

stoichiometric

principles-

The **principles** of **stoichiometry** are based upon the law of conservation of mass. Matter can neither be created nor destroyed, so the mass of every element present in the product(s) of a chemical reaction must be equal to the mass of each and every element present in the reactant(s).

: **Mole fraction** of solute = (**Moles** of Solute) / (Total number of **moles** of the solutes and the solvent).

CONCENTRATION TERM-

***MOLARITY**- Moles of solute in /volume of solution in L

***MOLALITY**- Moles of solute in /weight of solvent in kg

***NORMALITY**-gram equivalent of solvent /volume of solution in L

Problem : $2\text{Al} + 3\text{Cl}_2 \rightarrow 2\text{AlCl}_3$

When 80 grams of aluminum is reacted with excess chlorine gas, how many formula units of AlCl_3 are produced?

80g of Al/27g of Al \times 1 mole Al = 2.96 moles Al

There is a 1:1 ratio between Al and AlCl_3 , therefore there are 2.96 moles AlCl_3 .

(2.96 moles of AlCl_3)(6.02×10^{23} formula units)/ 1 mole AlCl_3 = 1.78×10^{25}

Problem : What is the mass of 2 moles of H₂S?

GFM of H = 1

GFM of S = 32
GFM of H₂S = 2×1 + 32 = 34 grams / mole

$$2\text{mole}/1\text{mole} \times 34 \text{ grams} = 68 \text{ grams}$$

***Density**-Density, mass of a unit volume of a material substance. The formula for **density** is **$d = M/V$** , where d is **density**, M is mass, and V is volume. **Density** is commonly expressed in units of grams per cubic centimetre. ... For example, the **density** of air is 1.2 kilograms per cubic metre.

*Density of solid and liquid depend on temperature

*Density of gas depend on temperature and pressure

*Weight density is also known as specific weight and is equal to weight of fluid/unit volume

*specific volume is reciprocal of density

ie. specific volume = $1/\text{density}$

*The term BULK DENSITY is used for solid substance and is equal to, MASS OF SOLID IN AIR/VOLUME OF SOLID

*specific gravity = density of fluid/density of reference fluid

GRAVITY SCALE—

A **gravity scale** is a system of measurement showing the relative density of fluids. ... A reading of 1.5 on the specific **gravity scale** indicates that the liquid tested is one and one-half times heavier than water, volume for volume.

1. Baume gravity scale definition-

The Baumé scale is a pair of hydrometer scales developed by French pharmacist Antoine Baumé in 1768 to measure density of various liquids. ... The Baumé of distilled water is 0.

*If liquid lighter than water then,

$$\text{Baume gravity scale} = 140/G - 130$$

*If liquid heavier than water then,

$$\text{Baume gravity scale} = 145 - 145/G$$

2.API SCALE-

the American Petroleum Institute gravity **scale**: a universally accepted **scale** of the relative density of fluids that is used in fuel technology and is measured in degrees **API**.

One degree **API is equal to** $(141.5/d) - 131.5$, where d = relative density at 288.7K.

#REAL GAS AND IDEAL GAS-

*Boyle's law-

Boyle's law is a gas law that states that a gas's pressure and volume are inversely proportional. When the temperature is kept constant

*Charles law definition-

Charles's law, a statement that the volume occupied by a fixed amount of gas is directly proportional to its absolute temperature, if the pressure remains constant.

*Gay-Lussac law definition-

Gay-Lussac's law states that the pressure of a given mass of gas varies directly with the absolute temperature of the gas when the volume is kept constant.

Ideal gas equation, $PV=nRT$

Values of R

8.3144598

8.3144598×10^3

8.3144598×10^{-2}

8.3144598

*62.363577

1.9872036×10^{-3}

8.2057338×10^{-5}

0.082057338

Units

J.K⁻¹.mol⁻¹

amu.m².s⁻².K⁻¹

L.bar.K⁻¹.mol⁻¹

m³.Pa.K⁻¹.mol⁻¹

L.Torr.K⁻¹.mol⁻¹

kcal.K⁻¹.mol⁻¹

m³.atm.K⁻¹.mol⁻¹

L.atm.K⁻¹.mol⁻¹

*Partial pressure -

A pressure exerted by a constituent by a mixture which its atom occupy the total volume at a given temperature is called partial pressure

