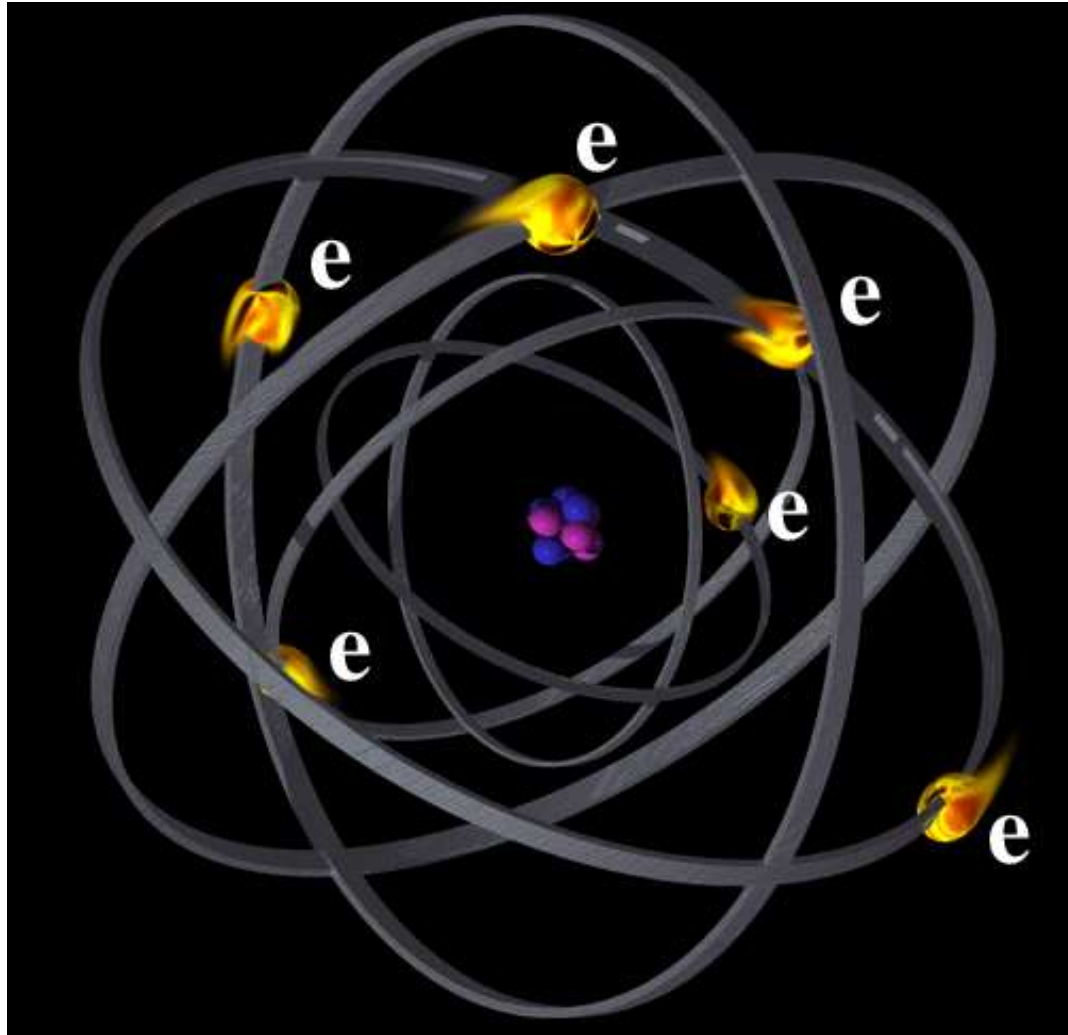


# Section 3.1 – Matter, Elements, & Atoms



8<sup>th</sup> Grade Earth & Space Science - Class Notes

# 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

## Periodic Table of Elements

IA																				0									
1 H	IIA																											2 He	
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne												
11 Na	12 Mg	III B	IV B	V B	VIB	VII B	VII		IB	IB	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar													
19 K	20 Ca	21 Sc	22 Ti	23 Y	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr												
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe												
55 Cs	56 Ba	57 La*	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn												
87 Fr	88 Ra	89 Ac*	104 Rf	105 Ha	106 106	107 107	108 108	109 109	110 110																				

\*Lanthinide Series

58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	Lu Lu
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\*Actinide Series

90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	Lr Lr
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# 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

**8<sup>th</sup> Grade Earth and Space Science**



# I am Dmitri Mendeleev!



**Periodic Table**

- Group numbering is based on the new IUPAC system.
- Atomic weights are based on  $^{12}\text{C} = 12$  and conform to the 1995 IUPAC reported values. Number in ( ) indicates the isotope of longest half-life.

1																	18	
H																	He	
Li	Be											B	C	N	O	F	Ne	
Na	Mg											Al	Si	P	S	Cl	Ar	
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	
Cs	Ba	Lanthanides	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn	
Fr	Ra	Actinides	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Uub	Uut	Uuq	Uup	Uuh	Uus	Uuo	
		La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
		Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr		

Illustrated by Masahiko Suenaga  
<http://www.Lbbiq.jp/zelefi/>

# I made the PERIODIC TABLE !

# What is the PERIODIC TABLE?

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



A close-up photograph of a portion of the periodic table. The elements shown are Carbon (C), Nitrogen (N), and Silicon (Si). Carbon is in the top-left cell, Nitrogen is in the top-right cell, and Silicon is in the bottom-left cell. The atomic numbers 6, 7, 14, and 15 are visible. The atomic weights 12.011 and 14.006 are also visible. The table is organized by chemical properties.

