19114039 Tutorial 2
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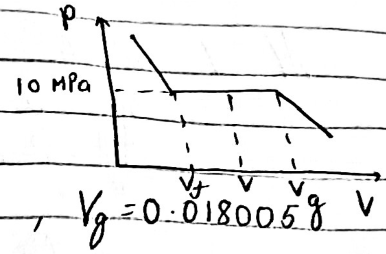
(O2) CSE

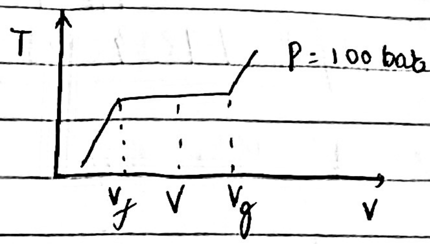
Ans. 1 (a) $P = 10\,MPa$, $V = 0.003\,m^3/kg$



$P = 100\,bar$

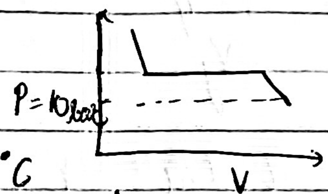
at $P = 100\,bar$: $V_f = 0.001452$, $V_g = 0.0180058$

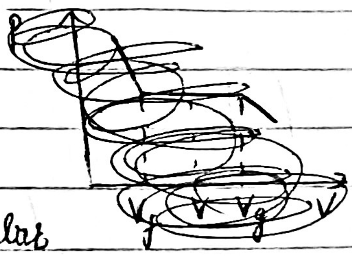
$\therefore$ $V_f < V < V_g$



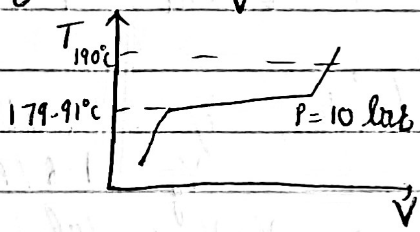
$\rightarrow$ $\boxed{\text{Mixture of saturated liquid \& vapour.}}$

Ans. 1 (b) $P = 1\,MPa$, $T = 190°C$





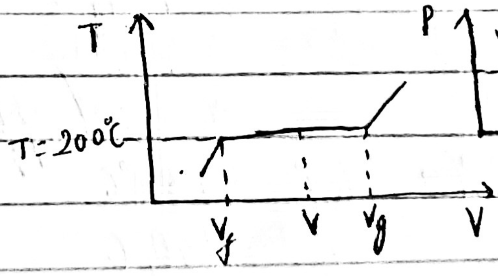
At $P = 10\,bar$, $T_{sat} = 179.91°C$

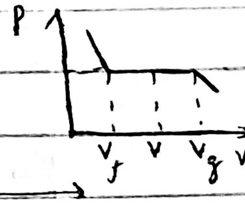


$\therefore$ $T > T_{sat}$

$\rightarrow$ $\boxed{\text{Superheated Vapor}}$

Ans. 1 (c) $T = 200°C$, $V = 0.1\,m^3/kg$

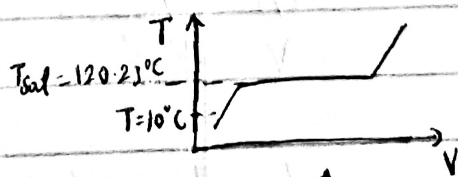




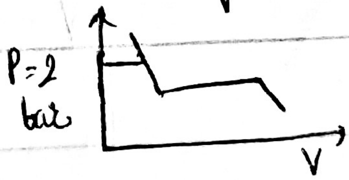
At $T = 200°C$, $V_f = 0.0011489$
$V_g = 0.14084$

$\therefore$ $V_f < V < V_g$ $\rightarrow$ $\boxed{\text{Mixture of saturated lqd \& vapor}}$

Ans. 1 (d) $P = 200\,kPa$, $T = 10°C$
$P = 2\,bar$, $T = 10°C$
At 2 bar: $T_{sat} = 120.23°C$

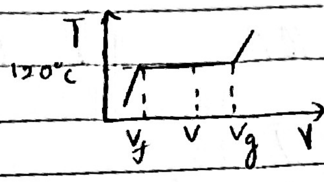


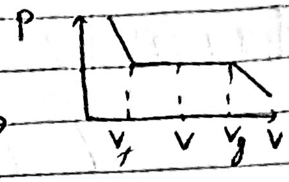
$T < T_{sat}$ $\Rightarrow$ $\boxed{\text{Compressed lqd}}$