Partial pressure= mole fraction x total pressure

Pure composition volume-

PCV of a gas that is present in a mixture of gas is the volume that would be occupied by that component gas if it alone were present at the same pressure and temperature as a mixture

#Dalton's law of partial pressure-

According to **Dalton's law of partial pressures**, the total **pressure** by a mixture of gases is equal to the sum of the **partial pressures** of each of the constituent gases. The **partial pressure** is defined as the **pressure** each gas would exert if it alone occupied the volume of the mixture at the same temperature.

$P_{\text{total}} = p_1 + p_2 + p_3 + \dots$

#Amgat's law-

According to Amgat's law,

The total volume occupied by gas mixture is equal to the sum of pure component volume

$$V_{\text{total}} = V_1 + V_2 + V_3 + \dots$$

#REAL GAS

Gases liquefy when their component molecules come into contact and interact with each other, this will always happen before absolute zero because **real gas** particles have volume. But an ideal **gas** has particles of zero volume, and no intermolecular interactions, by **definition**. Therefore it can not liquefy.

*van der Waals equation-

The **van der Waals equation** is an **equation** of state that corrects for two properties of **real gases**: the excluded volume of **gas** particles and attractive forces between **gas** molecules. The **van der Waals equation** is frequently presented as:
$$\left(P + \frac{an^2}{V^2}\right)(V-nb) = nRT$$

.

#VAPOR PRESSURE

Vapor pressure (or vapour pressure in British English; see spelling differences) or **equilibrium vapor pressure** is defined as the pressure exerted by a vapor in thermodynamic equilibrium with its condensed phases (solid or liquid) at a given temperature in a closed system. The equilibrium vapor pressure is an indication of a liquid's evaporation rate. It relates to the tendency of particles to escape from the liquid (or a solid). A substance with a high vapor pressure at normal temperatures is often referred to as volatile. The pressure exhibited by vapor present above a liquid surface is known as vapor pressure. As the temperature of a liquid increases, the kinetic energy of its molecules also increases. As the kinetic energy of the molecules increases, the number of molecules transitioning into a vapor also increases, thereby increasing the vapor pressure.

The vapor pressure of any substance increases non-linearly with temperature according to the Clausius–Clapeyron relation. The atmospheric pressure boiling point of a liquid (also known as the normal boiling point) is the temperature at which the vapor pressure equals the ambient atmospheric pressure. With any incremental increase in that temperature, the vapor pressure becomes sufficient to overcome atmospheric pressure and lift the liquid to form vapor bubbles inside the bulk of the substance. Bubble formation deeper in the liquid requires a higher temperature due to the higher fluid pressure, because fluid pressure increases above the atmospheric pressure as the depth increases. More important at shallow depths is the higher temperature required to start bubble formation. The surface tension of the bubble wall leads to an overpressure in the very small, initial bubbles

#Viscosity-

The **viscosity** of a [fluid](#) is a measure of its [resistance](#) to deformation at a given rate. For liquids, it corresponds to the informal concept of "thickness": for example, [syrup](#) has a higher viscosity than [water](#).^[1]

Viscosity can be conceptualized as quantifying the internal [frictional force](#) that arises between adjacent layers of fluid that are in relative motion. For instance, when a viscous fluid is forced through a tube, it flows more quickly near the tube's axis than near its walls. In such a case, experiments show that some [stress](#) (such as a [pressure](#) difference between the two ends of the tube) is needed to sustain the flow through the tube. This is because a force is required to overcome the friction between the layers of the fluid which are in relative motion. So for a tube with a constant rate of flow, the strength of the compensating force is proportional to the fluid's viscosity.

A fluid that has no resistance to shear stress is known as an *ideal* or *inviscid* fluid. Zero viscosity is observed only at [very low temperatures](#) in [superfluids](#). Otherwise, the [second law of thermodynamics](#) requires all fluids to have positive viscosity;^{[2][3]} such fluids are technically said to be viscous or viscid. A fluid with a high viscosity, such as [pitch](#), may appear to be a [solid](#).

