Matter

Essential Questions:

1. Describe atoms and their component parts.
2. How are energy levels and the number of electrons in the outer orbit related to the chemical properties of elements?
3. What are isotopes and their significance to radiometric dating?

Matter – Anything that has volume and mass. All matter is made of elements.
Elements – Substances that can't be broken down into simpler substances.

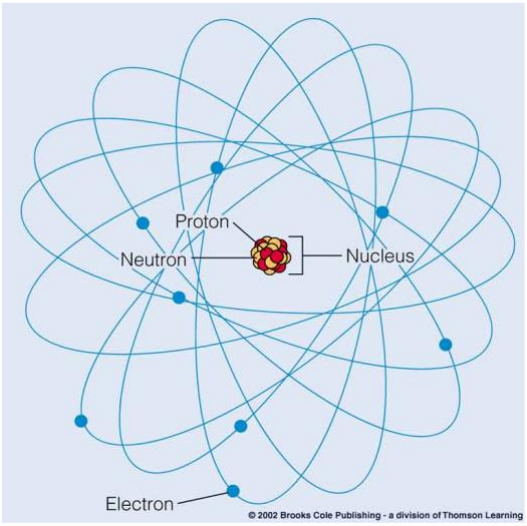
- 92 naturally occurring elements
- expressed using symbols
    - ex. H, He, Li, O, Fe….
    - 8 elements make up 98.5% of the Earth's crust

Oxygen =	O	46.6%
Silicon =	Si	27.7%
Aluminum =	Al	8.1%
Iron =	Fe	5.0%
Calcium =	Ca	3.6%
Sodium =	Na	2.8%
Potassium =	K	2.6%
Magnesium =	Mg	2.1%

