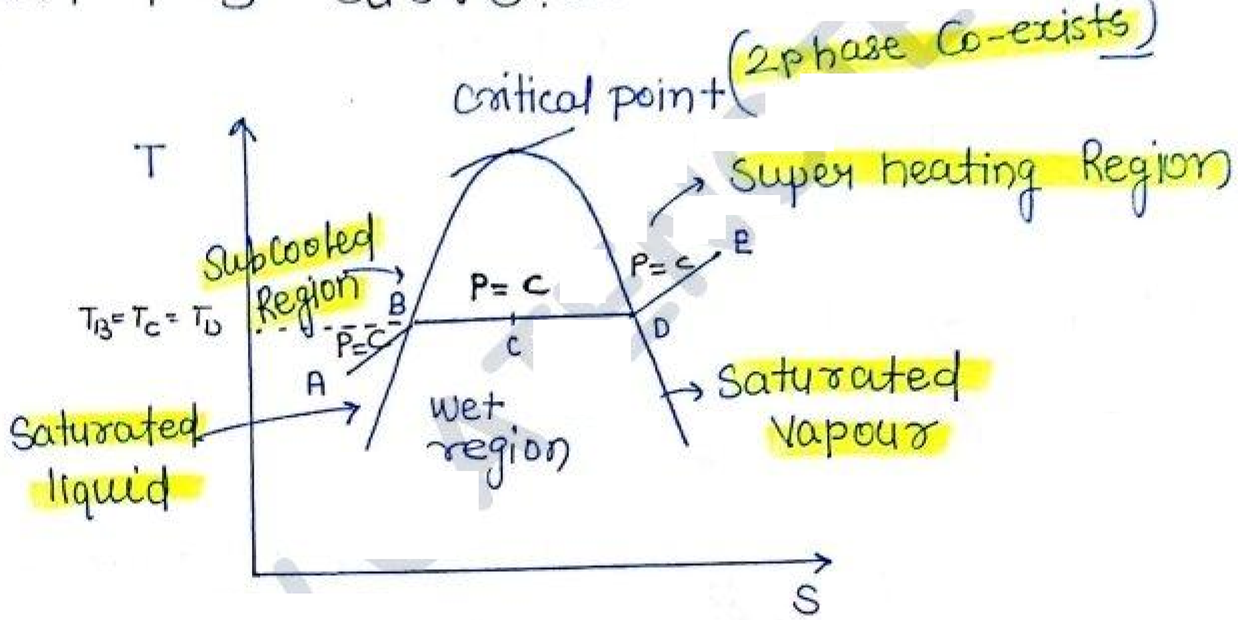
Pure substance

Representation of Constant Pressure line on T-S curve:—



critical pressure of H_2O = 221.2 bar

critical temp. of H_2O = 374°C

Degree of super-heating = $T_E - T_D$

Degree of subcooling or Undercooling = $T_B - T_A$

Super heating :- It is the process of increasing the temprature at constant pressure above saturated vapour.

Subcooling : It is the process of decreasing the temp. at constant pressure below saturated liquid.

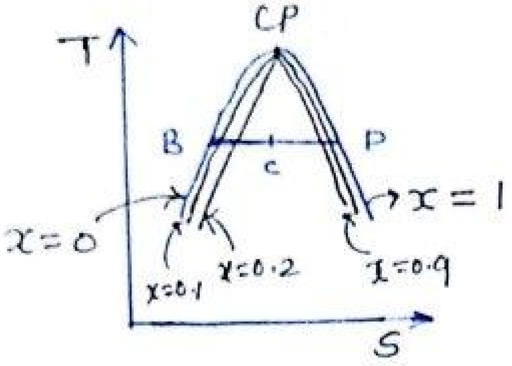
Wet Region :- It is the mixture of liquid and vapour

Critical point :- It is the point above which liquid will directly flash off into vapour

Note :- Enthalpy of vapourisation at critical point is zero (0)

Dryness fraction (x)/Quality :-

It is define as the ratio of mass of vapour to the total mass of mixture. The value of dryness fraction is zero ~~for~~ saturated liquid and '1' for saturated vapour