Viscosity is an important fluid property when analyzing liquid behavior and fluid motion near solid boundaries. The viscosity of a fluid is a measure of its resistance to gradual deformation by shear stress or tensile stress. The shear resistance in a fluid is caused by inter-molecular friction exerted when layers of fluid attempt to slide by one another.

- *viscosity is the measure of a fluid's resistance to flow*
- molasses is highly viscous
- water is medium viscous
- gas is low viscous

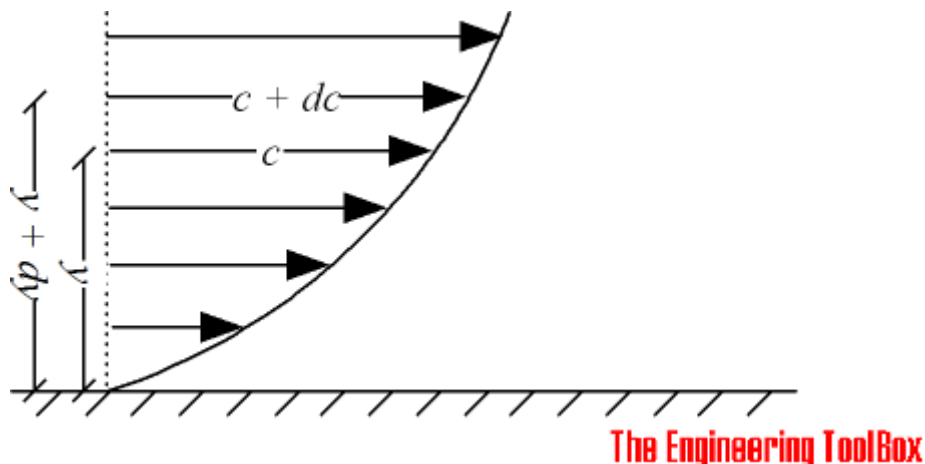
There are two related measures of fluid viscosity

- dynamic (or absolute)
- kinematic

*Dynamic (absolute) Viscosity-

Absolute viscosity - coefficient of absolute viscosity - is a measure of internal resistance. Dynamic (absolute) viscosity is the tangential force per unit area required to move one horizontal plane with respect to another plane - at a unit velocity - when maintaining a unit distance apart in the fluid.

The shearing stress between the layers of a non turbulent fluid moving in straight parallel lines can be defined for a Newtonian fluid as



Shear stress can be expressed

$$\begin{aligned}\tau &= \mu \, dc / dy \\ &= \mu \, \gamma\end{aligned}\tag{1}$$

where

τ = shearing stress in fluid (N/m²)

μ = dynamic viscosity of fluid (N s/m²)

dc = unit velocity (m/s)

dy = unit distance between layers (m)

$\gamma = dc / dy$ = shear rate (s^{-1})

Equation (1) is known as the **Newtons Law of Friction**.

(1) can be rearranged to express **Dynamic viscosity** as

$$\begin{aligned}\mu &= \tau \, dy / dc \\ &= \tau / \gamma\end{aligned}\quad (1b)$$

In the [SI system](#) the dynamic viscosity units are **N s/m², Pa s or kg/(m s)** - where

- $1 \text{ Pa s} = 1 \text{ N s/m}^2 = 1 \text{ kg/(m s)} = 0.67197 \text{ lb}_m/(\text{ft s}) = 0.67197 \text{ slug}/(\text{ft s}) = 0.02089 \text{ lb}_f \text{ s/ft}^2$

Dynamic viscosity may also be expressed in the metric CGS (centimeter-gram-second) system as **g/(cm s), dyne s/cm² or poise (p)** where

- $1 \text{ poise} = 1 \text{ dyne s/cm}^2 = 1 \text{ g/(cm s)} = 1/10 \text{ Pa s} = 1/10 \text{ N s/m}^2$

For practical use the *Poise* is normally too large and the unit is therefore often divided by 100 - into the smaller unit **centipoise (cP)** - where

- $1 \text{ P} = 100 \text{ cP}$
- $1 \text{ cP} = 0.01 \text{ poise} = 0.01 \text{ gram per cm second} = 0.001 \text{ Pascal second} = 1 \text{ milliPascal second} = 0.001 \text{ N s/m}^2$

Water at 20.2°C (68.4°F) has the absolute viscosity of one - 1 - centiPoise.