6 C Carbon 12.011	7 N Nitrogen 14.006
14 Si	15

**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

### PERIODIC TABLE OF THE ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Hydrogen 1 H 1.008																	Helium 2 He 4.003
Lithium 3 Li 6.941	Beryllium 4 Be 9.012																
Sodium 11 Na 22.990	Magnesium 12 Mg 24.305																
Potassium 19 K 39.098	Calcium 20 Ca 40.078	Scandium 21 Sc 44.956	Titanium 22 Ti 47.867	Vanadium 23 V 50.942	Chromium 24 Cr 51.996	Manganese 25 Mn 54.938	Iron 26 Fe 55.845	Cobalt 27 Co 58.933	Nickel 28 Ni 58.693	Copper 29 Cu 63.546	Zinc 30 Zn 65.409	Gallium 31 Ga 69.723	Germanium 32 Ge 72.64	Arsenic 33 As 74.922	Selenium 34 Se 78.96	Bromine 35 Br 79.904	Krypton 36 Kr 83.798
Rubidium 37 Rb 85.468	Strontium 38 Sr 87.62	Yttrium 39 Y 88.906	Zirconium 40 Zr 91.224	Niobium 41 Nb 92.906	Molybdenum 42 Mo 95.94	Technetium 43 Tc (98)	Ruthenium 44 Ru 101.07	Rhodium 45 Rh 102.906	Palladium 46 Pd 106.42	Silver 47 Ag 107.868	Cadmium 48 Cd 112.411	Indium 49 In 114.818	Tin 50 Sn 118.710	Antimony 51 Sb 121.760	Tellurium 52 Te 127.60	Iodine 53 I 126.904	Xenon 54 Xe 131.293
Cesium 55 Cs 132.905	Barium 56 Ba 137.327	Lanthanum 57 La 138.906	Hafnium 72 Hf 178.49	Tantalum 73 Ta 180.948	Tungsten 74 W 183.84	Rhenium 75 Re 186.207	Osmium 76 Os 190.23	Iridium 77 Ir 192.217	Platinum 78 Pt 195.078	Gold 79 Au 196.967	Mercury 80 Hg 200.59	Thallium 81 Tl 204.383	Lead 82 Pb 207.2	Bismuth 83 Bi 208.980	Polonium 84 Po (209)	Astatine 85 At (210)	Radon 86 Rn (222)
Francium 87 Fr (223)	Radium 88 Ra (226)	Actinium 89 Ac (227)	Rutherfordium 104 Rf (261)	Dubnium 105 Db (262)	Seaborgium 106 Sg (266)	Bohrium 107 Bh (264)	Hassium 108 Hs (277)	Mtnerium 109 Mt (268)	Darmstadtium 110 Ds (281)	Ununium * 111 Uuu (272)	Ununbium * 112 Uub (285)		Ununquadium * 114 Uuq (289)		** 116		** 118

Lanthanide series

Cerium 58 Ce 140.116	Praseodymium 59 Pr 140.908	Neodymium 60 Nd 144.24	Promethium 61 Pm (145)	Samarium 62 Sm 150.36	Europium 63 Eu 151.964	Gadolinium 64 Gd 157.25	Terbium 65 Tb 158.925	Dysprosium 66 Dy 162.500	Holmium 67 Ho 164.930	Erbium 68 Er 167.259	Thulium 69 Tm 168.934	Ytterbium 70 Yb 173.04	Lutetium 71 Lu 174.967
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Actinide series

Thorium 90 Th 232.038	Protactinium 91 Pa 231.036	Uranium 92 U 238.029	Neptunium 93 Np (237)	Plutonium 94 Pu (244)	Americium 95 Am (243)	Curium 96 Cm (247)	Berkelium 97 Bk (247)	Californium 98 Cf (251)	Einsteinium 99 Es (252)	Fermium 100 Fm (257)	Mendelevium 101 Md (258)	Nobelium 102 No (259)	Lawrencium 103 Lr (262)
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# 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?**



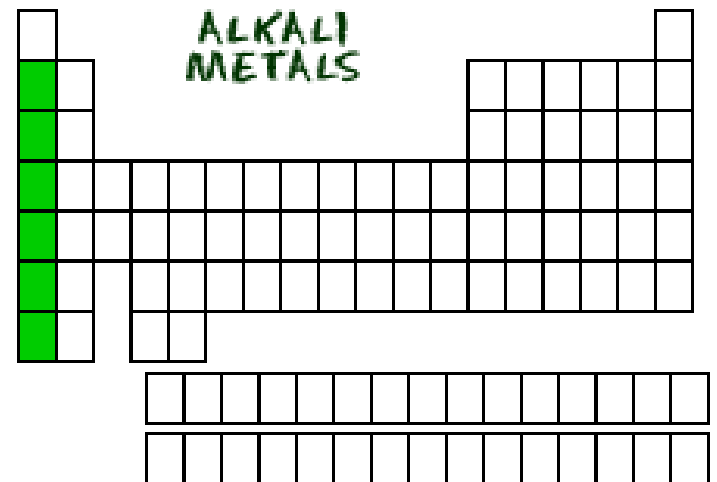
# The Columns are Groups or Families

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

# The Alkali Metals

## Group 1

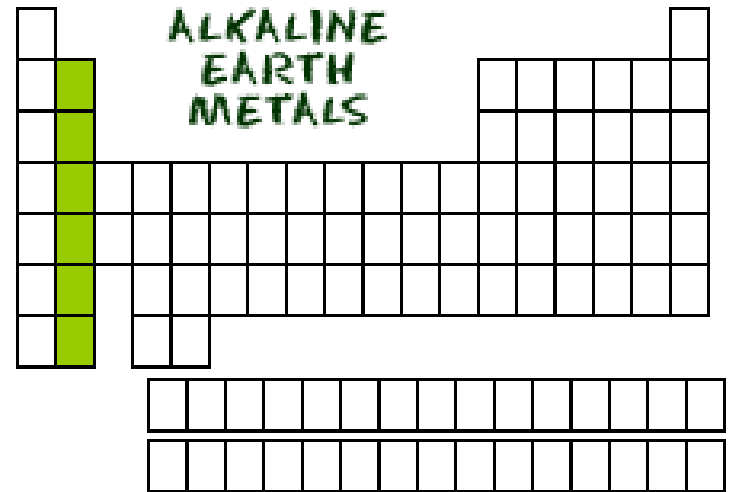
- Very reactive
- Cause explosions when mixed with water
- Metals
- Shiny
- Light weight



# The Alkaline Earth Metals

## Group 2

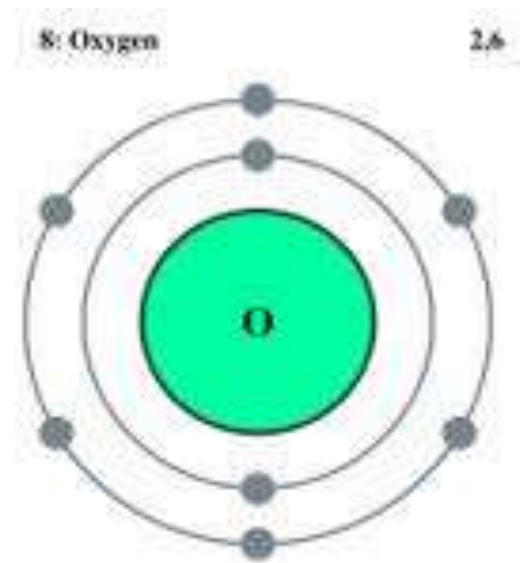
- Reactive, but not quite as much as Group 1
- Metals
- Shiny
- Light weight



