(1) In a double effect evaporator plant the second Effect is maintained under vacuum of 475 torr (mm Hg) Find the absolute pressure in KPa, bar and psi

475 torr = 475 mm Hg

760 mm Hg = 101.325 KPa

$$475 \text{ mm Hg} = \frac{475 \times 101.325}{760}$$

$$= 63.328125 \text{ KPa}$$

Absolute pressure = gage pressure + atm pressure

Absolute pressure = atm pressure − vacuum

= 101.325 − 63.328

= 38 KPa

1 atm = 101325 Pa

1 bar = 1×10^5 Pa

$$\frac{1 \text{ atm}}{1 \text{ bar}} = 1.01325$$

1 atm = 1.01325 bar.

760 mm Hg — 1.01325 bar

$$475 \text{ mm Hg} — \frac{475 \times 1.01325}{760}$$

= 0.6332 bar.

Absolute pressure = atm pressure − vacuum

= 1.01325 − 0.6332

= 0.38 bar.

1 atm = 760 mm Hg = 14.695 lbf/in^2

760 mm Hg = 14.695 lbf/in^2

$$475 \text{ mm Hg} = \frac{475 \times 14.695}{760} = 9.184 \text{ lbf/in}^2$$

Absolute pressure = 14.695 − 9.184

= 5.510 lbf/in^2.

(e) The volumetric flow rate of Kerosene in an 80 mm nominal diameter pipe is 75 Imperial gallons per minute. Taking the density of Kerosene as 0.8 Kg/dm3, find the mass flow in ~~Kg~~ Kg/s.

dm^3 = deci metre^3.

deci = 10^{-1}

decimetre = 10^{-1} metre
= 0.1 m
= 10 cm.

$dm^3 = 0.1\,m \times 0.1\,m \times 0.1\,m$
$= 10\,cm \times 10\,cm \times 10\,cm$
$= 1000\,cm^3$
$=$ 1 litre.

$1\,dm^3 = 1$ litre.

or $Kg/dm^3 = Kg/L$.

Volumetric flow rate $= 75$ gal/min.

$= \frac{75}{0.219}$

1 L = 0.219 Imperial gallon.

$= 342.46$ ~~Kg~~ l/min
$= 5.707$ l/s.

mass flow rate = Volumetric flow rate × density of Kerosene.
$= 5.707\,\frac{\cancel{l}}{s} \times 0.8\,\frac{Kg}{\cancel{l}}$
$= 4.566$ Kg/s.

(b) What is the density of air at 1.5 atm and 80°C

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\frac{1.5\ \cancel{atm} \times V_1}{(80+273)} = \frac{1\ \cancel{atm} \times 22.4\ l}{(0+273)}$$

$$\frac{1.5\ V_1}{353\ \cancel{K}} = \frac{22.4\ l}{273\ \cancel{K}}$$

$$1.5 \times 273\ V_1 = 22.4 \times 353\ l$$

[STP = 0°C, 1atm
At STP 1mol of gas occupies 22.4 litres.]

$$V_1 = \frac{22.4 \times 353}{1.5 \times 273}\ l$$

$$= \frac{7907.2}{409.5}$$

$$V_1 = 19.3\ l/mol.$$

$$= \frac{1}{19.3}\ \frac{mol}{l}$$

mol = $\frac{wt}{M.W}$

wt = mol. M W

$$= \frac{29}{19.3}\ \frac{g}{l}$$

$$= \frac{29}{19.3 \times 1000}\ \frac{g}{cc}$$

$$= \frac{29}{\cancel{19300.4}\ 19300}$$

$$= 0.0015\ g/cc.$$

Or

$$\rho = \frac{PM}{RT} = \frac{1.5\ atm \times 29\ \frac{g}{mol}}{82\ \frac{cm^3 atm}{g\ mol\ K} \times (80+273)K} = 0.0015\ g/cc.$$

(c) The specific gravity of steel is 7.9. What is the volume in cubic feet of steel ingot weighing 4000 lb.