$x = 0.20$ → 20% Vapour
→ 80% Liquid

$$x = \frac{m_V}{m_v + m_L}$$

x_B (sat. liq.) ⇒ $m_v = 0$, $x_B = 0$

x_D (sat. vp) ⇒ $x_D = 1$

$$\boxed{0 \le x \le 1}$$

①

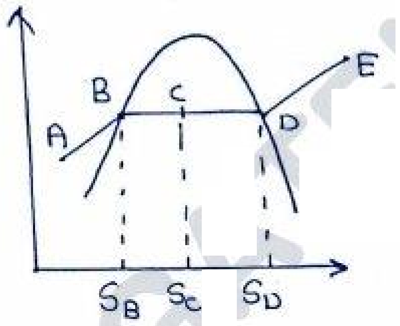
② ⇒ h_f, h_g, u_f, u_g, S_f, S_g, v_f, v_g

f → Saturated Liquid

g → Saturated Vapour.

③ The Refrenace state for the steam table is $u = 0$ & $S = 0$ at triple point of temp. (0.01°C) of water.

Expression of Enthapy and entropy at various point:-



① h_B (sat. liquid) $= h_f$

② h_D (sat. vap) $= h_g$

③ h_C (wet region) $= h_B + x\,h_{fg} = h_f + x(h_g - h_f)$

④ h_E (superheated region) $= h_D + (C_P)_{vapour}(T_E - T_D)$

$$h_E = h_g + (C_P)_{vapour}(T_E - T_D)$$

⑤ h_A (subcooled region) $= h_B - (C_P)_{liquid}(T_B - T_A)$

$$h_A = h_f - (C_P)_{liquid}(T_B - T_A)$$

Entropy

$${}^{\Delta}S_{fg} = \frac{h_{fg}}{T}$$

1. $S_B = S_f$

2. $S_D = S_g$

3. $S_C = S_B + x\, S_{fg} = S_f + x(S_g - S_f)$

$$S_C = S_f + x\left(\frac{h_{fg}}{T}\right)$$

4. $S_E = S_D + (C_p)_{Vapour} \ln\left(\frac{T_E}{T_D}\right)$

$$S_E = S_g + (C_p)_{Vapour} \ln\left(\frac{T_E}{T_D}\right)$$

$$Tds = dh - vdp \rightarrow 0$$

$$ds = \frac{C_p dT}{T}$$

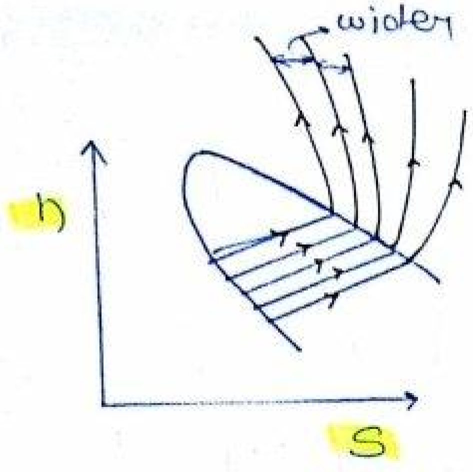
$$\Delta S = C_p \ln\left(\frac{T_f}{T_I}\right)$$

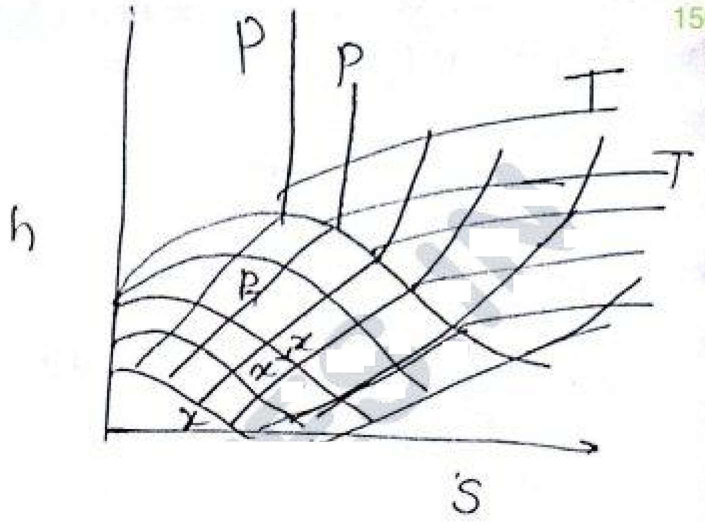
5. $S_A = S_B - (C_p)_{liq.} \ln\left(\frac{T_B}{T_A}\right)$

$$S_A = S_f - (C_p)_{liquid} \ln\left(\frac{T_B}{T_A}\right)$$

Mollier chart :-

It is the plot on h-s and the slope of constant pressure line on h-s curve is equal to absolute temprature. The constant pressure line are of diverging of nature in superheated region