# The Alkaline Chalcogens

## Group 16

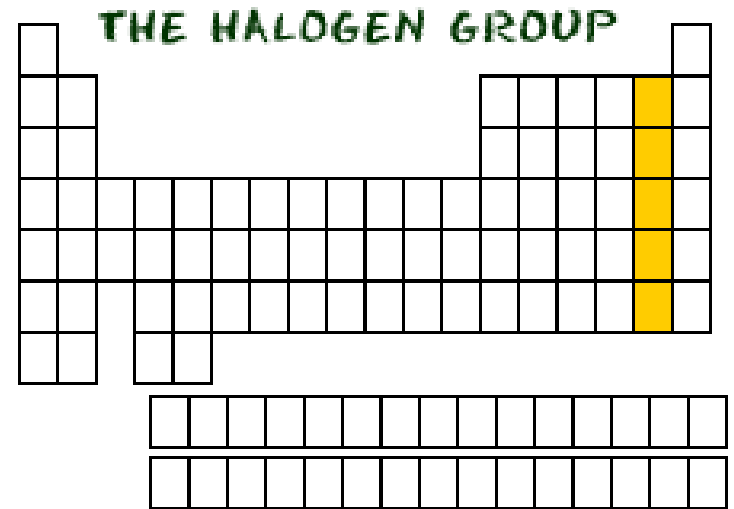
- A.K.A. -the oxygen family
- Mix of metals & metalloids
- Many are found in minerals



# The Halogens

## Group 17

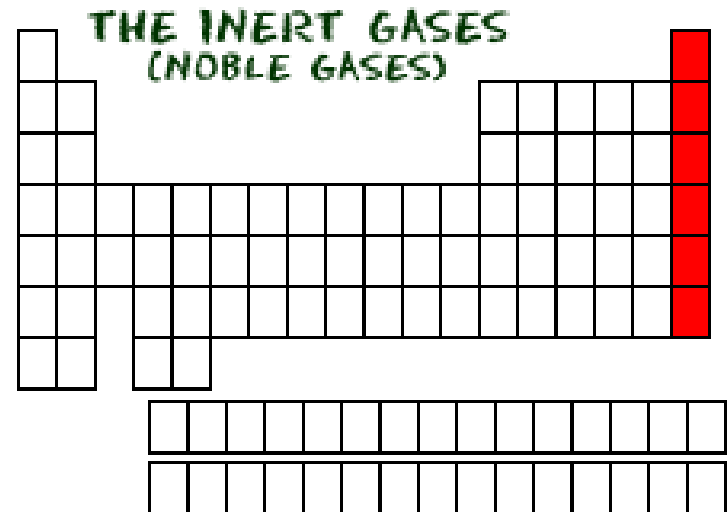
- Often bond with metals from Group 1
- Very reactive
- Often form salts



# The Inert (Noble) Gases

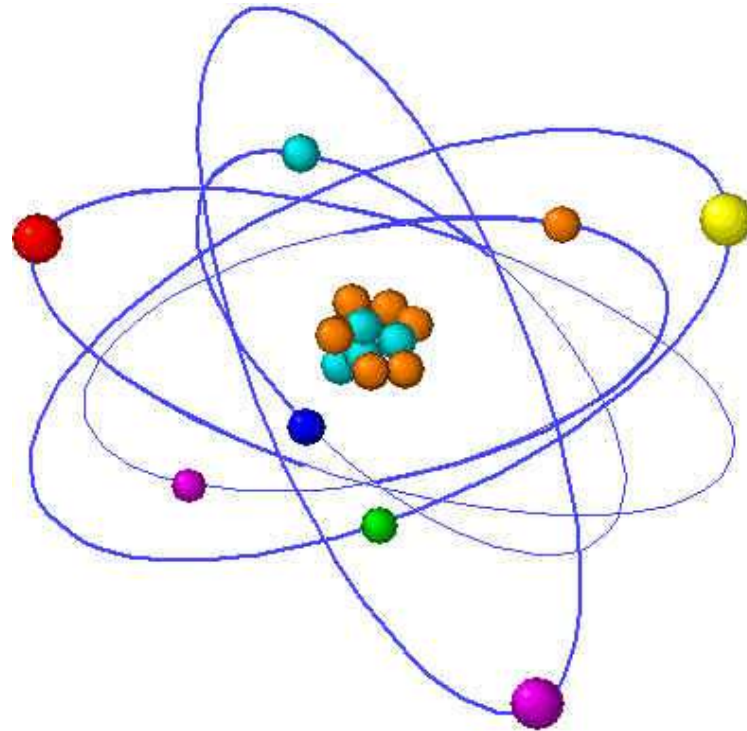
## Group 18

- 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.



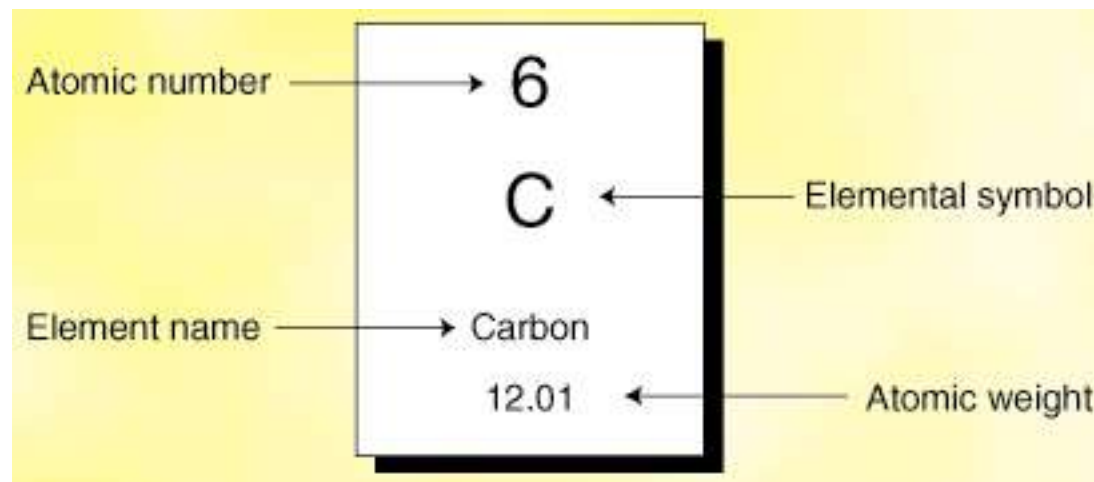
# Determining the Structure of Atoms

Steps:

