Chemical Engineering Principle answer

1) Define the following

a) Pressure:
is the ratio of force to the area over which the force acts.

b) Weight:
the weight of an object is the force exerted on it by gravitational attraction.

c) Force:
force is the product of mass and acceleration.

d) Density:
mass per unit volume.

e) Flowrate:
is the rate at which a material is transported through a process line.

f) Atomic Weight:
is the mass of the atom of an element.

g) Mole Fraction:
is the mole of substance to the total moles.

h) Concentration:
is the quantity of component per unit volume of the mixture.

2) Write the ideal gas law and mention its variables.

$$PV=nRT$$

(where $P_{absolute}$, $P_{of\ gas}$, V= Volume of gas , n= no. of mole, R= gas constant, T= absolute temprature of gas.)

3) Mention the 2 types of units system

a) SI system (international system of units)

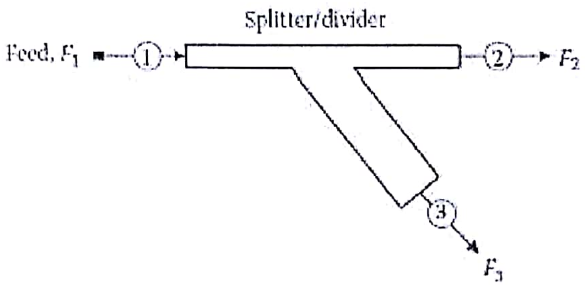
b) AES (American engineering system of units)

1) Mention the equation of number of degree of freedom for molecular species balance.

$$\text{NDF} = \begin{bmatrix}\text{Number of}\\\text{unknowns}\end{bmatrix} + \begin{bmatrix}\text{Number of}\\\text{independant}\\\text{chemical reaction}\end{bmatrix} - \begin{bmatrix}\text{Number of}\\\text{Independant molecular}\\\text{species balances}\end{bmatrix} - \begin{bmatrix}\text{Number of other}\\\text{equation relating}\\\text{variables}\end{bmatrix}$$

2) Draw and write a short note about each of the following process units.

a) Divider .