Sp. gravity of steel = 7.9

density of steel = Sp. gr of steel × density of H_2O

= 7.9 × 1000

= 7900 kg/m3 or 7.9 g/cc.

$$\boxed{1\ g/cm^3 = 62.427\ lb/ft^3}$$

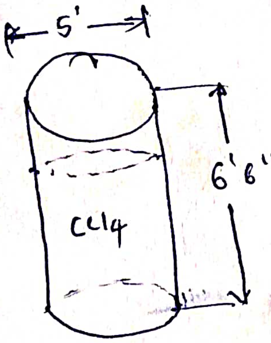
62.427 lb —— 1 ft³

4000 lb —— $\frac{4000 \times 1}{62.427}$

4000 lb. $= \underline{64.074\ ft^3.}$

4000 lb occupies 64.074 ft³.

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



1 ft = 0.3048 m.

5 × 0.3048

dia of tank = 5' × 0.3048 = 1.524 m

height of tank = 6.5' × 0.3048 = 1.9812

Volume of tank = $\frac{\pi D^2}{4} \times L$

$= \frac{\pi \times (1.524\,m)^2}{4} \times 1.9812\,m$

Volume. $= 3.614\,m^3$

= 3614 litres.

If the tank is 75% ~~fu~~ full

= 3614 × 0.75

= 2710.5 litres.

mass of CCl_4 = 2710.5 litre × 1.6 $\frac{kg}{l}$

$= \underline{4336.8\ kg.}$

Steam is flowing at the rate of 2000 kg/h in a 3" NB 40S schedule pipe at 440 kPa (4.4 bar or 4.49 kgf/cm²) absolute and 453 K (180°C). Calculate the velocity of the steam in the pipe line. Specific volume of steam at 440 kPa, V = 0.46166 m3/kg. Internal dia of 3" NB, 40S pipe = 3.068 in.

mass flow rate of steam = $2000 \frac{kg}{h} = \frac{2000}{3600} = 0.5554 kg/s$

Volumetric flow rate of steam = mass flow rate × Specific vol. of steam

$= 0.555 \frac{kg}{s} \times 0.46166 \frac{m^3}{kg}$

$= 0.2562 \; m^3/s.$

C/s area of pipe :-

Internal dia of pipe = $3.068'' \times \frac{25.4}{1000}$ m

$= 0.07792 \; m^2$

C/s area of pipe = $\frac{\pi}{4}(0.07792)^2$

$= 0.00477 \; m^2$

Velocity of steam = $\frac{0.2562 \; m^3/s}{0.00477 \; m^2} = 53.71 \; \frac{m}{s}$

1. 475 torr (mm Hg) to kPa, bar, psi.

760 mm Hg —— 101.325 kPa

475 mmHg —— ? $\frac{475 \times 101.325}{760} = \underline{63.328 \text{ kPa}}$

~~760 mm Hg —— 1×10⁵~~

1 atm = 101325 ~~kN~~ N/m²

1 bar = 1×10⁵ N/m².

$\frac{atm}{bar} = 1.01325$

atm = 1.01325 bar.

bar = $\frac{atm}{1.01325} = \frac{(475/760)}{1.01325} = ?$

$= \underline{0.616 \text{ bar}}$

1 atm = 14.695 lbf/in².

(475/760) —— $\left(\frac{475}{760}\right) \times 14.695$

$= \underline{9.184 \text{ psi}}$.

② A force equal to 19.635 kgf is applied on a piston with a diameter of 5 cm. Find the pressure exerted on the piston in kPa, bar and atm.

Pressure = $\frac{Force}{area} = \frac{19.635 \text{ kgf}}{\left(\frac{\pi (5)^2}{4}\right)} = \frac{19.635}{19.6375} = 1 \text{ kgf/cm}^2$.

$\boxed{1 \text{ atm} = 1.033 \text{ kgf/cm}^2}$.

1.033 kgf/cm² —— 1 atm.

1 kgf/cm² —— $\frac{1 \times 1}{1.033} = 0.968$ kgf/cm².