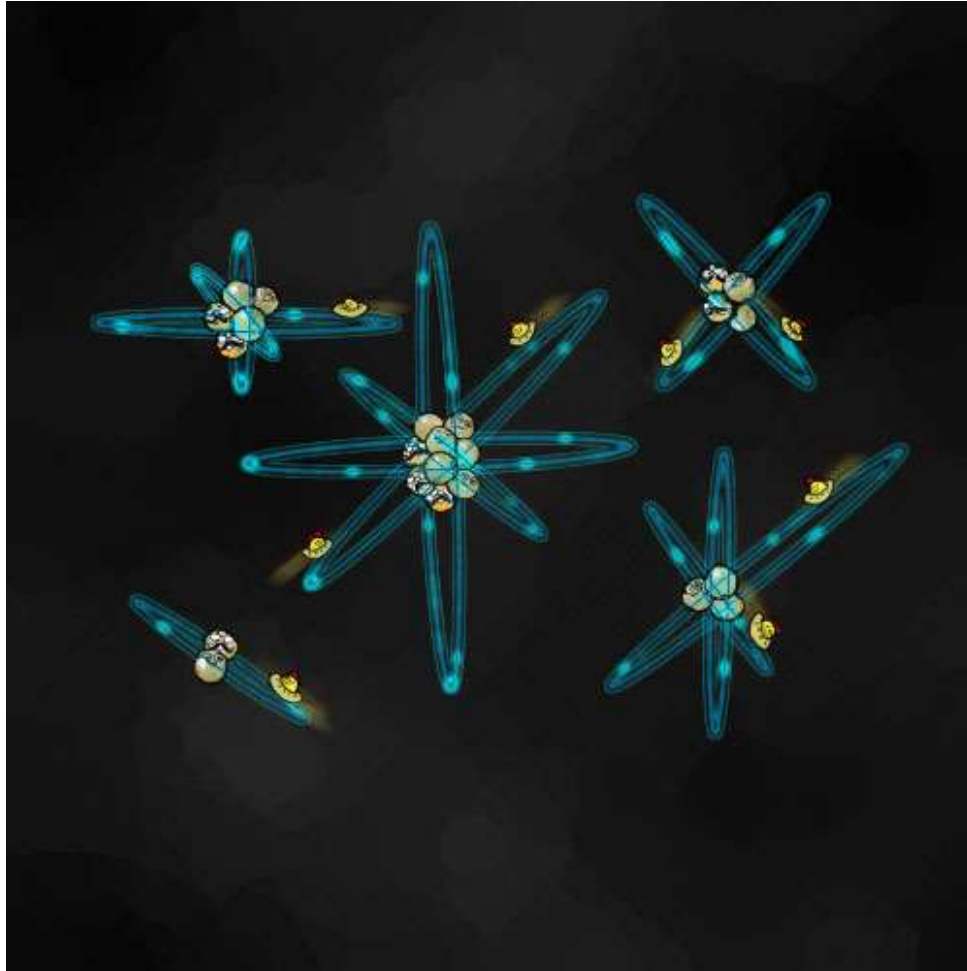
1. Use the atomic number to determine the number of protons and electrons in a neutral atom.
2. Use the atomic mass and the atomic number to determine the number of neutrons.
3. Make adjustments to numbers if dealing with an isotope or ion.

# Example

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



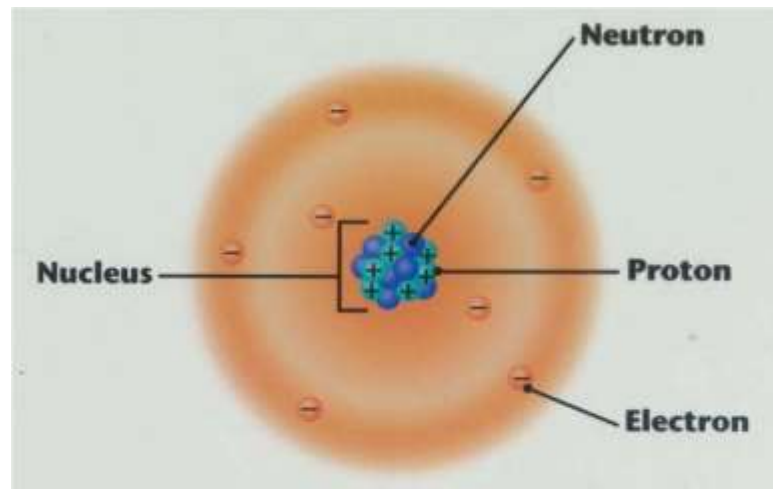
# Electrons!



8<sup>th</sup> Grade Earth & Space Science

# 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 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!

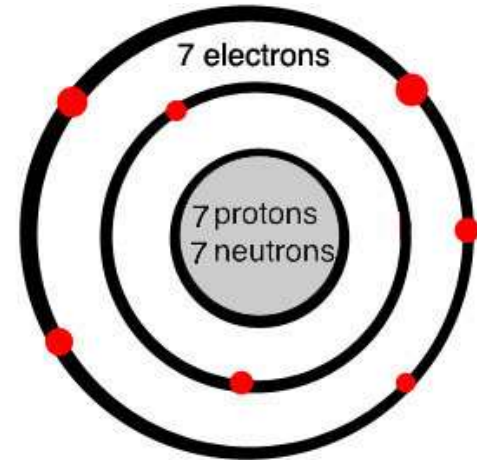
# Drawing Atomic Structures

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!

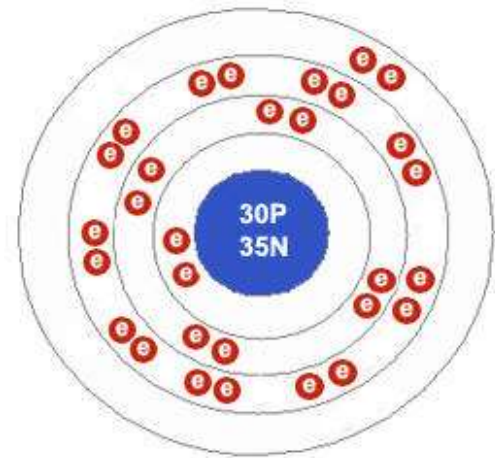


# Let's Practice!

- Draw the structure of N.