Mixture of Gases :-

Vandar wal's equation :-

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

$b =$ Co Volume $= \frac{V_c}{3} \rightarrow$ Critical Volume

$\frac{a}{V^2} =$ force of Cohesion.

☆

$$(C_p)_{mix} = \frac{m_1 C_{p_1} + m_2 C_{p_2}}{m_1 + m_2}, \quad (C_v)_{mix} = \frac{m_1 C_{v_1} + m_2 C_{v_2}}{m_1 + m_2}$$

$$(h)_{mix} = \frac{m_1 h_1 + m_2 h_2}{m_1 + m_2}, \quad (u)_{mix} = \frac{m_1 u_1 + m_2 u_2}{m_1 + m_2}$$

$$(R)_{mix} = \frac{m_1 R_1 + m_2 R_2}{m_1 + m_2}$$

n_1, n_2 } moles

$$x_1 = \frac{n_1}{n_1+n_2}$$

$$x_2 = \frac{n_2}{n_1+n_2}$$

Dalton law of partial pressure:-

$$P = P_1 + P_2 + P_3 \ldots$$

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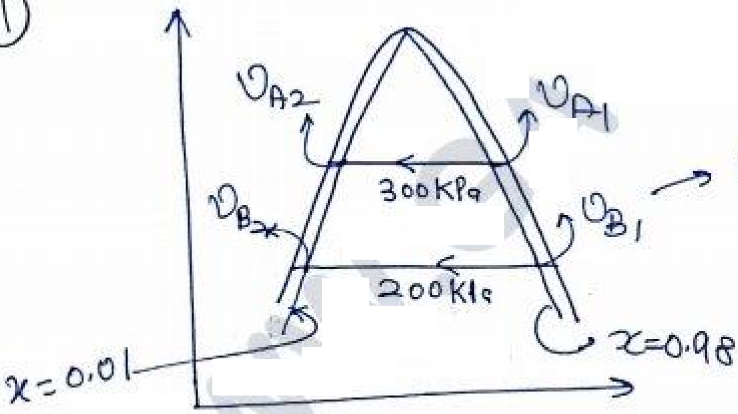
(1)



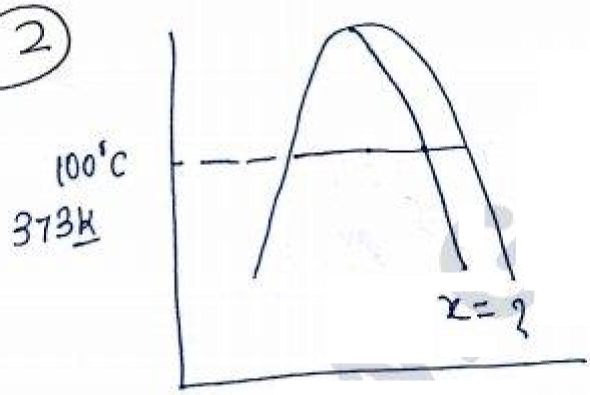
$g >>> f$

more S_{fg} so more heat content more vapour so $v_{B_1} > v_{A_1}$

Similarly $v_{B_2} < v_{A_2}$

(d)

(2)



liq $v_f = 0.001044 \; m^3/kg$

vap. $v_g = 1.6729 \; m^3/kg$

$$m = m_v + m_e$$

$$x = \frac{m_v}{m_v + m_e}$$

$$mv = m_v v_g + m_e v_f$$

$$v = \frac{m_v v_g + m_e v_f}{m_v + m_e}$$

$$v = \left(\frac{m_v}{m_v + m_l}\right) v_g + \left(\frac{m_l}{m_v + m_l}\right) v_f$$

$$v = x\, v_g + (1 - x)\, v_f \qquad 1 - \frac{m_l}{m_v + m_l}$$

m_l

$$v = v_g + v_f$$

$$v =$$

$$V_v = 8 V_L$$

$$x = \frac{m_v}{m_v + m_L} = \frac{\frac{(Vol)_v}{v_g}}{\frac{(Vol)_v}{v_g} + \frac{(Vol)_L}{v_l}}$$