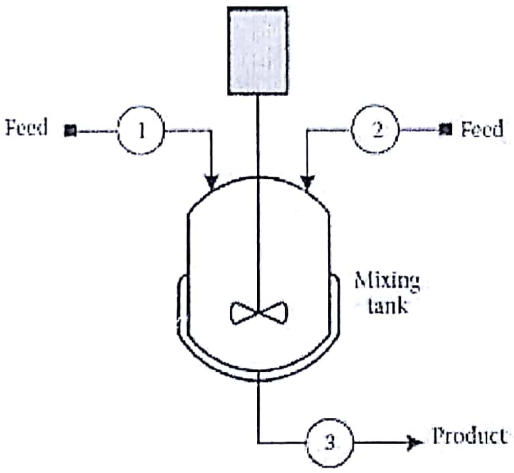


Flowrate of A,B,C maybe different

Composition stream A,B,C are the same

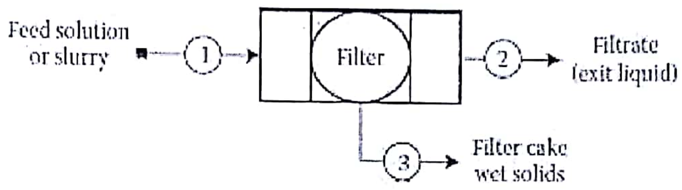
The total mass balance A=B+C

b) Mixer



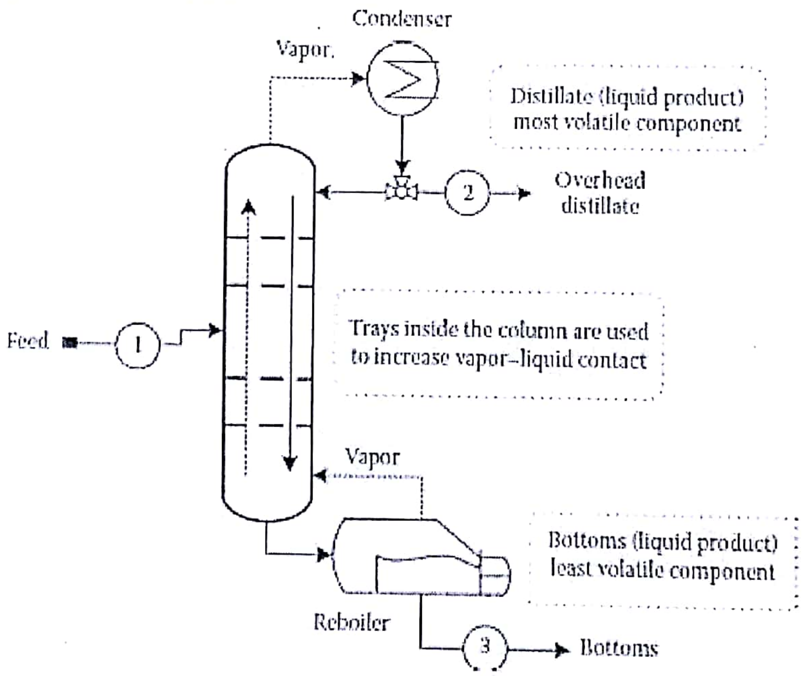
2 or more entering stream only one exits or the mixed stream maybe used any type of places.

c) Filter



Exit liquid free of solid filtrate is saturated with soluble components. The filter cake leaves with some liquid attached exit liquid and filter cake concentration are the same.

d) Distillation column



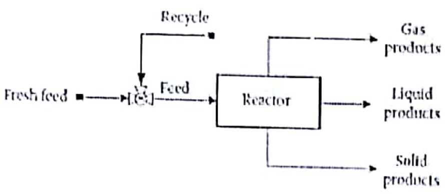
More volatile components are in the distillate.

Less volatile components are in the bottom.

Separation is accomplished by boiling

Perfect separation is not possible.

c)chemical reactor



Chemical reaction taking place within it. A reactor is sometimes preceded by a fictitious mixer, if the combined reactor feed is specified or must be determined. Multiple exit streams are shown to remind you to watch for streams that separate because of their different phases .

4- A gauge on a tank reads 15 psi. what is the absolute pressure in the tank?

Solution:

$P_{abs} = P_{gauge} + P_{atm}$

Since atmospheric pressure was not given, we must assume it is 14.69 psi. thus, we find the absolute pressure in the tank as

$P_{abs} = 14.69 + 15 = 30$ psia

4-b)Convert an acceleration of 1 cm/s2 to its equivalent in km/y h time.

Solution: $\frac{1\,cm}{s^2}\left|\frac{3600^2 s^2}{1^2 h^2}\right|\frac{24^2 h^2}{1^2 day^2}\left|\frac{365^2 day^2}{1^2 yr^{-2}}\right|\frac{1\,m}{10^2 cm}\left|\frac{1\,km}{10^3 m}\right.$

$$= \frac{(3600x24x365)^2}{10^2 x 10^3}\frac{km}{yr^{-2}} = \boxed{9.95x10^9 km/y^2}$$

4-c)Convert the following:

a) 1 mile/h to km/h b) 1 ft/s to liter/s

Solution: a) $\frac{1\ mile}{h}\Big|\frac{1760\ x\ 3\ ft}{mile}\Big|\frac{30.48\ cm}{1\ ft}\Big|\frac{1\ m}{100\ cm}\Big|\frac{km}{1000}$

$$= \frac{1760x3x30.48}{10^5} = 1.61\frac{km}{h}$$

b) $\frac{1ft^3}{s}\Big|\frac{(30.48)^3cm^3}{1ft^3}\Big|\frac{1\ lit}{10^3cm^3} = 28.32\ lit/s$