- Draw the structure of Zn.

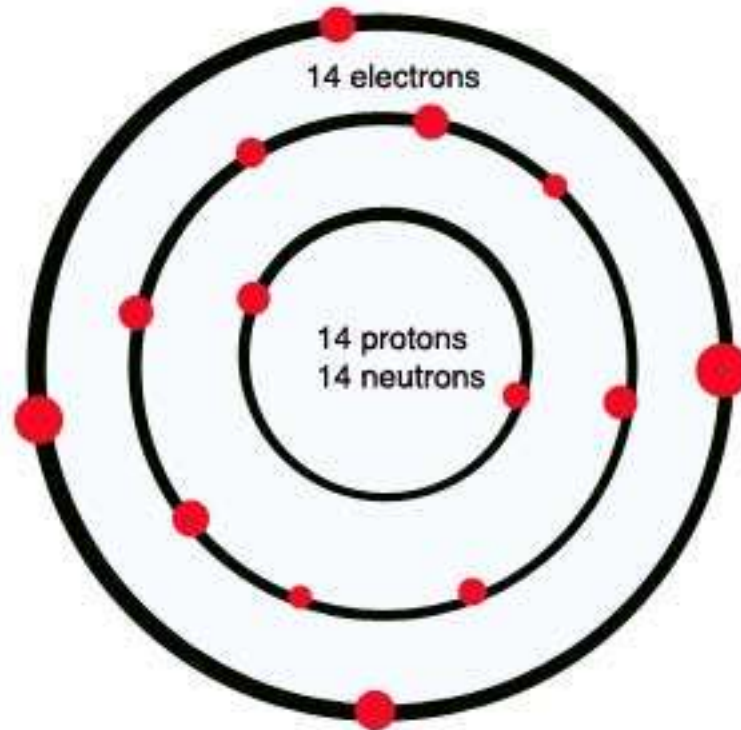


# Valence Electrons and Stability

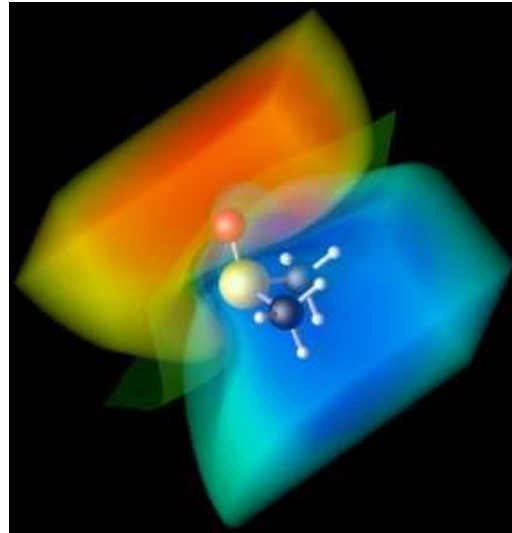
- To be considered “stable” an electron must have a full outer valence.
  - For the first level, 2 is considered a full valence.
  - For all other levels, 8 is considered a full valence.
- If an atom is not stable, it will combine with other atoms to become stable.

# 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



8<sup>th</sup> Grade Earth and Space  
Science  
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 called  $^{35}_{17}\text{Cl}$  and  $^{37}_{17}\text{Cl}$ .

Protons - 17  
Electrons - 17  
Neutrons - 18

Protons - 17  
Electrons - 17  
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

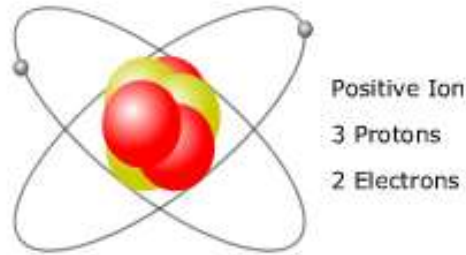
# What Is An Ion?

- *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?

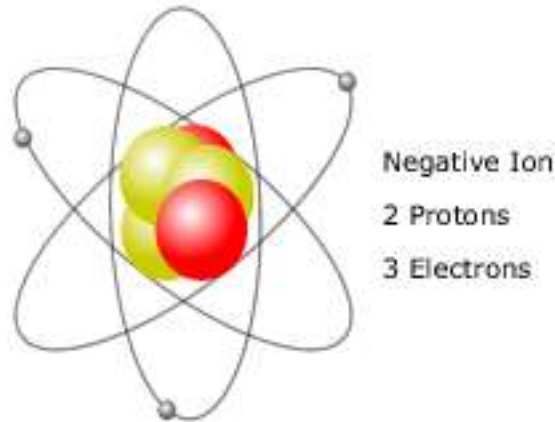
- Atoms that lose electrons will have a positive charge

– Example:



- Atoms that gain electrons will have a negative charge

– Example:  $\text{Cl}^-$



# Steps to Determining the Atomic Structure of an Ion

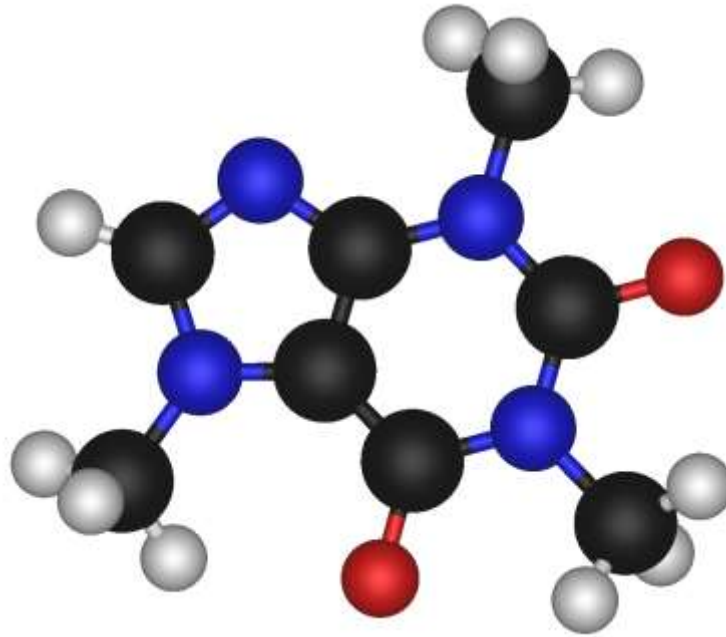
1. Use the atomic number to determine the number of protons and electrons in a neutral atom.
2. Use the (atomic mass – atomic number) to determine the number of neutrons.
3. Adjust the electron number to make the ion.
  - If an ion is negative, add electrons.
  - If an ion is positive, subtract electrons.