Atoms – fundamental units of elements

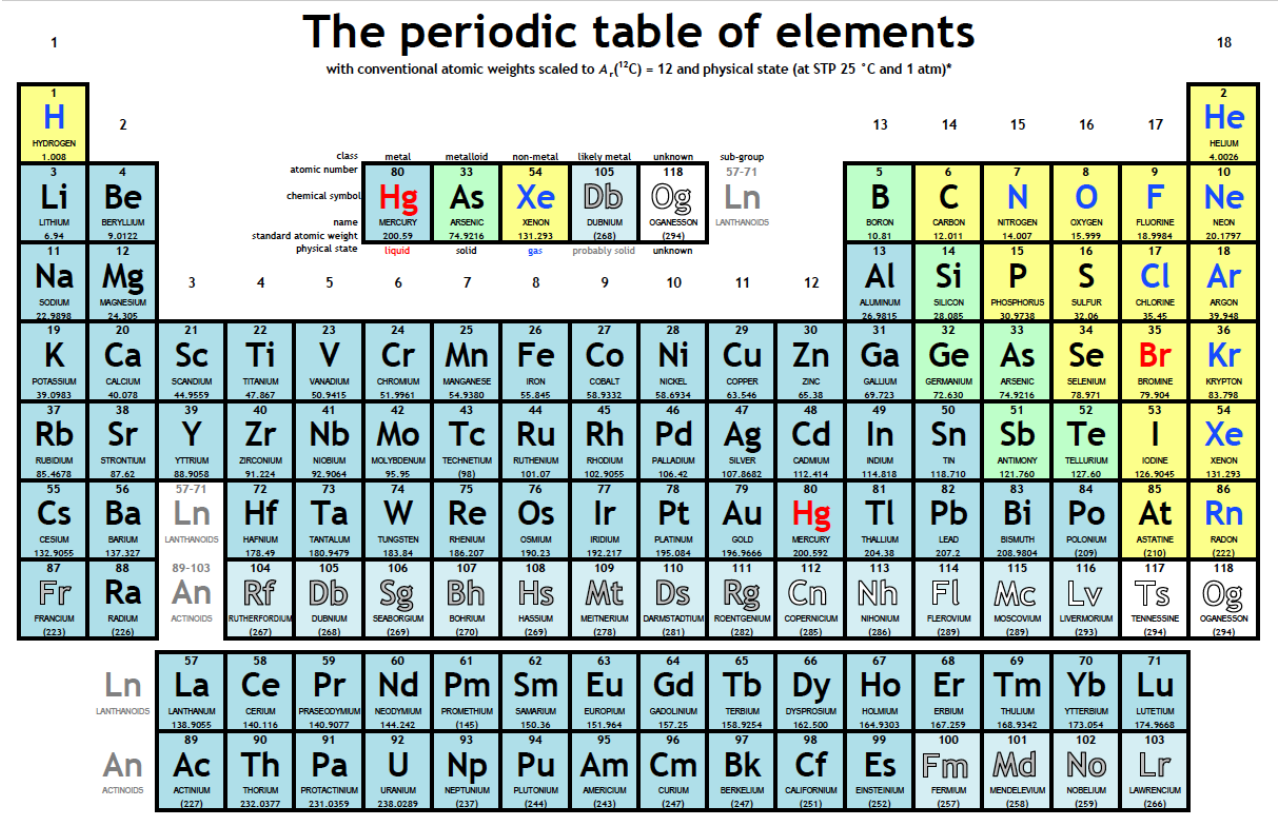
–Atoms consist of

- **Protons**: have a positive charge and contribute mass located in the nucleus
- **Electrons**: have a negative charge and little mass orbit the nucleus in shells
- **Neutrons**: electrically neutral, found in the nucleus

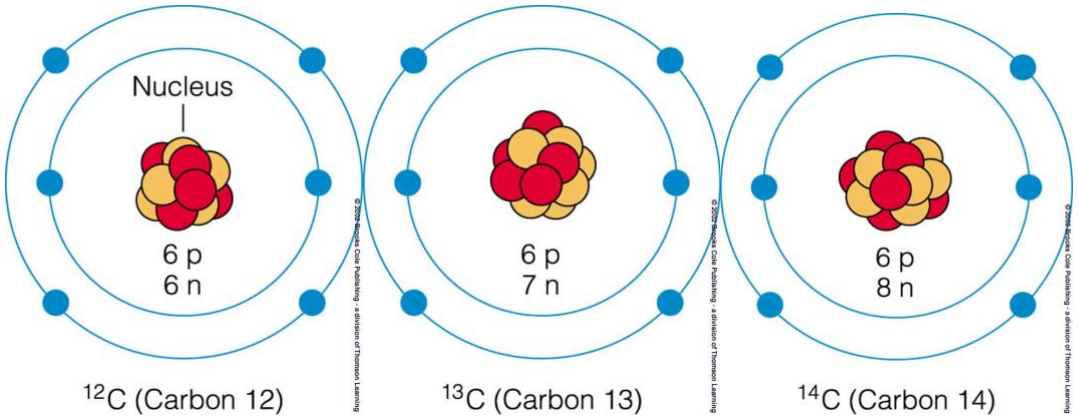


- **Atomic number**: equals the number of protons
  - ex. Oxygen = 8
    Hydrogen = 1
    Carbon = 6

- **Atomic mass number**: the number of neutrons + protons
  - ex. Carbon = 12 (6 protons + 6 neutrons)
    Carbon = 13 (6p + 7n)
    Oxygen = 16 (8p + 8n)

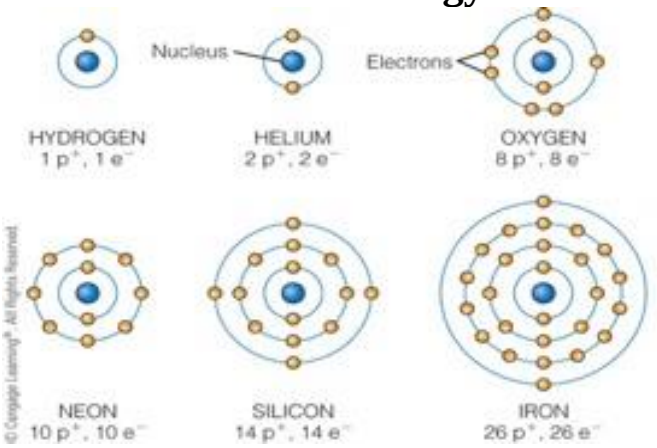


- **Isotopes**: Atoms with varying numbers of neutrons. This will change the atomic mass number, not the atomic number. Carbon has 3 isotopes.



