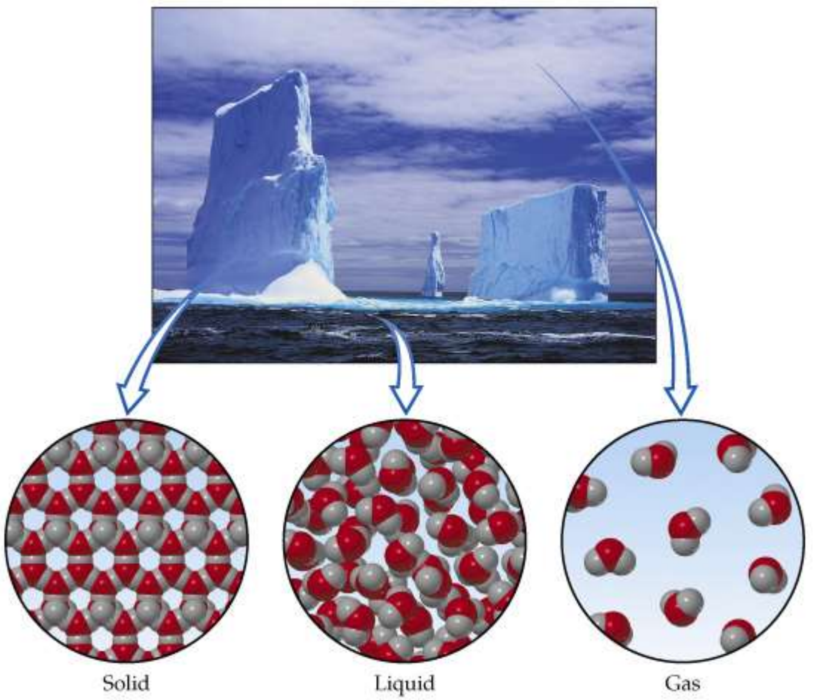
- *Solids* – substances with densely packed particles, which can be ions, atoms, or molecules – mostly crystalline with a definite shape & volume
  - *Crystalline solids* – particles are arranged in a regular geometric pattern (perfect is rare)
  - **poly**crystalline solids are most common
  - *Glass* – particles are arranged randomly

Examples of Solids



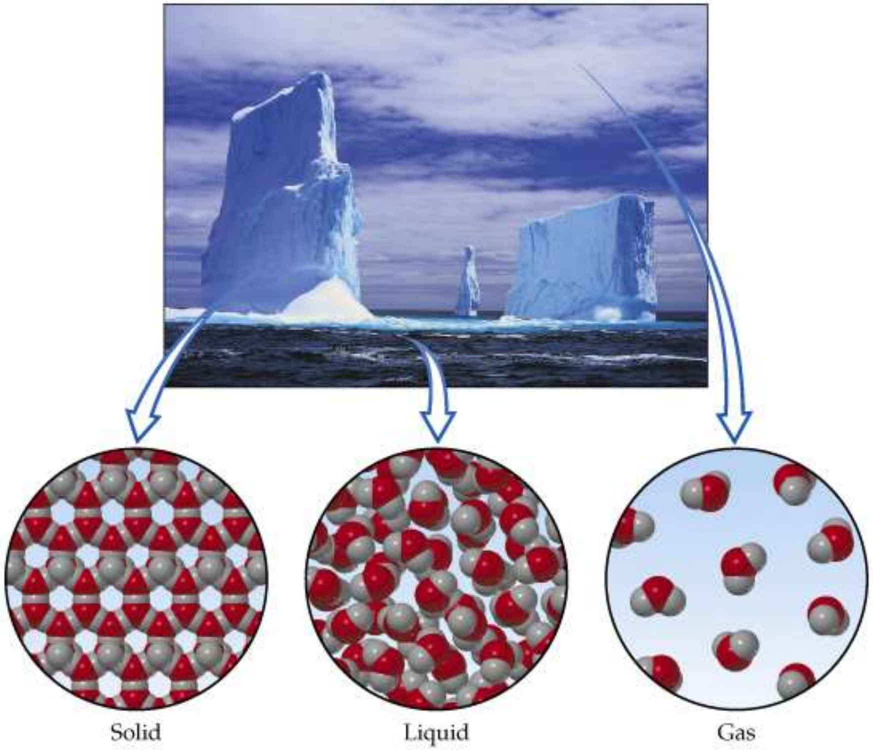
Liquids

- *Liquids* – substances that have definite volume, but no definite shape – they take the shape of their container.