# Let's Practice

Determine the atomic structure of  $\text{Na}^+$ .

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

# Compounds and Bonding



8<sup>th</sup> Grade Earth and Space Science  
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<sub>2</sub>O

- 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  
 $\text{NaCl}$



Sugar  
 $\text{C}_6\text{H}_{12}\text{O}_6$

# Chemical Bonds

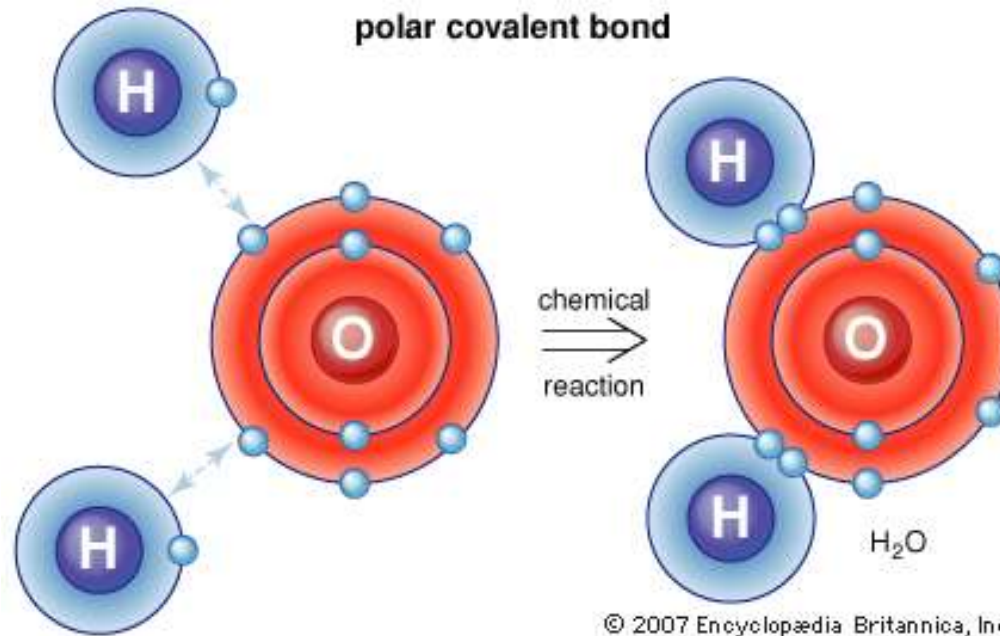
- Remember that an atom is stable when its valence is full.
- When an atom does not have a full valence it can create one by joining with other atoms to make a chemical bond.
- Chemical bonds are what holds compounds together.

# 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 ( $\text{H}_2\text{O}$ )

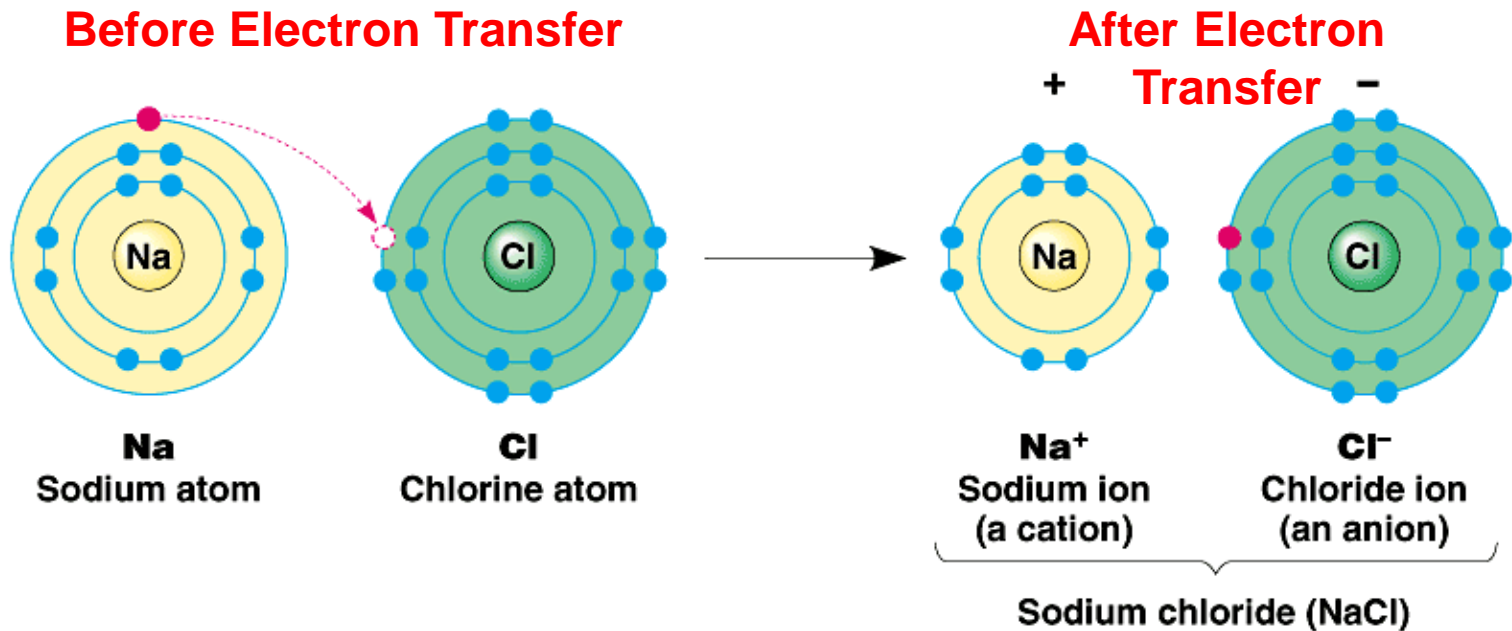


# Ionic Bonds

- *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)