Kinematic Viscosity-

Kinematic viscosity is the ratio of - *absolute (or dynamic) viscosity to density* - a quantity in which no force is involved. Kinematic viscosity can be obtained by dividing the absolute viscosity of a fluid with the fluid mass density like

$$\nu = \mu / \rho \quad (2)$$

where

ν = kinematic viscosity (m^2/s)

μ = absolute or dynamic viscosity ($N\ s/m^2$)

ρ = density (kg/m^3)

In the SI-system the theoretical unit of kinematic viscosity is m^2/s - or the commonly used **Stoke (St)** where

- $1\ St\ (Stokes) = 10^{-4}\ m^2/s = 1\ cm^2/s$

Stoke comes from the CGS (Centimetre Gram Second) unit system.

Since the *Stoke* is a large unit it is often divided by 100 into the smaller unit **centiStoke (cSt)** - where

- $1\ St = 100\ cSt$
- $1\ cSt\ (centiStoke) = 10^{-6}\ m^2/s = 1\ mm^2/s$
- $1\ m^2/s = 10^6\ centiStokes$

The specific gravity for water at 20.2°C (68.4°F) is almost *one*, and the kinematic viscosity for water at 20.2°C

Viscosity and Reference Temperature

The viscosity of a fluid is highly temperature dependent - and for dynamic or kinematic viscosity to be meaningful the **reference temperature** must be quoted. In ISO 8217 the reference temperature for a residual fluid is 100°C. For a distillate fluid the reference temperature is 40°C.

- for a liquid - the kinematic viscosity **decreases** with higher temperature
- for a gas - the kinematic viscosity **increases** with higher temperature

Other Viscosity Units--

Saybolt Universal Seconds (or SUS, SSU)

Saybolt Universal Seconds (or *SUS*) is an alternative unit for measuring viscosity. The efflux time is Saybolt Universal Seconds (*SUS*) required for 60 milliliters of a petroleum product to flow through the calibrated orifice of a Saybolt Universal viscometer - under a carefully controlled temperature and as prescribed by test method ASTM D 88. This method has largely been replaced by the kinematic viscosity method. Saybolt Universal Seconds is also called the *SSU number (Seconds Saybolt Universal)* or *SSF number (Saybolt Seconds Furol)*.

Kinematic viscosity in SSU versus dynamic or absolute viscosity can be expressed as

$$\begin{aligned}v_{SSU} &= B \mu / SG \\ &= B v_{\text{centiStokes}}\end{aligned}\quad (3)$$

where

v_{SSU} = kinematic viscosity (SSU)

$B = 4.632$ for temperature 100°F (37.8°C)

$B = 4.664$ for temperature 210°F (98.9°C)

μ = dynamic or absolute viscosity (cP)

SG = [Specific Gravity](#)

$v_{\text{centiStokes}}$ = kinematic viscosity (centiStokes)

- [SSU at other temperatures](#)

Degree Engler

Degree Engler is used in Great Britain as a scale to measure kinematic viscosity. Unlike the *Saybolt* and *Redwood* scales, the *Engler* scale is based on comparing the flow of the substance being tested to the flow of another substance - water. Viscosity in *Engler* degrees is the ratio of the time of a flow of *200 cubic centimeters* of the fluid whose viscosity is being measured - to the time of flow of *200 cubic centimeters* of water at the same temperature (usually 20°C but sometimes 50°C or 100°C) in a standardized *Engler* viscosity meter.

Newtonian Fluids

A fluid where the shearing stress is linearly related to the rate of shearing strain - is designated as a **Newtonian Fluid**.

A Newtonian material is referred to as true liquid since the viscosity or consistency is not affected by shear such as agitation or pumping at a constant temperature. Most common fluids - both liquids and gases - are Newtonian fluids. Water and oils are examples of Newtonian liquids.

Shear-thinning or Pseudo-plastic Fluids

A Shear-thinning or pseudo-plastic fluid is a fluid where the viscosity decrease with increased shear rate. The structure is time-independent.