- **Radioactive Isotopes**: The nucleus breaks down and emits energy in the form of radiation.
    - When radioactive decay happens, the nucleus can:
        1. Lose protons and neutrons
        2. Change a proton to a neutron
        3. Change neutron to a proton
    - Radioactive decay will change the element into a different element. This happens when you change the number of protons.
    - Radioactive decay occurs at a predicable rate. As a result, we can use radioactive decay to calculate the age of rocks

- **Electrons in Energy Levels**



Element	Symbol	Atomic Number	Distribution of Electrons			
			First Shell	Second Shell	Third Shell	Fourth Shell
Hydrogen	H	1	1	—	—	—
Helium	He	2	2	—	—	—
Carbon	C	6	2	4	—	—
Oxygen	O	8	2	6	—	—
Neon	Ne	10	2	8	—	—
Sodium	Na	11	2	8	1	—
Magnesium	Mg	12	2	8	2	—
Aluminum	Al	13	2	8	3	—
Silicon	Si	14	2	8	4	—
Phosphorus	P	15	2	8	5	—
Sulfur	S	16	2	8	6	—
Chlorine	Cl	17	2	8	7	—
Potassium	K	19	2	8	8	1
Calcium	Ca	20	2	8	8	2
Iron	Fe	26	2	8	14	2

- **Valence electrons:** electrons in the outermost energy level
    - determine the chemical behavior of the element
    - elements with same number of valence electrons have similar chemical behavior.
    - elements that don't have a full outer orbit are reactive
    - elements with a full outer orbit are unreactive

*****Atoms like to have their outer shell (orbit) full or empty. *****
Therefore, atoms tend to bond with other atoms

Chemical Bonding

Essential Questions:

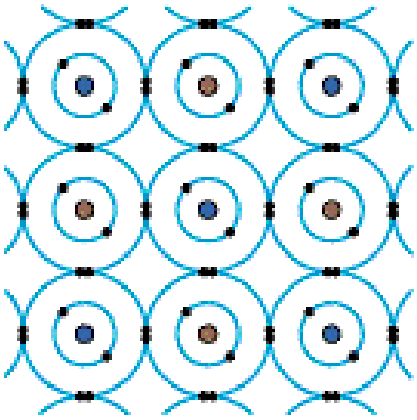
1. What are the different types of chemical bonds?
2. How are the different types of bonds related physical characteristics of compounds?
3. What are the different types of mixtures and solutions?

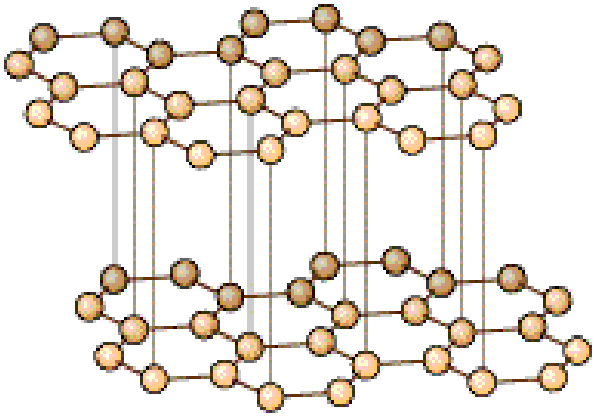
Compounds: are formed by the bonding of two or more elements.
Molecule: two or more atoms held together by covalent bonds.
- electrically neutral or no charge

Polar Molecule: unequal sharing of electrons.
- results in a molecule that has a positive and negative end. ex: H_2O

Covalent Bonding: attraction of two atoms for a shared pair of electrons that holds the atoms together

Formed by adjacent atoms sharing electrons in diamond and graphite. Van der Waals bonding between sheets of covalently bonded carbon atoms are weak, while the sheets themselves are strong.





ex. Quartz = $Si\ O_2$

Si^{4+} = : Si : O^{2-} = O

O : Si : O

Ionic Bonding

The electron in the outermost shell of sodium is transferred to the outermost shell of the chlorine atom. Once the transfer is made, the atoms are positively and negatively charged ions.