Ans.2 (a) H_2O : $T = 120°C$, $v = 0.5\ m^3/kg$

At $T = 120°C$





$v_f = 0.0010606$
$v_g = 0.8915$

$\therefore$ $v_f < v < v_g$

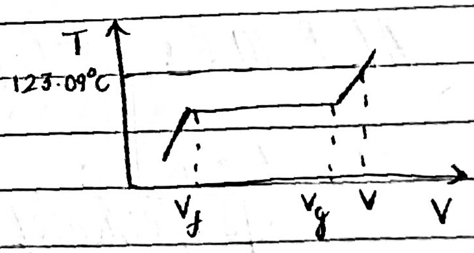
→ Mixture of Saturated lqd & vapor

$\therefore$ $\boxed{P = 1.9854\ bar}$

Now, $v = v_f + x v_g$

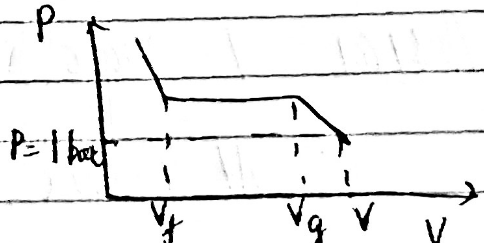
$\Rightarrow \boxed{x = \frac{v - v_f}{v_g} = 0.56}$

(b) H_2O : $P = 100\ kPa$, $v = 1.8\ m^3/kg$



$P = 1\ bar$, $v_f = 0.001043$
$v_g = 1.677$

$\therefore$ $v > v_g \Rightarrow$ superheated vapor



$x \rightarrow$ not applicable

Now, $T_{sat} = 99.62°C$, $v_{sat} = 1.677$
$T_2 = 150°C$, $v_2 = 1.93636$

By extrapolation:

$$\frac{T_2 - T_{sat}}{v_2 - v_{sat}} = \frac{T - T_{sat}}{v - v_{sat}}$$

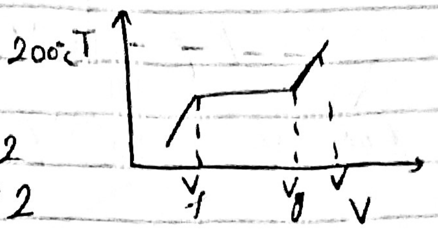
$\Rightarrow T = 123.09°C$

Ans. 3 $m = 2\,kg$, $V_{tot} = 1\,m^3 \Rightarrow V = 0.5\,m^3/kg$

$T = 200°C$, $V_g = 0.12716\,m^3/kg$

$\Rightarrow V > V_g \rightarrow$ Superheated vapor

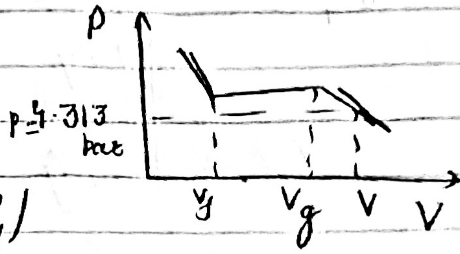
At 200°C,



$P_1 = 4$ bar , $V_1 = 0.53422$

$P_2 = 5$ bar , $V_2 = 0.42492$

By extrapolation: $\dfrac{P_2 - P_1}{V_2 - V_1} = \dfrac{P - P_1}{V - V_1}$



$\Rightarrow P = P_1 + \left(\dfrac{V - V_1}{V_2 - V_1}\right)(P_2 - P_1)$

$\Rightarrow \boxed{P = 4.313\text{ bar} = 431.3\text{ kPa}}$

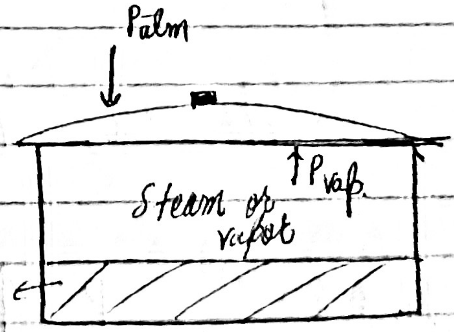
Ans. 4 $A = 5\,mm^2$

$P_{atm} = 101.3\,kPa$

$T = 120°C$

To allow boiling, $P_{vap} = P_{sat}$ at $T = 120°C$

$P_{vap} = 1.9854$



$\Rightarrow F_{atm} + mg = F_{vap}$

$\Rightarrow m = \dfrac{F_{vap} - F_{atm}}{g} = \dfrac{(1.9854 - 1.0130) \times 10^5 \times 5 \times 10^{-6}}{9.8}$

$\Rightarrow \boxed{m = 0.0496\,kg}$

$m = \boxed{49.6\,g}$

Ans 5 $\quad T = 100^\circ C$

$V_f = \frac{V_g}{10} \Rightarrow m_f V_f = \frac{m_g V_g}{10} \rightarrow \boxed{\frac{m_f}{m_g} = 160.3}$

