1. Make following conversions:
   (a) Wavelength 5500 A^0 to nm.
   (b) 175 grain moisture/lb dry air to g moisture/kg dry air.

2. In a double effect evaporator plant, the second effect is maintained under vacuum of 475 torr (mm Hg). Find the absolute pressure in kPa.

3. A force equal to 192.6 kg_f is applied on a piston with a diameter of 5 cm. Find the pressure exerted on the piston in kPa, bar and psi.

4. Iron metal weighing 500 lb occupies a volume of 29.25 L. Calculate the density of iron in kg/dm^3.

5. The diameter and height of a vertical cylindrical tank are 5 ft and 6 ft 6 inches respectively. It is full up to 75% height with carbon tetrachloride (CCl_4), the density of which is 1.6 kg/L. Find the mass in kilograms.

6. A bag filter of 5 micron rating is designed for a pressure drop of 0.05 lb_f/in^2 per US gallon per minute of water solution. Calculate pressure drop in kPa from the filter water flow rate of 10 m^3/h.

7. Corrosion rates are normally reported in mills per year (mpy) in the chemical process industry. For the measurement of the rates, a corrosion test coupon is inserted in the process stream for a definite period. The loss of weight is measured during the period of insertion.
   In a particular test, a coupon of carbon steel was kept in cooling water circuit. The dimension of the coupon were measured to be **7.595 cm x 1.276 cm x 0.1535 cm**. Mass of the coupon before insertion in the circuit and after exposure for 50 days were measured to be **14.9412 g** and **14.6254 g**, respectively. Calculate the rate of corrosion. Take the density of carbon steel to be the same as the one calculated in question 4. (1mill = 1/1000 inch).

8. Vapour pressure of benzene in the temperature range of 280.65K (7.5^{0}C) to 377.15K (104^{0}C) can be calculated using the following Antoine Equation.

$$\mathbf{Log_{10}P = 6.9057 - \frac{1211.0}{T+220.80}}$$

   Where P = Vapour Pressure in torr (mm Hg), and
   T = Temperature in ^{0}C

   Convert the above equation in SI Units.

9. Heat capacity of gaseous n-butane is given by

$$C_{mp}^0 = 4.429 + 40.159 \times 10^{-3}T - 68.562 \times 10^{-7}T^2$$

   Where C_{mp}^0 = Heat capacity in Btu/(lb mole. ^{0}R) and

   T = Temperature in ^{0}R

Convert the equation in SI units.

10. Pressure drop across a venture can be calculated using following Calvert Equation[12]

$$\Delta \boldsymbol{P} = \left(\mathbf{5} \times \mathbf{10^{-5}}\right)\boldsymbol{V^2}\,\boldsymbol{L}$$

Where ΔP = pressure drop, inches water column

L = liquid flow rate, US gal/1000 ft^3 gas

V = gas velocity in the venture throat, ft/s

Convert the equation in SI units.

11. In the case of fluids, the local heat-transfer coefficient for long tubes and using bulk-temperature properties in expressed by the empirical equation[13].

$$\boldsymbol{h} = \mathbf{0.023}\boldsymbol{G^{0.8}} \times \boldsymbol{k^{0.67}} \times \boldsymbol{C_p^{0.33}}/(\boldsymbol{D^{0.2}} \times \boldsymbol{\mu^{0.47}})$$

Where h = heat-transfer coefficient, Btu/(h.ft^2.^{0}F)

G = Mass velocity of fluids, lb/(ft^2.s)

C_p= heat capacity of fluid at constant pressure, Btu/(lb.^{0}F)

k = thermal conductivity, Btu/(h.ft.^{0}F)

D = diameter of tube, ft and

μ = viscosity of liquid, lb/(ft.s)

Convert the equation in SI units.