$(Vol)_v \to 8 V_L$, $8V \leftarrow (Vol)_v$

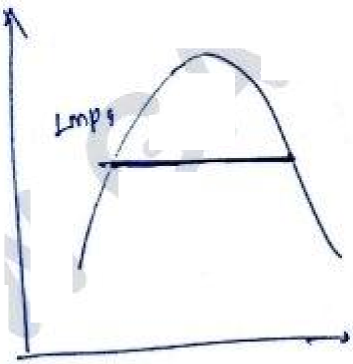
$$v = \frac{Vol}{m}$$

$$m = \frac{Vol}{v}$$

$$= \frac{8/v_g}{8/v_g + 1/v_f} = \underline{0.005}$$

③ $u_1 = u_2$

$P = 1\,MPa$



$$(m_l + m_v)_A = (x\, m_v)_A$$

$$(m_l + m_v)_B = (x\, m_v)_B$$

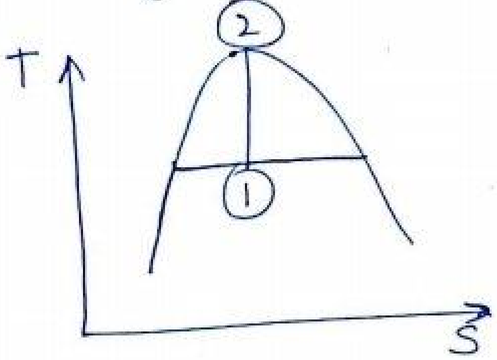
$$U_1 = U_2$$

$$m_A u_A = m_B u_B$$

$$\frac{m_A}{m_B} = \frac{u_g}{u_f} = \frac{2583.6}{761.7} = \underline{3.4}$$

(5) $V_c = 0.00317\ m^3/kg$ $P = 10\,MPa$

$T_c = 311.06\ ^\circ C$



$dQ = 0$

$T_1 = T_2$

$v_1 = v_c$

$v_c = x v_g + (1-x) v_f$

$$0.00317 = x(0.01802) + (1-x)\,0.001452$$

$$x = 0.10$$

(7) $(\rho)_{mix} = 36.12\ kg/m^3$ $(\rho)_l = 1377\ kg/m^3$

$T = -30^\circ C$ $(\rho_v) = 7.379\ kg/m^3$

$$x = \frac{m_v}{m_v + m_l}$$

$m = \frac{\rho}{V}$ $\rho = \frac{m}{V}$

$m_v = \frac{\rho_v}{V_v}$

$m = \rho V$

$m v = m_0 v_0 + m_L v_L$

$\rho \frac{V}{v} = \rho_0 \frac{V}{v}$

$\frac{1}{e} = \frac{x}{e_1}$ $x = \frac{v/\rho}{v/\rho + 1/\rho}$

$$v = v_f + x(v_g - v_f)$$

$\rho = \frac{m}{Vol}$ $\frac{1}{\rho} = \frac{1}{\rho_f} + x\left(\frac{1}{\rho_f} - \frac{1}{\rho_f}\right)$

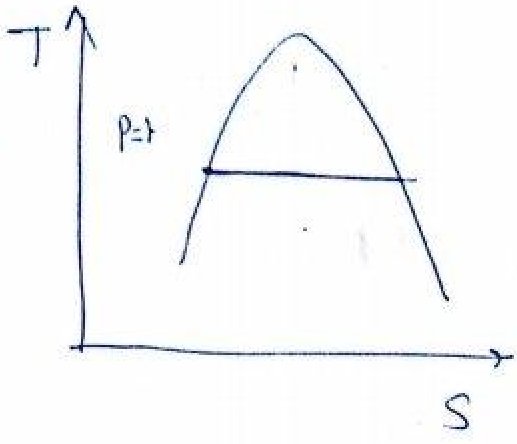
$v = \frac{Vol}{m} = \frac{1}{\rho}$

$$x = 0.2$$

(9)