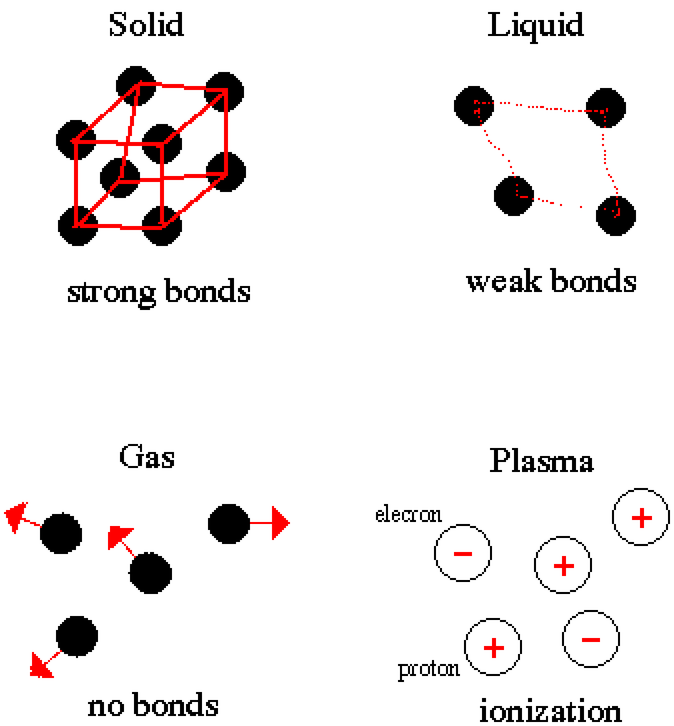
Gases

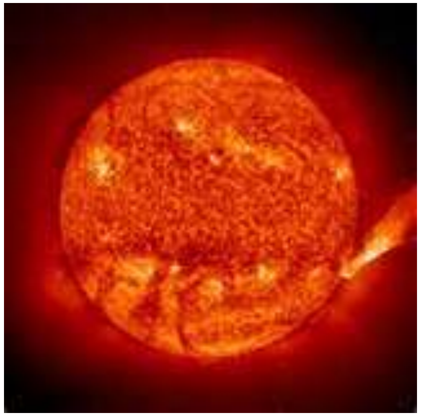
- *Gases* – particles are separated by very large distances; have no definite shape or volume (unless restrained)



Plasma

- *Plasma* – Occurs at over 5,000°C; highly ionizied, electricity conducting gas





Thermal Vibrations

- *Thermal vibrations* – vibrations that occur in all states of matter; they increase with increasing temperature
  - At any temperature above absolute zero (-273° C), the atoms in a substance will vibrate.
  - The state of matter of a substance is ultimately determined by how vigorous these thermal vibrations become.
  - Vibrations are at their highest in plasma and lowest in solids

Melting

- *Melting* – when thermal vibrations become strong enough to break the forces holding a solid together.
- At the melting point of a substance the thermal vibrations become vigorous enough to break the forces holding the solid together & the particles then slide past each other.

Evaporation

- *Evaporation* – the process of change from a liquid to a gas at temperatures below the boiling point. At the boiling point the thermal vibrations become great enough to provide enough energy for particles to escape the liquid as a gas.
  - *Sometimes called "vaporization"*

Condensation

- *Condensation* – when gas is cooled to the boiling point & becomes a liquid. Energy is released & the gas returns to the liquid state.

Sublimation

- *Sublimation* – occurs below the boiling point; slow change of state from solid to a gas without the intermediate state - liquid
  - *Particles gain enough energy from thermal vibrations to escape the solid (skips the liquid state)*

Formation of Plasma

- *Formation of plasma* – > 5000°C
- Collisions between the particles become so violent that electrons are knocked away from the atoms
  - *Results is gases of positive ions and free electrons*

Law of Conservation of Energy

- *1st Law of Thermodynamics* – Energy cannot be created nor destroyed; it can change from one type to another