4-d)Convert 23 lb_m.ft/min² to its equivalent kg.cm/s²

Solution: as before, begin by writing dimensional equation, fill in the units of conversion factors (new/old) and then do the numerical values of these factors, and then do the arithmetic. The result is,

$$\frac{23\ lb_m.ft}{min^2}\Big|\frac{0.453593\ kg}{1\ lb_m}\Big|\frac{100\ cm}{3.281\ ft}\Big|\frac{1^2min^2}{(60)^2s^2}$$

(Cancellation of units leaves kg.cm/s²)

$$\frac{(23)(0.453593)(100)}{(3.281)(3600)}\frac{kg.cm}{s^2} = \boxed{0.088\frac{kg.cm}{s^2}}$$

4-e)Calculate the average molecular weight of air(1) from its approximate molar composition of 79% N_2, 21% O_2(2) from its approximate composition by mass of 76.7% N_2, from its 23.39%, O_2.

Solution:

$$\bar{M} = y_{M_2}M_{M_2} + y_{O_2}M_{O_2}$$

$$= \frac{0.79kmolN_2}{kmol}\Big|\frac{28\ kgN_2}{kmol} + \frac{0.21\ kmolO_2}{kmol}\Big|\frac{32\ kgO_2}{kmol}$$

$$= \boxed{29\frac{kg}{kmol}}\left(= 29\frac{lb_m}{lb-mol} = 29\frac{g}{mol}\right)$$

How many of each of the following are contained in 100.0 g of CO2 (M=44.01) 3 moles C, 4 mol O, 5 moles on 6 g O; 7 g O2; 8 molecules of CO2

Solution:

$$\frac{100.0\ gCO_2}{}\Big|\frac{1\ molCO_2}{44.01\ gCO_2} = \boxed{2.2773\ molCO_2}$$

$$\frac{2.273\ molCO_2}{}\Big|\frac{1\ lb-mol}{453.6\ mol}=\boxed{5.011x10^{-3}lb-molCO_2}$$

$$\frac{2.273\ molCO_2}{}\Big|\frac{1\ molC}{1\ molCO_2}=\boxed{2.273\ molC}$$

$$\frac{2.273\ molCO_2}{}\Big|\frac{2\ molO}{1\ molCO_2}=\boxed{4.546\ molO}$$

$$\frac{2.273\ molCO_2}{}\Big|\frac{1\ molO_2}{1\ molCO_2}=\boxed{2.273\ molO_2}$$

$$\frac{4.546\ molO}{}\Big|\frac{16.0\ gO}{1\ molO}=\boxed{72.7\ gO}$$

$$\frac{2.273\ molO_2}{}\Big|\frac{32.0\ gO_2}{1\ molO_2}=\boxed{72.7\ gO_2}$$

$$\frac{2.273\ molCO_2}{}\Big|\frac{6.02x10^{23}molecules}{1\ mol}=\boxed{1.37x10^{24}molecules}$$

Batch process: In a batch process, raw materials are fed into the process at the outset. The process then runs for some length of time, producing product, but no product is removed, and no additional raw materials are input (but energy may be input or withdrawn), while the process runs. At the end, the product is removed. The bottom line is that no mass enters or leaves while the process is running. Continuous process: In this type of process, raw materials continuously enter and product continuously leaves the process.

Semibatch process: A semibatch process does not fall fully under either "batch" or "continuous" classification.

Steady-state operation: Under steady-state, the values of all variables associated with the process do not change with time. That is, at any given location in the process, the values of temperature, pressure, composition, flow rates, etc. are independent of time. Even though a process may be steady state, it is important to realize that temperature, flow rates, or other variables may, and typically do, change from one location to another (e.g. from one process stream to another).

Transient or unsteady-state operation: If some process variables change with time, then the process is transient. A process must be either steady-state or transient.

Batch and semibatch processes must be transient. Continuous processes may be transient or steady-state.