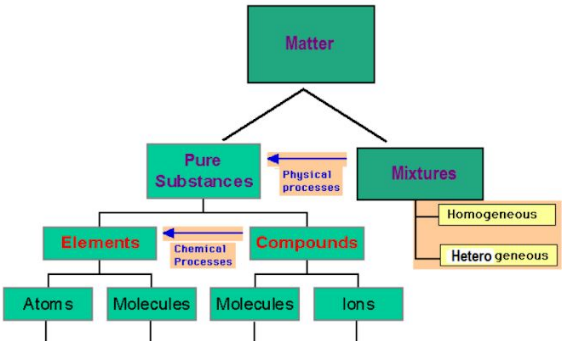
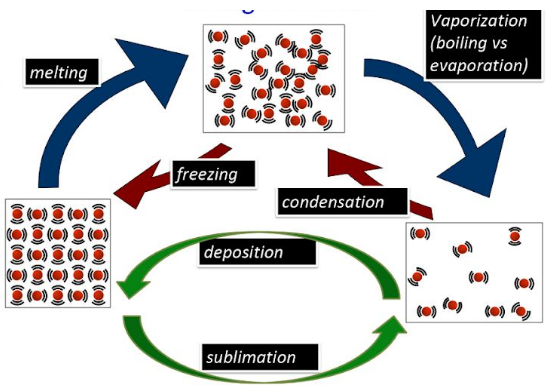
STOICHIOMETRIC RELATIONSHIPS

Particulate nature of matter

- The matter is anything that has mass and occupies space
- Atoms are the building blocks of everything on Earth
- A chemical element is a substance that cannot be broken down into simpler substances by chemical methods. All atoms of an element have the same number of protons.
- A compound is a substance formed by the chemical combination of two or more elements in a fixed ratio.
- Mixtures contain more than one element and/or compound that are not bonded chemically together. Because of this, the components of the mixture retain their individual properties.
    - Homogeneous.- All components of the mixture are in the same phase, have uniform properties. Example: air.
    - Heterogeneous.- There is a physical boundary between two phases, non-uniform properties. Example: oil and water.

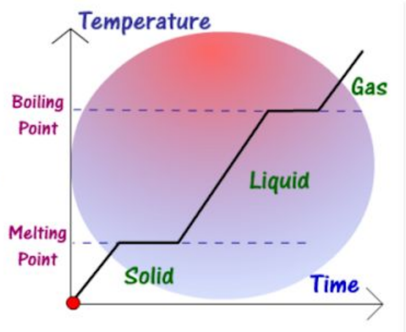


- Solid-state
    - Fixed shape and volume
    - Cannot be compressed
    - Particles held together by intermolecular forces in a fixed position
    - Particles vibrate in fixed positions
    - As heat is supplied, it reaches a temperature when the vibration is enough to overcome the attractive forces that hold the solid together and it melts.
- Liquid state
    - Fixed volume
    - Cannot be compressed
    - Takes up the shape of the container
    - Particles held closely together by intermolecular forces, weaker than solids
    - Particles vibrate, rotate and translate
    - As heat is supplied, particles move faster. Some faster than



others, creating a vapor. When the pressure of the vapor = pressure above, the liquid boils.

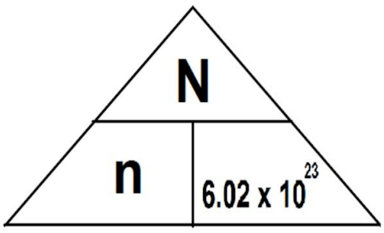
- Gaseous state
  - No fixed volume
  - No fixed shape - expands to occupy space available
  - Can be compressed
  - Forces between particles are negligible
  - Particles vibrate, rotate and translate faster than in a liquid
- Heating curves
  - The melting point and boiling points are flat lines because the energy added at phase change goes into breaking intermolecular forces and not to raise the temperature.



- Ions are atoms with a positive charge (cation) or a negative charge (anion)
- Polyatomic ions are covalent molecules with a charge that acts as a unit in ionic compounds.

Ammonium NH4+	Carbonate CO3 2-	Hydroxide OH-
Nitrite NO2 -	Nitrate NO3 -	Sulphite SO3 2-
Sulfate SO4 2-	Phosphite PO3 2-	Phosphate PO4 2-

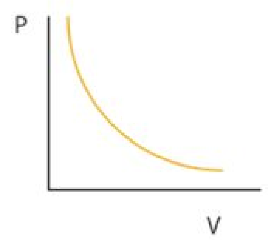
<u>The mole concept</u>



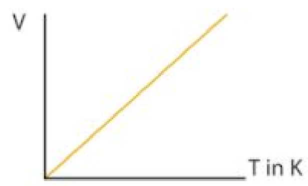
- Mole is the unit of the amount of a substance. One mole of a substance has a mass equal to its formula mass in grams. One mole of a substance contains 6.02×10^{23} (Avogadro's constant) of atoms, ions or molecules.
- N stands for the number of particles (ions, atoms, molecules, etc.
- n stands for the number of mols
- Hydrogen atoms have 1/12 of the mass of a carbon 12 atoms
- Relative atomic mass is the weighted mean of all the naturally occurring isotopes of the element relative to carbon 12.
- Molar mass is the mass of one mole of any substance.
- $Number\ of\ moles\ = \frac{mass}{molar\ mass}$ $\quad n = \frac{m}{M}$
- Percentage composition is the amount of each element in a compound expressed as a percentage
- The empirical formula of a compound is defined as the simplest whole-number ratio of atoms of different elements in the compound.
- The molecular formula of a compound is the actual number of atoms of different elements
- covalently bonded in a molecule.