$P = 1\,bar$

$T = 99.63^\circ$



$S_f = 1.3026$

$S_g = ?$

$$S_g = S_f + x\left(\frac{h_g - h_f}{T}\right)$$

$$= 1.3026 + 1\left(\frac{2675.5 - 417.5}{293 + 99.63}\right)$$

$$S_g = 7.362$$

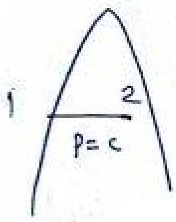
(11) a

(12) $m = 2\,kg$

$p = 10\,bar$

$T = 179.9^\circ c$

$Q = 10\,kJ$



$dQ = dh$

$dQ = h_2 - h_1$

$$\frac{10}{2}\left(\frac{kJ}{kg}\right) = \left[h_f + x\left(h_{fg}\right)\right] - h_f$$

$$5 = x\,(2583.6 - 762.8)$$

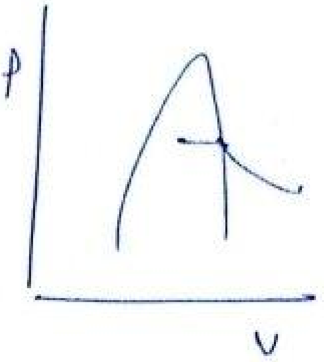
$$x = 2.48 \times 10^{-3}$$

$$x = \frac{m_v}{m_v + m_l} = 2.48 \times 10^{-3}$$

2

$$m_v = 4.96\,gm$$

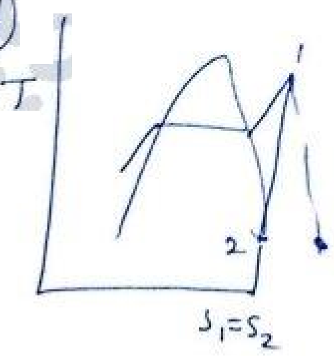
(13) b (19) (13)



$pV = Con$

$\uparrow p \propto \frac{1}{v} \downarrow$

(14) B



(15) $Tds = du + pdv \rightarrow 0$

$dQ = du = u_B - u_A$

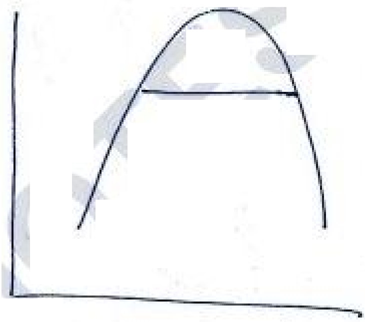
(16) B (17) D (18) D

(20) C (21) d $P \downarrow$ h con

(22) ~~Tds = dQ~~

$Tds = du + pdv$

$dQ = Tds$



s

4×10^6 Pa

4000 kPa

$s = s_g + x(s_g - f)$

$6.9362 = 7.5939 + x(7.5939 - 1.091)$

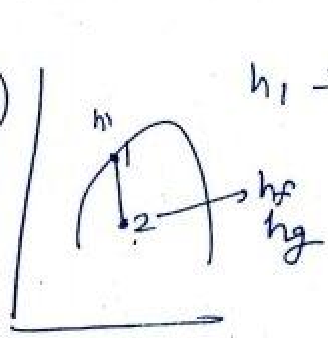
$x = 0.9$

(26) $p = \frac{a}{v^2}$

$\frac{F}{A} = \frac{a}{\left(\frac{Vol}{m}\right)^2}$

$a = \frac{m^5}{kg\text{-}s^2}$

(27) $h_1 = h_2$



$h_1 = h_f + x(h_g - h_f)$

$1400 = 800 + x(2000)$

$x = 0.1$

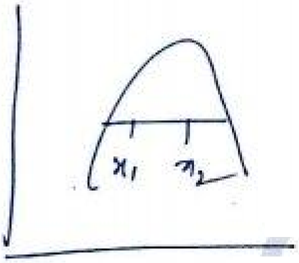
(29)

$$R = \frac{m_1 R_1 + m_2 R_2 + m_3 R_3}{m_1 + m_2 + m_3}$$

$$R = \frac{0.6\left(\frac{1}{28}\right) + 0.3\left(\frac{1}{32}\right) + 0.1\left(\frac{1}{44}\right)}{1} \times 8314$$

$R =$ 43 ~~463.95~~ 274.99

(28)