1 atm = 101.325 kPa

101.325 kPa —— 1.033 kgf/cm²

1.033 kgf/cm² = 101.325 kPa

1 kgf/cm² $\frac{1 \times 101.325}{1.033} = 98.088$ kPa.

$$\boxed{1\ bar = 1.019716\ kgf/cm^2}$$

$1.019716\ kgf/cm^2$ — $1\ bar$

$1\ kgf/cm^2$ — $\frac{1\times1}{1.019716} = 0.98066\ bar.$

$$\boxed{1.033227\ kgf/cm^2 = 14.695\ lbf/in^2}$$

$1\ kgf/cm^2$ — $\frac{1\times 14.695}{1.033227}$

$= 14.222\ lbf/in^2.$

③ Convert 55 gal/hr to m^3/s.

$1\ l = 0.219969$ Imperial gal

$= 0.264172$ US gal

~~55 × 0.219919~~

$\left(\frac{55}{0.219969}\right)$ ~~lbf~~ l/hr

$= 259.43\ l/hr.$ $\qquad 1000\ l = 1\ m^3.$

$= \left(\frac{259.43}{1000}\right)$

$= 0.2594\ m^3/hr.$

$= 0.2594\ \frac{m^3}{3600\ s.}$

$= 0.000072\ m^3/s.$

④ 75 lbf/in^2 to N/m^2

$14.7\ lbf/in^2 = 1\ atm = 101325\ \frac{N}{m^2}$

~~101325~~ $75\ lbf/in^2 = ?$ $\qquad \frac{75\times101325}{14.7}$

$516964.28\ N/m^2$

(5) Convert $112\ Btu/(hr)(ft)(°F)$ to $\dfrac{Cal}{s\ (cm)\ (°c)}$

$$112 \times \frac{\frac{1000}{3.968}}{(3600\ s)\ 30.48\ cm \cdot \frac{5}{9}(1-32)}$$

1000 Cal = 3.968 Btu.

$\left(\frac{1000}{3.968}\right)$ Cal = Btu.

$°C = \frac{5}{9}(°F-32)$

(5) 800 mm Hg to kPa.

760 mmHg —— 101.325 kPa

800 mm Hg —— ? $\dfrac{800 \times 101.325}{760}$

= 106.657 kPa.

(6) $4\ kgf/cm^2$ to lbf/in^2.

$1.033227\ kgf/cm^2 = 14.69595\ lbf/in^2$

$1.0\ kgf/in^2 = \dfrac{1 \times 14.69595}{1.033227}$

$1\ kgf/in^2 = 14.223\ lbf/in^2$

$4\ kgf/cm^2$ — ? $\dfrac{4 \times 14.223}{1}$

$= 56.893\ lbf/in^2$

① Iron metal weighing 500 lb occupies a volume of 29.25 l. Calculate the density of Fe in kg/dm3.

$1 \text{ kg} = 2.204623 \text{ lb}.$

$2.204623 \text{ lb} = 1 \text{ kg}$

$500 \text{ lb} \text{ — } ? \quad \frac{500 \text{ lb} \times 1 \text{ kg}}{2.204623 \text{ lb}}$

$= 226.796 \text{ kg}$

$$\frac{226.796 \text{ kg}}{29.25 \text{ l}} = 7.7537 \text{ kg/L}.$$

② If a plane travels at twice the speed of sound (speed of sound is 1100 ft/s), how fast is it going in miles per hour?

Speed of plane $= 2 \times 1100$ ft/s

$= 2200$ ft/s

$1 \text{ km} = 1000 \text{ m} = 0.62137$ miles

$3280 \text{ ft} = 0.62137$ miles

$2200 \text{ — } ? \quad \frac{2200 \times 0.62137}{3280}$

$= 0.4167$ miles

$$\frac{0.4167 \text{ miles}}{s}$$

1hr = 3600s

$$= \frac{0.4167}{\left(\frac{1}{3600}\right)}$$

$= 1500.88$ mile/hr

③ Change 400 in3/day to cm3/min.

$$= \frac{400 \cdot (2.54)^3 \cdot \text{cm}^3}{1440}$$

1 day = 24 hr.
= 24 × 60 min
= 1440 min.

$= 4.5519 \text{ cm}^3/\text{min}.$

∵ in × in × in
2.54 × 2.54 × 2.54