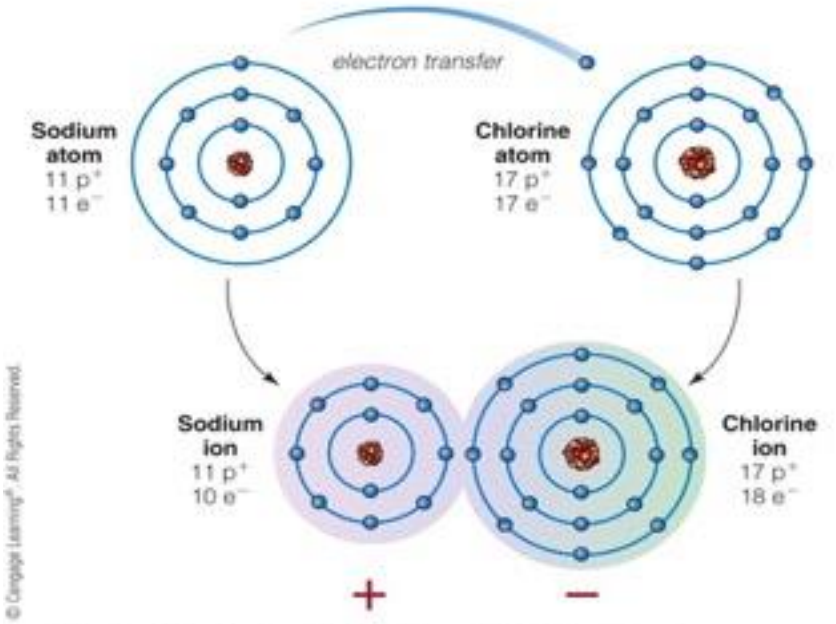
ex. Salt = Cl and Na

$7e^- \rightarrow :\dot{\underset{\cdot\cdot}{\underset{\cdot\cdot}{Cl}}}\cdot + {}^{+}Na \leftarrow 1e^-$

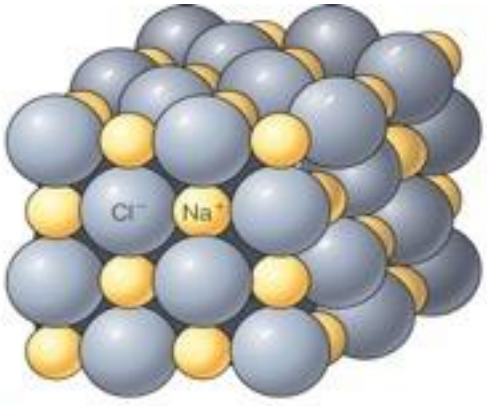
In outer orbit

In outer orbit

$:\dot{\underset{\cdot\cdot}{\underset{\cdot\cdot}{Cl}}}\ {}^{+}Na$ ← to fill their outer orbits, they bond together



a Transfer of the electron in the outermost shell of sodium to the outermost shell of chlorine. After electron transfer, the sodium and chlorine atoms are positively and negatively charged ions, respectively.