Thixotropic Fluids

A Thixotropic fluid has a time-dependent structure. The viscosity of a thixotropic fluid decreases with increasing time - at a constant shear rate.

Ketchup and mayonnaise are examples of thixotropic materials. They appear thick or viscous but are possible to pump quite easily.

Dilatant Fluids

A Shear Thickening Fluid - or Dilatant Fluid - increases the viscosity with agitation or shear strain. Dilatant fluids are known as non-Newton fluids.

Some dilatant fluids can become almost solid in a pump or pipe line. With agitation cream becomes butter and candy compounds. Clay slurry and similar heavily filled liquids do the same thing.

Bingham Plastic Fluids

A Bingham Plastic Fluid has a yield value which must be exceeded before it will start to flow like a fluid. From that point the viscosity decreases with increasing agitation. Toothpaste, mayonnaise and tomato ketchup are examples of such products.

Example - Air, Convert between Kinematic and Absolute Viscosity

boiling point, temperature at which the [pressure](#) exerted by the surroundings upon a [liquid](#) is equaled by the pressure exerted by the [vapour](#) of the liquid; under this condition, addition of [heat](#) results in the transformation of the liquid into its vapour without raising the temperature.



At any temperature a liquid partly vaporizes into the space above it until the pressure exerted by the vapour reaches a [characteristic value](#) called the [vapour pressure](#) of the liquid at that temperature. As the temperature is increased, the vapour pressure increases; at the [boiling](#) point, bubbles of vapour form within the liquid and rise to the surface. The boiling point of a liquid varies according to the applied pressure; the normal boiling point is the temperature at which the vapour pressure is equal to the standard sea-level [atmospheric pressure](#) (760 mm [29.92 inches] of mercury). At [sea level](#), water boils at 100° C (212° F). At higher altitudes the temperature of the boiling point is lower.

NORMAL BOILING POINT-

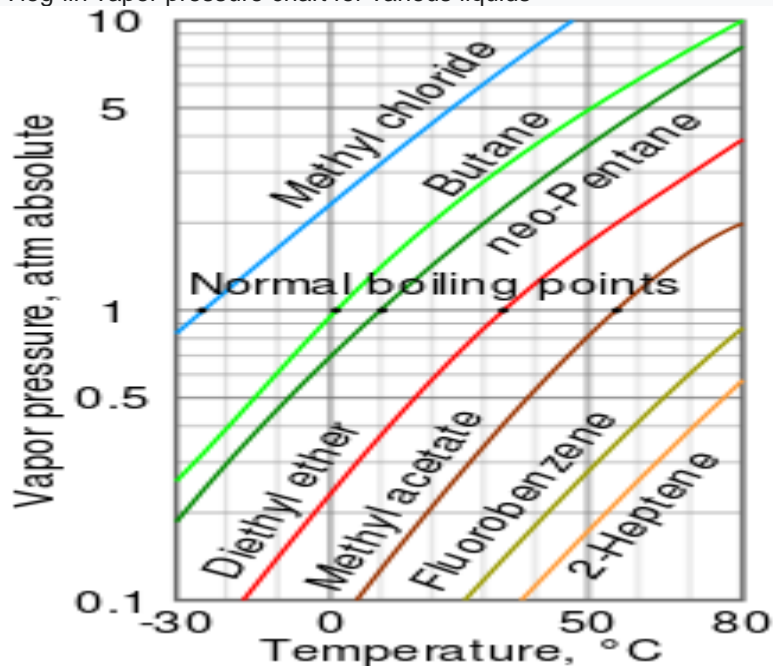
The **normal boiling point** (also called the **atmospheric boiling point** or the **atmospheric pressure boiling point**) of a liquid is the special case in which the vapor pressure of the liquid equals the defined atmospheric pressure at sea level, one [atmosphere](#).^{[4][5]} At that temperature, the vapor pressure of the liquid becomes sufficient to overcome atmospheric pressure and allow bubbles of vapor to form inside the bulk of the liquid. The **standard boiling point** has been defined by [IUPAC](#) since 1982 as the temperature at which boiling occurs under a pressure of one [bar](#).^[6]

The [heat of vaporization](#) is the energy required to transform a given quantity (a mol, kg, pound, etc.) of a substance from a liquid into a gas at a given pressure (often atmospheric pressure).