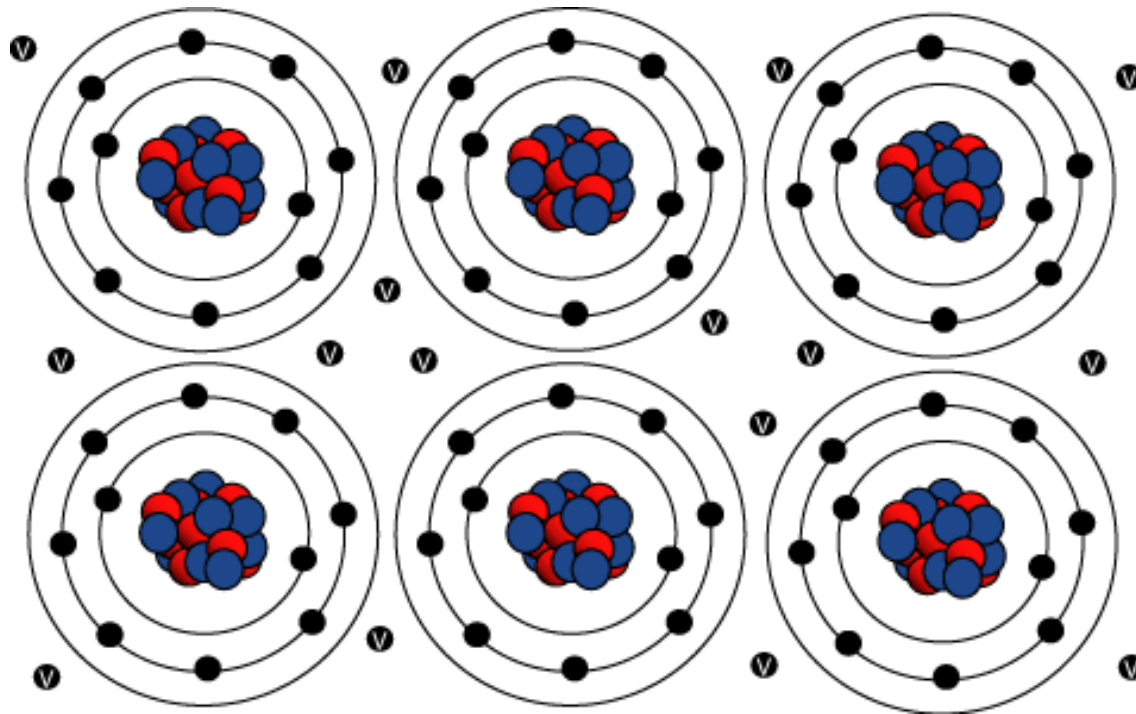


# Metallic Bonds

- *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

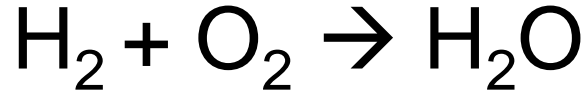
## Aluminum



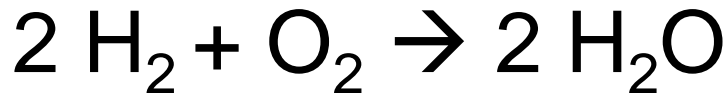
# Chemical Reactions

- *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



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

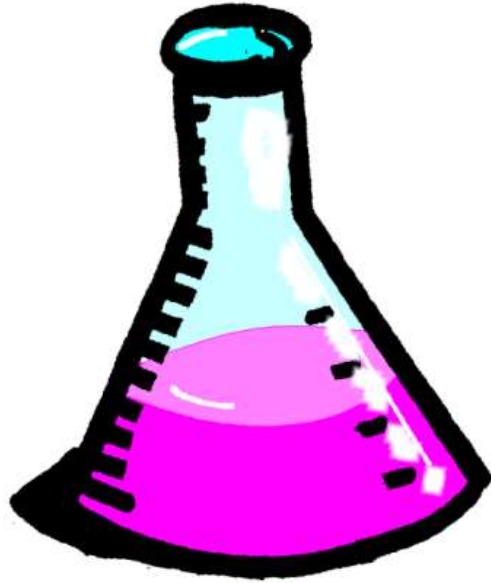


4 H atoms + 2 O atoms **yields** 4 H atoms & 2 O atoms as 2 water molecules.

**reactants**

**product**

# Mixtures and Solutions



8<sup>th</sup> Grade Earth and Space Science  
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

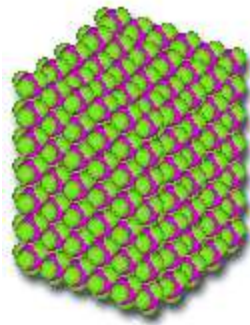
# Solutions as Acids and Bases

- *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

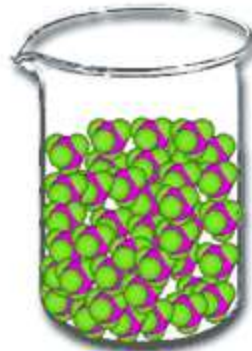
# Solutions as Acids and Bases

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

# States of Matter



Solid



Liquid



Gas

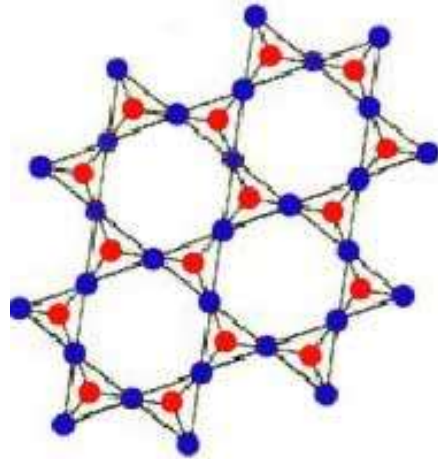
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# Solids

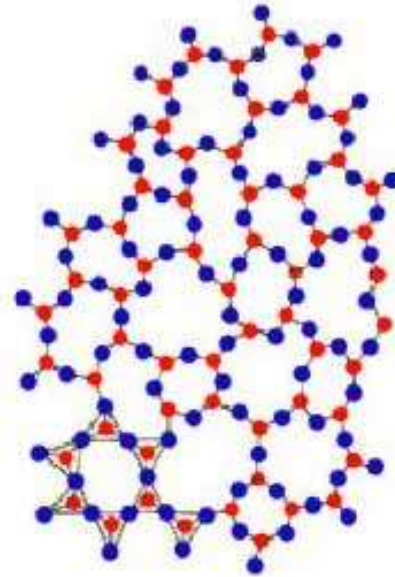
- *Solids* – substances with densely packed particles, which can be ions, atoms, or molecules – mostly crystalline with a definite shape & volume
  - *Crystalline solids* – particles are arranged in a regular geometric pattern (perfect is rare)
  - **polycrystalline** solids are most common
  - *Glass*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