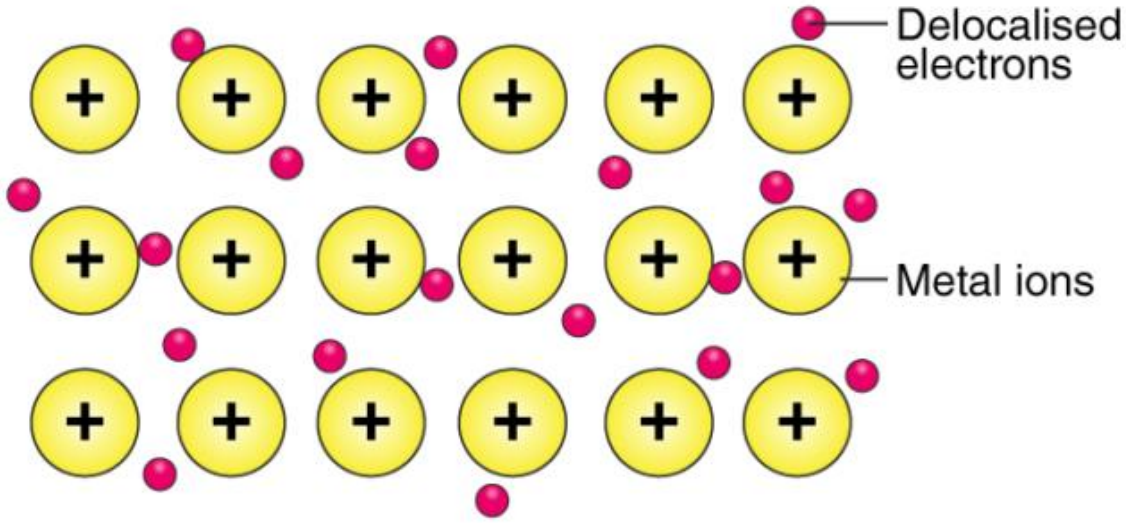


b This diagram shows the relative sizes of the sodium and chlorine atoms and their locations in a crystal of halite.

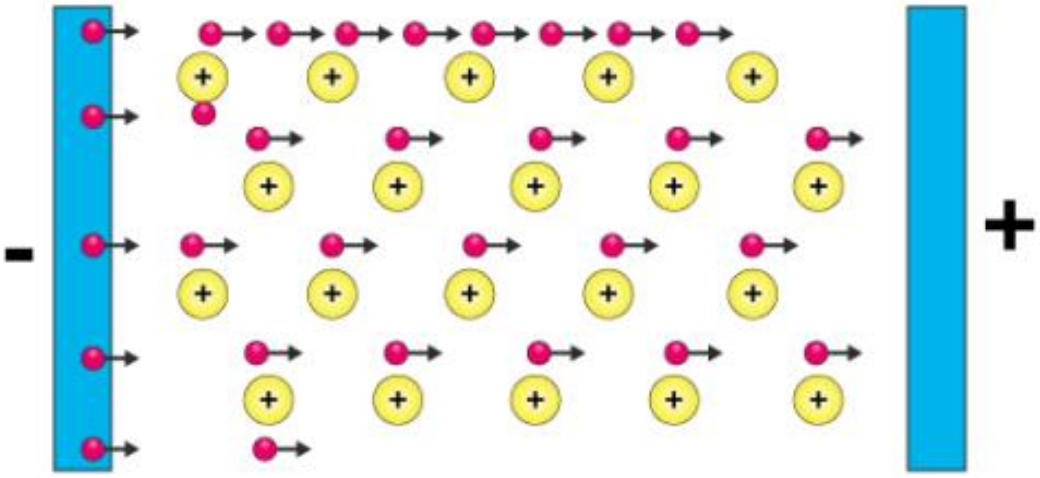
c Tiny crystals of halite.

Metallic Bonding

Form when valence electrons are shared *equally* among all the positively charged atoms. Think of a piece of metal as a group of positive ions (atoms lacking electrons) surrounded by a sea of freely moving electrons (which are negative).



- this type of bond makes metals good conductor of electricity
    - electricity is the flow of electrons in a wire.



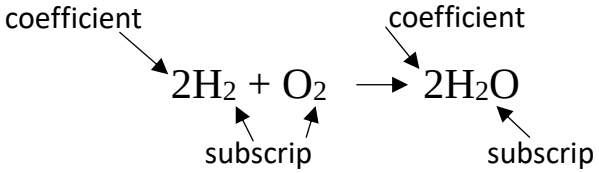
- metals are good conductors of heat
- metals are malleable (easily deformed)

Chemical Reactions

Chemical reactions happen when compounds form when ionic or covalent bonding occurs.

- Chemical reactions are described by chemical equations

Example: H_2O is formed by chemical reaction between hydrogen gas (H_2) and oxygen gas (O_2)



- Both sides of the equation must have the same number/amount of each atom. 4 atoms of hydrogen and 2 atoms of oxygen.
- How to identify the coefficients and subscripts in the following formulas. If there is not one, that means 1.

Example: $4Fe + 3O_2 \longrightarrow 2Fe_2O_3$

Number of Iron atoms on each side? _____
Number of Oxygen atoms on each side? _____

Mixtures

Combination of two or more components/items that retain their identities. When a mixture's components are easily recognizable, it is called a ***heterogeneous mixture***.

