Tutorial 3

Thermodynamics

* Vapor Quality: is the % by mass of the vapor in the mixture (total).

$$X = \frac{M_{vapor}}{M_{total}}$$

* Triple Point ?

Tutorial-2

Soln: 1→ $200\,kPa = 200 \times 10^3\,Pa$

$= 2 \times 10^5\,Pa$ $\quad$ $1\,bar = 10^5\,Pa$

$= 2\,bar$

$H = U + PV$

$U = H - PV$

$= 3072.1\,kJ - 2 \times 10^5 \times 1.3162\,J$

$= 3072.1\,kJ - \frac{2 \times 10^5 \times 1.3162}{10^3}\,kJ$

$$\boxed{U = 2808.86\,kJ}$$

Set^{n} 2:

* Latent heat of vaporization, $h_{fg} = h_g - h_f$

* Specific volume –

$$V = X V_g + (1-x) V_f$$

* Specific Enthalpy –

$$H = X h_g + (1-x) h_f$$

X = Quality

* Specific internal Energy –

$$\boxed{U = H - PV}$$

<u>Que:</u> 2kg of steam at $P = 5$ bar is produced from water at 25°C. Find the amount of heat supplied if the steam is 90% dry.

<u>Sol^{n}:</u> $X = 0.9$

Enthalpy for 1 kg of water –

$$h_w = h_f + X h_{fg}$$
$$= 640.12 + 0.9 (h_g - h_f)$$
$$= 640.12 + 0.9 (2747.5 - 640.12)$$
$$\boxed{h_w = 2536.76 \text{ KJ/Kg}}$$

at 25°C, Enthalpy of water, $h = 104.89$ KJ/Kg

Heat Required $= 2 (2536.76 - 104.89)$

$= $ —

Ques: Calculate Specific Volume, Specific Enthalpy & Specific internal
* energy of wet steam at 18bar, dryness fraction is 0.9.

Solⁿ:

Tutorial 2

Sol 2:

$$2890 = 2855.1 + \left(\frac{3064.8 - 2855.1}{300-20}\right) \times (T - 200)$$

Sol 3: At 90°C, from steam table –

$P = 0.7011$ bar

Required Volume –

$$10\,V = x V_g + (1-x) V_f$$

$$= 0.2 \times 2.3610 + 0.8 \times 0.0010361$$

$$= \_\_\_\_ \; m^3$$

Tutorial-4

1. $P = 50\,bar = 50 \times 10^5\,Pa$

$T = 500 + 273 = 773K$

$V = 1m^3$

$$PV = nRT$$

$$n = \frac{50 \times 10^5\,Pa \times 1m^3}{8.314 \times 773} = 778 \text{ moles}$$

1 mole of water = 18 g

778 moles → 778 × 18 g

= 14004 g

= 14.004 kg

Van der Waal's EOS –

$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

$$\left(P + \frac{an^2}{V^2}\right)\left(\frac{V}{n} - b\right) = RT$$

$$\left(50\times10^5 + \frac{553.667\times n^2}{(1)^2}\right)\left(\frac{1}{n} - 0.3\times10^{-3}\right) = 8.314\times773$$

$$0.554n^2 + 50\times10^5 - 1500n = 6427.722n$$

$$0.554n^2 - 7962.72n + 50\times10^5 = 0$$

$$n = 658,\ 13715.1$$

✓ ✗

$$wt. = \frac{658\times18}{1000} = 11.844\ kg$$

Ans 2: Total Volume = $3 m^3$

$1 m^3 \rightarrow$ Sat. liquid

$2 m^3 \rightarrow$ Sat. Vapor

$P = 3\times10^6 Pa = 30$ bar

$$m_{liq.} = \frac{V_{liq.}}{v_f} \qquad m_{steam} = \frac{V_{steam}}{v_g}$$

from ~~St.~~ Saturated Pressure Steam Table, at $P = 30$ bar –

$$m_{liq.} = \frac{1}{0.0012163} \qquad m_{steam} = \frac{2}{0.06636}$$

$$m_{liq.} + m_{steam} = m_{Total}$$

$$\text{Quality} = \frac{\text{Mass of Steam}}{\text{Total Mass}} = 0.03304$$

$$\text{Enthalpy} = x h_g + (1-x) h_f$$

$$h = 0.03304 \times 2802.3 + (1 - 0.03304) \times 1008.40 = 1067.67\ KJ/kg$$

$$h = U + PV$$

$$U = h - PV$$

$$= 1067.67 - 30\times10^5 \times (x v_g + (1-x) v_f)$$

Sol 4: T → Same P → Same V → Same (Cylinder)

$$PV = nRT$$

$$n_{N_2} = n_{CH_4} \Rightarrow \frac{7\times10^3}{28} = \frac{m}{28\times10^{-3}}$$

$$\boxed{m = 7\ kg}$$

Sol 3: $\text{quality} = \frac{M_{vapor}}{\text{Total mass}} = 0.6$ $\qquad v =$

$P = 10^6 Pa = 10\ bar$

$\Delta V = V_{final} - V_{initial}$

from Steam table, at $P = 10 bar$ –

$V_i = \underbrace{0.1943}_{v_g} \times \underbrace{0.6}_{x}$

at $300^\circ C$ (Superheated) –

$V_f = 0.2580 \times 0.6$

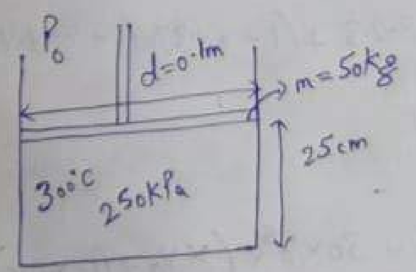
$\Delta V = 0.6(0.2580 - 0.1943)$

Enthalpy Change $= (3052.1 - 2776.2) \times 0.6$

$= 272.9 \times 0.6 = 163.74\ KJ$

Tutorial-3

Sol 2:



(a) $P_{outside} = 100 kPa + \frac{50 \times 10 \times 4}{3.14 \times 0.1 \times 0.1 \times 1000}\ kPa$

$= (100 + 63.69) kPa = 163.69 kPa$

$$\frac{P_{outside}}{T'} = \frac{P_{inside}}{T_{inside}}$$

$$T' = 573.13K \times \frac{163.69\,kPa}{250\,kPa}$$

$$= 573.13 \times 0.6547$$

$$\boxed{T' = 375.22K}$$

(b.) $V_i = \frac{0.25 \times 3.14 \times 0.1 \times 0.1}{4} = \cancel{1.96\,m^3}$ or $1.96L$

$T_i = 375.22K$ $\qquad\qquad$ $T_f = 293.13K$

$$V_f = \frac{V_i}{T_i} T_f = \frac{1.96 \times 293.13}{375.22} = 1.53L$$

$\Delta V = A \times h$

$$h = \frac{0.43L \times 4}{3.14 \times 0.1 \times 0.1\,m^2} = \frac{0.43 \times 10^{-3}\,m^3 \times 4\cancel{00}}{3.14 \times 0.1 \times 0.1\,m^2 / 10\cancel{00}} = \frac{172}{3140}$$

$$= 0.054\,m$$

$$= 5.4\,cm$$