Reacting masses and volumes

- $\%yield = \frac{Actual\ yield}{Theoretical\ yield} \times 100$
- $\%error = \frac{Actual\ yield - theoretical\ yield}{Theoretical\ yield} \times 100$
- The limiting reactant determines the amount of product that is formed, as it is depleted first in the reaction.
- Avogadro's law.- "at the same temperature and pressure, equal volumes of different gases contain the same numbers of particles". Avogadro's law enables the mole ratio of reacting gases to be determined from volumes of the gases.
  - 1 mole of gas = 22.7L at STP (0C, 273K, 100kPa)
  - $\frac{V1}{n1} = \frac{V2}{n2}$
- Gases are highly compressible, thermally expandable, have high viscosity, low densities and infinitely miscible.
- An ideal gas
  - The particles in a gas are in constant and rapid motion.
  - The particles collide with one another as well as with the walls of the container, but there is no energy loss (perfectly elastic).
  - Gas particles are considered to be dimensionless, with no significant volume.
  - No attraction or repulsion between particles.
  - Particles of a gas are very far apart from each other based on their relative size.
  - No limit to compression.
- Real gas
  - A real gas is more like an ideal gas in low pressure and high temperature.
    - A high-pressure gas, particles are closer together and cause the volume of the particles to be considered
    - Low temperature, particles have less KE, so they have some attractive forces.
  - Do not flight straight. When particles pass through each other, they deviate their path a little.
  - *Do have repulsion or attraction (electrostatic forces).*
  - Loose energy in collisions, little slower when particles collide.
  - *Have a different volume than other gas particles and have one.*
  - Limit to compression.



- Boyle's law.- At constant temperature. As the volume decreases, the concentration of the particle increases, resulting in more collisions with the container walls. The pressure exerted by the gas is the result of this collisions. This means that an increase in pressure is inversely proportional to the volume. (ONLY CURVED LINE)
  - P1V1=P2V2



- Charle's law.- At constant mass and pressure, the volume and temperature are directly proportional. At higher temperatures, the particles have greater average velocity so individual particles will collide with the container walls with greater force. For the pressure to be constant, there must be fewer collisions per unit area, so the volume of the gas must increase.

- $\frac{V1}{T1} = \frac{V2}{T2}$

- Gay-Lussacs Law.- At constant mass and volume, pressure and temperature are directly proportional. Increasing the temperature increases the average kinetic energy so the force of the collisions from particles and the container increases, hence pressure increases.
    - $\frac{P1}{T1} = \frac{P2}{T2}$
- Ideal gas law
    - PV=nRT
    - Pressure (Pa)
    - Volume (m3)
    - Number of moles
    - Temperature (K)
    - Universal Gas constant
- Dalton's law of partial pressures.- As the type of gas does not affect the gas laws it follows then that each gas must act as a unit in causing gas pressure. The Law of Partial Pressure states that the total gas (vapor) pressure is equal to the partial pressures of each individual gas in the mixture
- Combined gas law → $V1P1T2 = V2P2T1$
- Collision theory
    - Particles must collide in order to react
    - Collisions must have enough KE to break chemical bonds (activation energy)
    - As temperature increases, particles move faster, increasing the likelihood of bond breakage upon collision.
    - Need to be in the right angle and orientation
- Concentration
    - Solute.- something that dissolves
    - Solvent.- is something that does the dissolving
    - Concentration.- It is a measure of the amount of solute in a solution. $C = \frac{n}{V}$
    - Units for concentration.- M, moldm-3, mol/dm3
- Molarity is the measurement of the concentration of a solution
    - M= moles of solute/ liters of solution = mol/L
- Titration is a method to determine the concentration of an unknown using a known concentration called the titrant or standard solution.
    - The analyte is the chemical being measured and is also called the aliquot or titrate.
    - The indicator is a chemical that changes color to signal the equivalence point.
- Dilutions.- When a solution is diluted, more solvent is added to the same number of moles of solute.
    - M1V1 = M2V2
    - M1=original molarity of the solution
    - V1=original volume of solution
    - M2=new molarity of solution after dilution
    - V2=new volume of a solution after dilution

- A stock solution is a concentrated solution that will be diluted to a lower concentration for actual use