Examples of heterogeneous mixtures: beach sand,

Solutions

When a mixture is homogeneous. The components cannot be distinguished from each other, even though they *retain* their original properties. Can be a liquid, gas or solid.

Examples of solutions: seawater, air, metal alloys (brass), molten rock.

Acids

A solution that contains hydrogen ions (H^+). A hydrogen ion is created when hydrogen loses its electron. H^+ = a single proton. Acids are often referred to as *proton donors*. Makes food taste sour. A solution below 7 on the pH scale is acidic.

- Strong acids
    - Hydrochloric acid: HCl stomach acid
    - Sulfuric acid: H_2SO_4 used in manufacturing
    - Nitric acid: HNO_3 fertilizers and explosives

- Weaker acids
    - Carbonic acid: pop
    - Boric acid: cleaning
    - Acetic acid
    - Citric acid

Bases

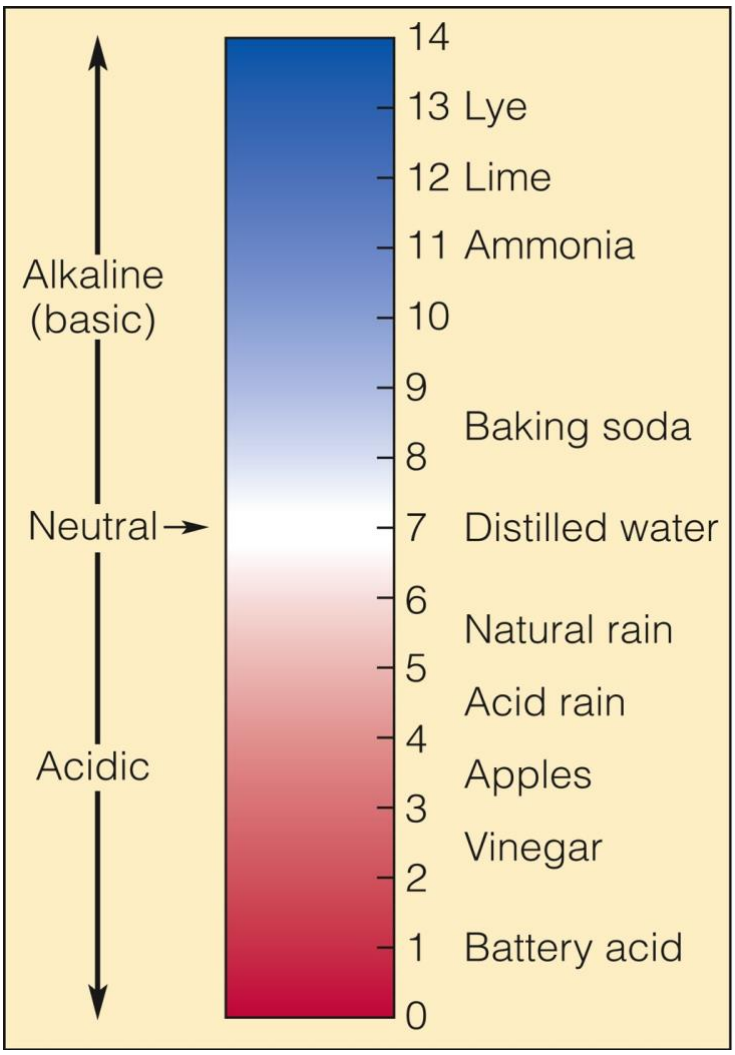
A solution that contains hydroxide ions (OH^-). Makes food taste bitter. A solution above 7 on the pH scale is basic. Makes food taste bitter and will emulsify/dissolve fat. They also make things slippery. Therefore, many household cleaners are basic.