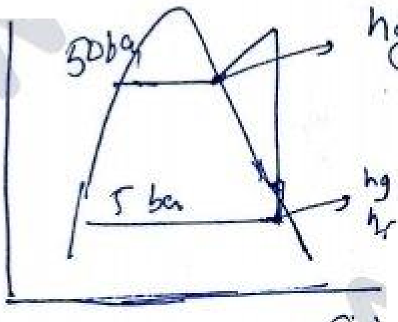
$$dQ = (h_2 - h_1)\, m$$

$$= (h_f + x_1 (h_{fg}) - (h_f + x\, h_{fg})) \times 2$$

$$= ((x_2 - x_1)\, h_{fg}) \times 2$$

$dQ = 1761$ KJ

(30)



$x = 0.9$

$P = \dot{m}\,[h_2 - h_1]$

(i) $P = \dot{m}\,[h_{g_1} - (h_{f_2} + x(h_{g_2} - h_{f_2}))]$

$P = 5[\qquad]$

$P = 1282$ kW

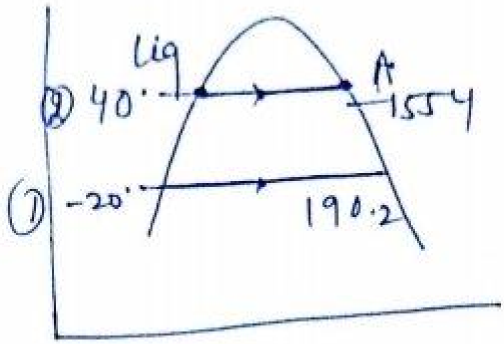
(ii) reversible adiabatic

$S_1 = S_2$

$S_{g_1} = S_{f_2} + x(S_{g_2} - S_{f_2})$

$x = 0.829$

Q.24



S_1

u / h / s

kJ/kg kJ/kg kJ/kgK

$h = u + Pv$

$h > u$

$h > u > s$

$g >>> f$

$h_f = u_f + Pv_f$ — Product very less

g g g

$h_f \approx u_f$

h_f & u_f are very closly

t, P
1 2 3 4 5 6 7 8
-20° u_f s_f h_f s_g u_g h_g
40

24 — D

25 — b

$h_1 = h_2$

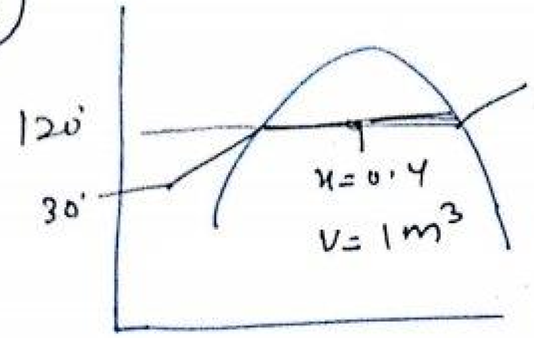
$(h_f + x h_{fg})_{40°C} = (h_f + x h_{fg})_{-20°C}$

$(h_f)_{40} = (h_f + x h_{fg})_{-20°}$

$371.43 = 89.05 + x(1418.0 - 89.05)$

$x = 0.212$

(8)



$t_2 = 30°C$

$h_2 = u_2 = 125.77$

$dQ = h_1 - h_2$

$= (h_f + x\, h_{fg}) - h_2$

$= (504.7 + 0.4(2706.70 - 504.7)) - 125.77$

$= 1260 \frac{kJ}{kg}$

$v = \frac{Vol}{m}$ $\Rightarrow m = \frac{Vol}{v_1} = \frac{1}{v_f + x\, v_{fg}}$

$m = 2.81 kg$

$dQ = 1260 \times 2.81$

$= 3550 \underline{kJ}$

(10) Rigid

C

$m = \frac{Vol}{v} = \frac{20}{0.1944} = 102.88$

$dv = 0$

$Tds = \underline{du} \Rightarrow dQ = h_2 - h$

$= \{h_f + x(h_g - h_f)\}_{0.1} - (h_g)_{0.1}\} \times 102.88$

$(v_g)_1 = (v_f + x(v_g - v_f))_{0.1}$

$x = 0.11$

$= 198.\underline{3}\ MJ$