Liquids may change to a vapor at temperatures below their boiling points through the process of [evaporation](#). Evaporation is a surface phenomenon in which molecules located near the liquid's edge, not contained by enough liquid pressure on that side, escape into the surroundings as [vapor](#). On the other hand, [boiling](#) is a process in which molecules anywhere in the liquid escape, resulting in the formation of vapor bubbles within the liquid.

Relation between the normal boiling point and the vapor pressure of liquids

A log-lin vapor pressure chart for various liquids



The higher the vapor pressure of a liquid at a given temperature, the lower the normal boiling point (i.e., the boiling point at atmospheric pressure) of the liquid.

The vapor pressure chart to the right has graphs of the vapor pressures versus temperatures for a variety of liquids.^[10] As can be seen in the chart, the liquids with the highest vapor pressures have the lowest normal boiling points.

For example, at any given temperature, [methyl chloride](#) has the highest vapor pressure of any of the liquids in the chart. It also has the lowest normal boiling point (−24.2 °C), which is where the vapor pressure curve of methyl chloride (the blue line) intersects the horizontal pressure line of one atmosphere ([atm](#)) of absolute vapor pressure.

The [critical point](#) of a liquid is the highest temperature (and pressure) it will actually boil at.

Saturation temperature and pressure

Demonstration of the lower boiling point of water at lower pressure, achieved by using a [vacuum pump](#).

Main article: [Vapor–liquid equilibrium](#)

A *saturated liquid* contains as much thermal energy as it can without boiling (or conversely a *saturated vapor* contains as little thermal energy as it can without [condensing](#)).

Saturation temperature means *boiling point*. The saturation temperature is the temperature for a corresponding saturation pressure at which a liquid boils into its [vapor phase](#). The liquid can be said to be saturated with [thermal energy](#). Any addition of thermal energy results in a [phase transition](#).

If the pressure in a system remains constant ([isobaric](#)), a vapor at saturation temperature will begin to condense into its liquid phase as thermal energy ([heat](#)) is removed. Similarly, a liquid at saturation temperature and pressure will boil into its vapor phase as additional thermal energy is applied.

The boiling point corresponds to the temperature at which the vapor pressure of the liquid equals the surrounding environmental pressure. Thus, the boiling point is dependent on the pressure. Boiling points may be published with respect to the [NIST, USA standard pressure](#) of 101.325 [kPa](#) (or 1 [atm](#)), or the [IUPAC](#) standard pressure of 100.000 kPa. At higher elevations, where the atmospheric pressure is much lower, the boiling point is also lower. The boiling point increases with increased pressure up to the [critical point](#), where the gas and liquid properties become identical. The boiling point cannot be increased

beyond the critical point. Likewise, the boiling point decreases with decreasing pressure until the [triple point](#) is reached. The boiling point cannot be reduced below the triple point.

If the heat of vaporization and the vapor pressure of a liquid at a certain temperature are known, the boiling point can be calculated by using the [Clausius–Clapeyron equation](#), thus:

Saturation pressure is the pressure for a corresponding saturation temperature at which a liquid boils into its vapor phase. Saturation pressure and saturation temperature have a direct relationship: as saturation pressure is increased, so is saturation temperature.

If the temperature in a [system](#) remains constant (an [isothermal](#) system), vapor at saturation pressure and temperature will begin to [condense](#) into its liquid phase as the system pressure is increased. Similarly, a liquid at saturation pressure and temperature will tend to [flash](#) into its vapor phase as system pressure is decreased.

There are two conventions regarding the *standard boiling point of water*. The *normal boiling point* is 99.97 °C (211.9 °F) at a pressure of 1 atm (i.e., 101.325 kPa). The IUPAC recommended *standard boiling point of water* at a standard pressure of 100 kPa (1 bar)^[7] is 99.61 °C (211.3 °F).^{[6][8]} For comparison, on top of [Mount Everest](#), at 8,848 m (29,029 ft) elevation, the pressure is about 34 kPa (255 Torr)^[9] and the boiling point of water is 71 °C (160 °F). The Celsius temperature scale was defined until 1954 by two points: 0 °C being defined by the water freezing point and 100 °C being defined by the water boiling point at standard atmospheric pressure.