- Strong bases
    - Sodium Hydroxide NaOH drain cleaner
    - Potassium Hydroxide KOH battery electrolyte
    - Calcium Hydroxide $Ca(OH)_2$ plaster
    - Magnesium Hydroxide $Mg(OH)_2$ laxative/antacid

- Weak bases
    - Ammonium Hydroxide NH_4OH cleaner
    - Aluminum Hydroxide $Al(OH)_3$ deodorant

*Acids can neutralize bases and bases can neutralize acids. *
Equal amounts of H^+ and OH^- = water H_2O

$$H^+ + OH^- = H_2O$$



ph Scale – based on the amount of hydrogen ions in a solution. Scale of 0-14

0 = most acidic
14 = most basic
7 = being neutral

What do the pH numbers mean?

pH 4 = .0001 g/L of H^+
.0000000001 g/L of OH^-

pH 7 = .0000001 g/L of H^+
.0000001 g/L of OH^-

pH of 1 = 10^{-1} g/L of H^+

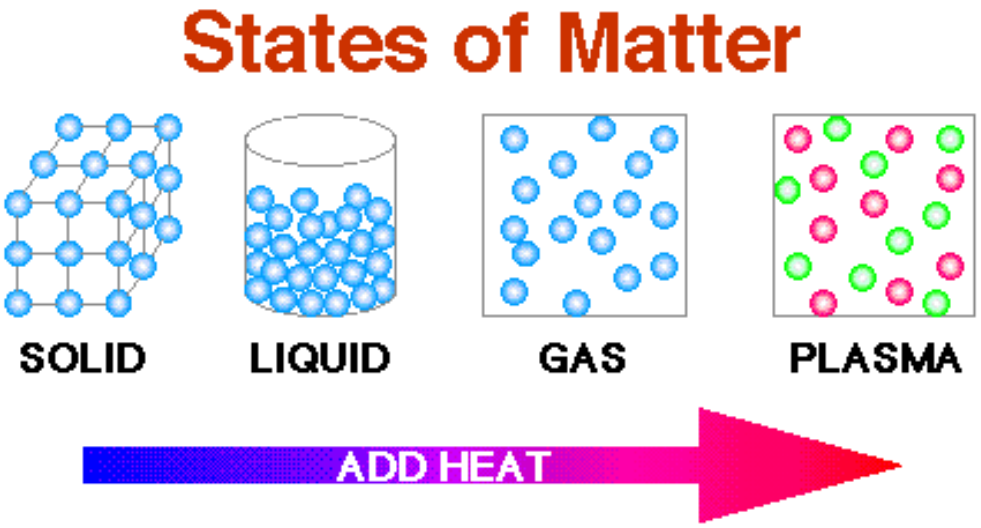
pH of 13 = 10^{-13} g/L of H^+

States of Matter

Essential Questions:

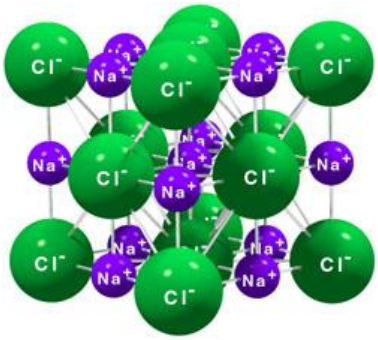
1. What are the different states of matter on Earth?
2. Why does matter exist in these states?
3. How is thermal energy related to changes in states of matter?

Matter exists in four states in the universe.



Solids

Are substances that have densely packed particles and have a definite shape and volume. Most solids have a crystalline structure: particles are arranged in a regular geometric pattern. Table salt (halite) is an example. It has a cubic shape.

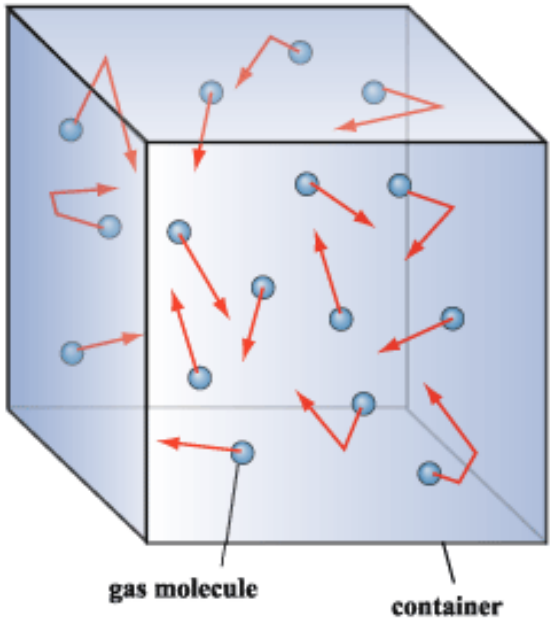


Liquids

Densely packed, ever-changing arrangements of atoms and molecules are liquids. Liquids take the shape of the container they are in. they have a definite volume.