$\rightarrow P = P_{sat} = 1.01325$ bar

Now, $V \rightarrow$ fixed (as closed tank)

$$\boxed{x_1 = \frac{m_g}{m_g + m_f} = 0.0062}$$

$\rightarrow V = V_f + x_1 V_g = (0.0010437) + (0.0062)(1.6730)$

$= 0.0114163 \ m^3/kg$

$\Rightarrow V_1 = V_2 \rightarrow V = 0.0114163$ at 20 bar

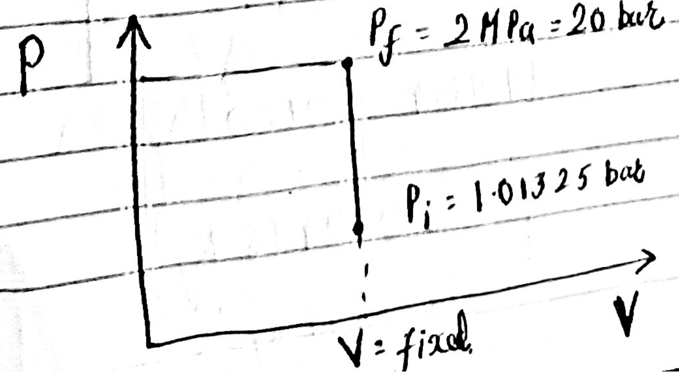
$\therefore V_f < V < V_g \rightarrow$ mixture

$$\boxed{T = T_{sat} = 212.42^\circ C}$$

$x_2 = \frac{V - V_f}{V_{fg}} = \frac{0.0114163 - 0.001176}{0.098191} = 0.104$

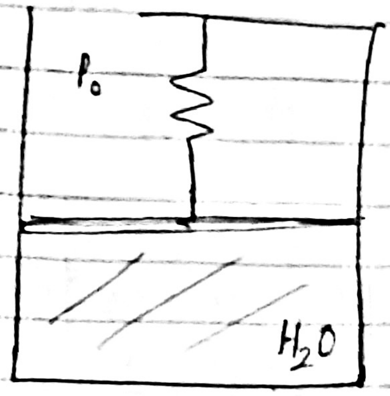
As, $x_2 > x_1 \rightarrow$ More Vapor

Ans 6



Ans.6 50 bar, $T = 400°C$ → $v = 0.05781$ (Superheated steam)

$$m = \frac{V_c}{v} = \frac{0.1}{0.05781} = 1.73\ kg$$



$$\rightarrow P = P_a + kV$$

$$\rightarrow P - P_a = kV \rightarrow k = \frac{P - P_a}{V}$$

$$\rightarrow \frac{P_2 - P_a}{V_2} = \frac{P_1 - P_a}{V_1}$$

$$\rightarrow V_2 = V_1 \frac{(P_2 - P_a)}{(P_1 - P_a)} = (0.05781)\left(\frac{12-2}{50-2}\right)$$

$$\rightarrow \boxed{V_2 = 0.01204\ m^3/kg}$$

At 12 bar, $v_f < v < v_g$

$$\rightarrow \boxed{T = T_{sat} = 187.99°C}$$

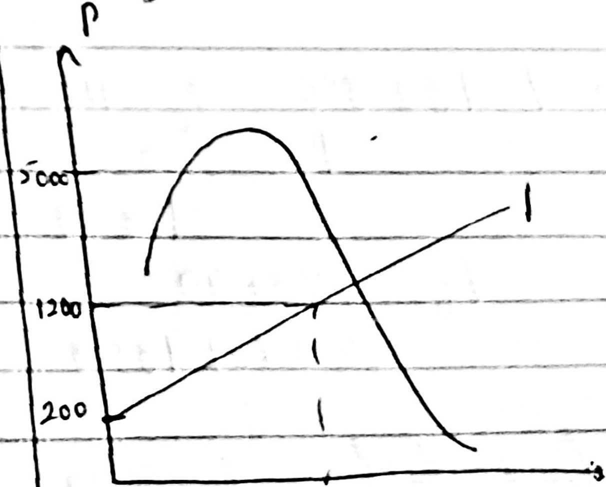
$v_f = 0.001138$, $v_g = 0.16326$ → $x \approx 0.066$

Ans.7 $P_c = 48.7$ bar

$$P_r = \frac{P}{P_c} = \frac{30}{48.7} = 0.616$$

$$\Rightarrow T_c = -122°C \Rightarrow 151K$$

$$T_r = \frac{T}{T_c} = \frac{243}{151} = 1.61$$



→ Using generalized chart: $Z = 0.96$

$$m = \frac{PV}{ZRT} = \frac{(3000)(5)}{(0.96)(0.2081)(243)}$$

$$= \boxed{308.98\ kg}$$

Using $m = \frac{PV}{RT}$ → $m = 296.63 \, kg$

$\% \text{ error} = \left(\frac{308.98 - 296.63}{308.98}\right) \times 100 \; (0.039) \times 100 \approx 4\%$

Ans 8 Superheated ammonia → 40°C, 5 bar

~~Using table~~ → ~~V = 0.0~~

$\boxed{V = 0.29227 \, m^3/kg}$

→ Using $V = \frac{RT}{P} = \frac{(0.488)(273.140)}{500}$

$= 0.305488 \, m^3/kg$

$\% \text{ error} = \frac{0.305488 - 0.29227}{0.29227} \times 100 \approx 4.52\%$

→ $T = 132.3°C$, $P_c = 113.33$ bar

$P_r = \frac{5}{113.33} = 0.044$

$T_r = \frac{273 + 40}{273 + 132.3} = 0.77226$

from chart: $V = \frac{ZRT}{P} \approx 0.29632 \, m^3/kg$

$\% \text{ error} = \frac{0.29632 - 0.29227}{0.29632} \times 100 \approx 1.38\%$