# Examples of Solids

Crystalline SiO<sub>2</sub>  
(Quartz)



Amorphous SiO<sub>2</sub>  
(Glass)

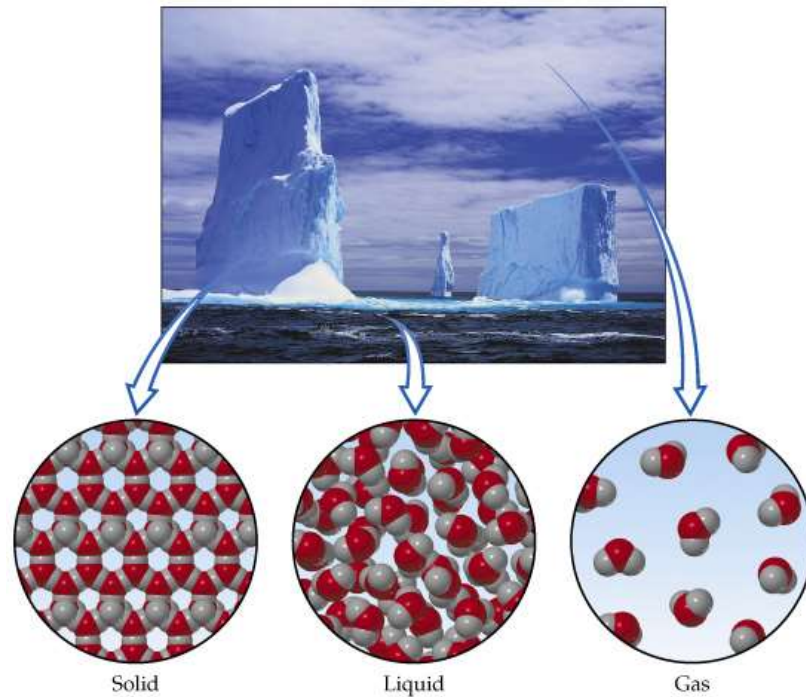


● Si ● O



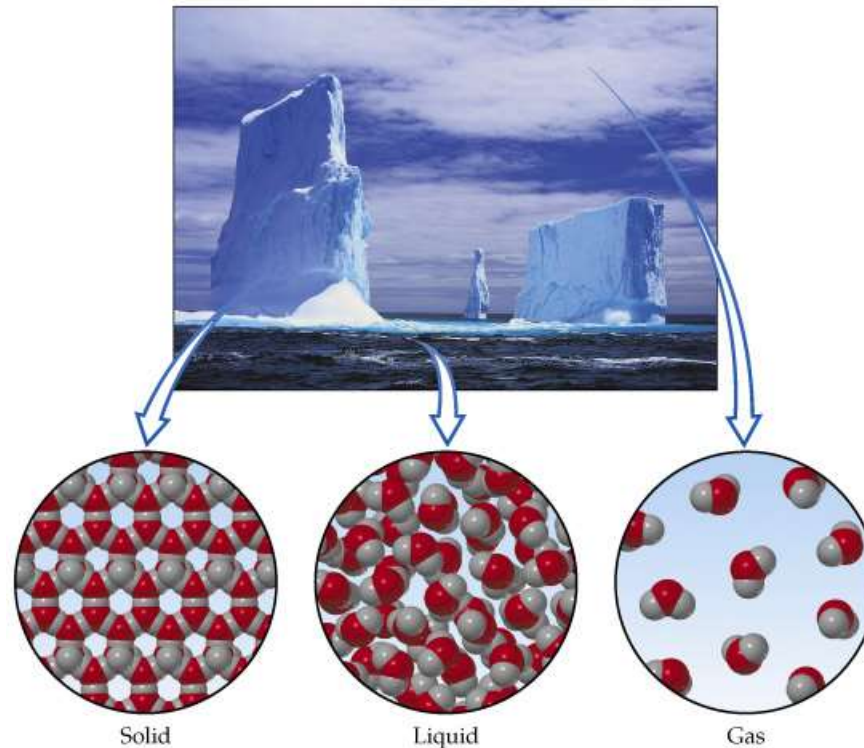
# Liquids

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



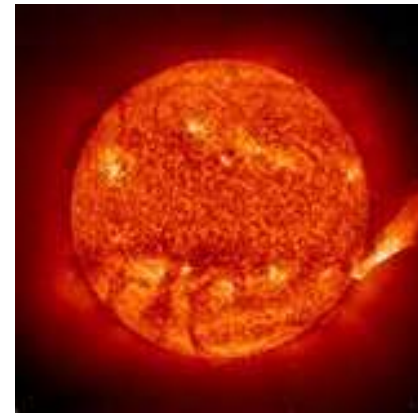
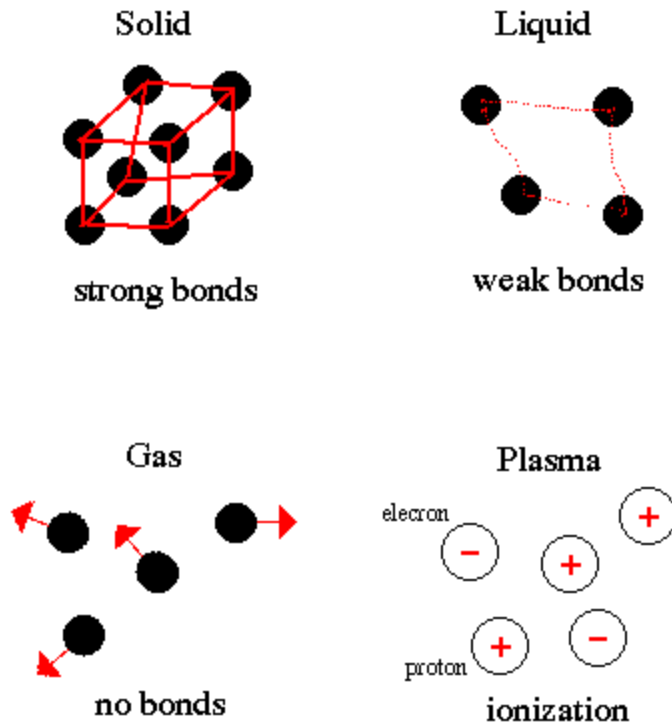
# Gases

- *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 ionized, 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 ( $-273^{\circ}\text{C}$ ), 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

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