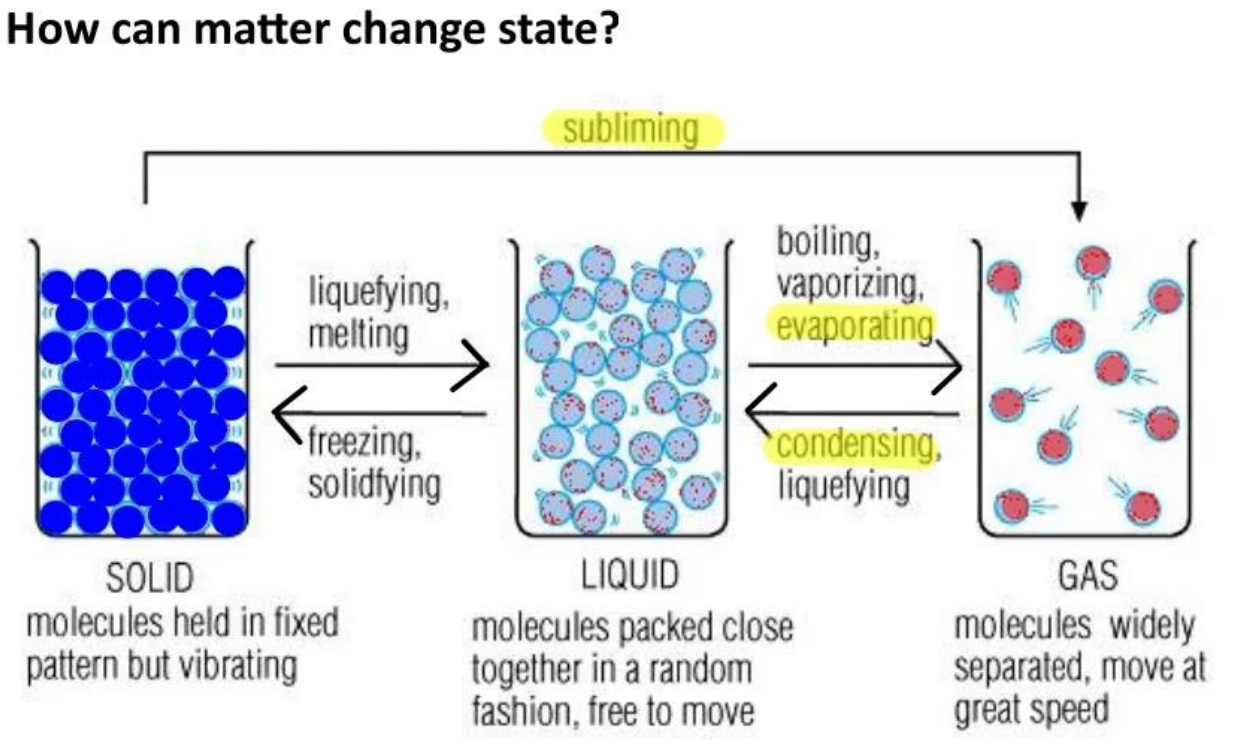
Gases

Atoms or molecules always occupy the whole of the space in which they are contained. No definite shape or volume unless restrained by a container or by gravity (our atmosphere).



Changes of State

Changes of state are physical changes in matter. They are reversible changes that do not involve changes in matter's chemical makeup or chemical properties. Changes of state occur when there is a change in thermal energy. Common changes of state include **melting, freezing, sublimation, deposition, condensation, and vaporization**.



Sublimination: change of state from a solid to a gas.

Condensation: change of a gas to a liquid.

Evaporation: slow change from a liquid to a gas at temperatures well below the boiling point.