MATERIAL AND ENERGY BALANCES

1. Evaluate the ratio
   $C_p\mu/k$ from the data
   C_p = 1.0 BTU /(lb)(^{0}F); μ=0.01gm/(cm)(sec); k = 0.34 BTU / (hr)(ft)(^{0}F)

2. Convert the following
   (a) 100 miles/h to km/sec
   (b) 50 N/m^2 to lb/ft^2
   (c) 5.5 kw to J/sec
   (d) 50 lb/m^2 to kg/cm^2
   (e) 7.1 cm/(hr)^2 to ft/s^2
3. A handbook gives the equation for concentration or entrance loss of fluid entering a sudden reduction in pipeline as

$$L = \frac{kV^2}{2g_c}$$

   Where V = the velocity in ft/sec, k = a dimensionless constant
   L = the 'loss'

   What are the unit of 'loss'? If CGS units were used, what would the formula be?

4. In a pipeline 8000 bbl of oil per hour is flowing. How many cubic meters per second of oil is flowing?
5. What volume of air (V) will pass through a capillary tube of length L = 52.5cm and radius R = 0.075mm, in time θ = 45 min, if the pressure difference Δp = 20mm Hg.?
   Poiseuille's law states that

$$V = \frac{\pi R^4 \theta \Delta p}{8LZ}$$

   Viscosity Z = 0.0001824 gm /(sec)(cm) for air at 23^{0}C.

6. The emissive power of a black body depends on the fourth power of the temperature and is given by

$$W = AT^4$$

   Where W = emissive power in BTU/(ft)^2(hr)
   A = Stefan Boltzmann constant, 0.171 X 10^{-8}BTU/(h)(ft)^2(^{0}R)^4
   T = temperature in ^{0}R
   What is the value of A in the units erg/(cm)^2(sec)(^{0}K)^4?

7. The Fanning equation expresses the relation for isothermal turbulent flow in a straight pipe. It is

$$\frac{dF}{dL} = \frac{4fV^2}{2D}$$

Where F = friction loss, $\frac{(ft)(lb_f)}{(lb)_m fluid}$, L = Length of pipe, ft

f = friction factor, no units, D = pipe diameter, ft

(a) Is the fanning equation as shown dimensionally sound?

(b) If not give the proper expression for the fanning equation

(c) Express the Fanning equation in terms of G, the mass velocity, instead of V the velocity, the units of G are lb_m fluid/(sec)(ft)^2 cross section.

8. Suppose you measure the density of uranium-di-oxide slurry and find that the variation in density if best expressed by the following equation.

$$\rho = C_0[1 + C_1 T] + C_2 e^{C_3 x}$$

In the formula ρ = density, lbm/ft^3, T = Temperature, ^{0}F, x = wt. fraction uranium oxide and C_0,C_1,C_2 and C_3 empirically determined constant. If the equation is to be dimensionally sound, what should be the units of C_0, C_1, C_2 and C_3?

9. Calculate Reynolds member for the following sets of data

$$N_{Re} = \frac{D\vartheta\rho}{\mu}$$

Parameters	1	2	3	4
D	1 inch	10 ft	2 ft	1 mm
Θ	10 ft/sec	10 mph	5 m/sec	3 cm/ft^3
P	62.4 lb/ ft^3	1 lb/ ft^3	12.5 kg/m^3	25 lb/ ft^3
μ	0.3 lbm/(h)(ft)	0.14 ×10^{-4} lbm/ (s)(ft.)	2 ×10^{-6}cP	1 × 10^{-6} cP

10. The Colburn equation for heat transfer is

$$\left(\frac{h}{C_p G}\right)\left(\frac{C_p \mu}{k}\right)^{\frac{2}{3}} = \frac{0.023}{\left(\frac{DG}{\mu}\right)^{0.2}}$$

C_p = heat capacity, BTU/(lb)(^{0}F), μ=lb/(hr)(ft), k = BTU/(h)(ft)(^{0}F), D = pipe dia(ft) G = mass velocity , lb/(h)(ft)^2 cross sec, What are the units of 'h'.

11. An electric heater uses 1200 watts, how much heat in BTU does it produce in one minutes.