MATERIAL

BALANCE

INTRODUCTION -The material balance is the fundamental tool of chemical engineering. It is the basis for the analysis and design of chemical processes. So it goes without saying that chemical engineers must thoroughly master its use in the formulation and solution of chemical processing problems. In chemical processing we deal with the transformation of raw materials of lower value into products of higher value and, in many, cases unwanted by products that must be disposed of. In addition many of these chemical compounds may be hazardous. The material balance is the chemical engineer's tool for keeping track of what is entering and leaving the process as well as what goes on internally. Without accurate material balances, it is impossible to design or operate a chemical plant safely and economically.

#Types of Material Balance

First let us look at the types of material balance problems that arise in chemical engineering. There are four basic types of problems:(

- 1) Flow sheet material balance models for continuous processes operating in the steady state,
- (2) Mixing and blending material balances,

(3) Flow sheet material balances for non-steady state processes, either continuous or batch, and

4) Process data analysis and reconciliation

A flow sheet is a schematic diagram of a process which shows at various levels of detail the equipment involved and how it is interconnected by the process piping (See, for instance Figures II-1 and II-2 in Chapter II). A flow sheet material balance shows the flow rates and compositions of all streams entering and leaving each item of equipment. Most of the emphasis on material balance problems has been on continuous processes operating in the steady state. Again one might ask why. The reason is simple. Of the total tonnage of chemicals produced, the vast majority is produced using continuous steady-state processes. This includes oil refineries as well as chemical plants producing large tonnage products such as sulfuric acid, ethylene, and most of the other commodity chemicals, petrochemicals and

rate and product quality and calculated backwards through the process. Intermediate specifications would be used as additional starting points for calculations. As will be seen later in these notes, such an approach goes against the output-from-input structure of the process and can lead to severe numerical instabilities. The growing availability of digital computers in the late 1950's led to the development of the first material balance programs such as IBM's GIFS, Dartmouth's PACER and Shell's CHEOPS. Almost every major oil and chemical company soon developed in-house programs of which Monsanto's Flowtran is the best-known example. By the 1970's several companies specializing in flow sheet programs had come into existence. Today companies such as Simulation Sciences, Aspen Technology and Hyprotech provide third-generation

versions of steady-state flow sheet simulation programs that provide a wide range of capabilities and are relatively easy to use compared to earlier versions. Dynamic simulation is less advanced than steady-state simulation. This is due, in part, to the lack of emphasis until recently on the dynamic aspects of chemical engineering operations. This situation is changing rapidly due to demands for improved process control and for simulators for training operating personnel. The companies mentioned in the previous paragraph have all recently added dynamic simulators to their product lines. In addition several companies such as ABB on offer training simulators for the process industries.

C. Material Balance Methodology

There are two major steps involved in applying the principle of conservation of mass to chemical processing problems. The first is the formulation of the problem; the second, its solution. By formulation of the problem is meant determining the appropriate mathematical description of the system based on the applicable principles of chemistry and physics. In the case of material balances, the appropriate physical law is the conservation of mass. The resulting set of equations is sometimes referred as a mathematical model of the system. What a mathematical model means will be made clearer by the examples contained in these notes. However, some general comments are in order. First, there may be a number of mathematical models of varying levels of detail that can apply to the same system. Which we used upon what aspects of the process we wish to study. This will also become clearer as we proceed. Second, for many systems of practical interest, the number of equations involved in the model can be quite large, on the order of several hundred or even several thousand.

CONSERVATION OF MASS

The principle of conservation of mass is fundamental to all chemical engineering analysis. The basic idea is relatively easy to understand since it is fact of our everyday life. Let us consider a simple example.

Suppose we are required to prepare one kilogram of a solution of ethanol in water such that the solution will contain 40% ethanol by weight. So, we weigh out 400 grams of ethanol and 600 grams of water and mix the two together in a large beaker. If we weigh the resulting mixture (making appropriate allowance for the weight of the beaker), experience says it will weigh 1000 grams or one kilogram. And it will.