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Ch En 2300 HW2

1. a) $V^L_{spec} = \frac{20L}{50g} \times \frac{0.001\, m^3}{1L} \times \frac{1000\, g}{1\, kg} = 0.40 \frac{m^3}{kg}$, 10 bar = 1.0 MPa

- check steam table: @ 1.0 MPa, $V^L = 1.127\times10^{-3} \frac{m^3}{kg}$

Since $0.4 \frac{m^3}{kg} > 1.127\times10^{-3} \frac{m^3}{kg}$, the vessel contains $\boxed{\text{gas}}$

- check superheated steam tables @ 1.0 MPa and interpolate.

$$T = T_{low} + \frac{(V - V_{low})}{(V_{high} - V_{low})} \cdot (T_{high} - T_{low}) = 550°C + \frac{(0.4 - 0.3777)\frac{m^3}{kg}}{(0.4011 - 0.3777)\frac{m^3}{kg}} \cdot (600 - 550)°C$$

$\boxed{= 597.6°C}$

b) $V^L_{spec} = \frac{20L}{17.8\,kg} \times \frac{0.001\, m^3}{1L} = 1.124\times10^{-3} \frac{m^3}{kg}$, P = 5 MPa

@ 5 MPa, $V^L = 1.286\times10^{-3} \frac{m^3}{kg} > 1.124\times10^{-3} \frac{m^3}{kg}$ ∴ $\boxed{\text{Liquid}}$

~~use~~ ~~[illegible]~~ check compressed liquid steam table @ 5 MPa and $1.124\times10^{-3} \frac{m^3}{kg}$

→ $\boxed{T = 180°C}$

c) $V^L_{spec} = \frac{20L}{0.4\,kg} \times \frac{0.001\, m^3}{1L} = 0.05 \frac{m^3}{kg}$, P = 5 MPa

@ 5 MPa, $V^L = 1.286\times10^{-3} \frac{m^3}{kg} < 0.05 \frac{m^3}{kg}$ ∴ vessel contains ~~[illegible]~~ $\boxed{\text{gas}}$

- Check superheated steam tables @ 5 MPa and $0.05 \frac{m^3}{kg}$

Interpolate: $T = T_{low} + \frac{(V - V_{low})}{(V_h - V_{low})} \cdot (T_h - T_{low})$

$$\therefore T = 300 + \frac{(0.05 - 0.0453)}{(0.052 - 0.0453)} \cdot (350 - 300)°C \boxed{= 335.1°C}$$

Thermo HW2

2.)

$T\ ^\circ C$	P, MPa	V, m^3/kg	Phase descrip
212.38	2.0	0.0996	Sat. vap
150	5	(a) 0.001088	Sat. liquid
325	10	0.019877	Sat vap
200	1.55490	0.0450	Sat. mix

(a) ~~V = 0.001077~~ $V = V_{low} + \frac{(T - T_{low})}{(T_{high} - T_{low})} \cdot (V_{high} - V_{low})$

$\therefore V = 0.001077 + \frac{(150-140)}{160-140} \cdot (0.001099 - 0.001077) = 0.001088 \frac{m^3}{kg}$

3.) $m\Delta(u + \cancel{\frac{v^2}{2}} + gz) = \cancel{Q} + \cancel{W}_{EC} + \cancel{W}_s$ $\quad m = 1\,kg,\ T_1 = 15^\circ C$

~~$m \cdot mc(T_2 - 15) + mgz$~~

$\cancel{m}\Delta u = -\cancel{m}gz \rightarrow \Delta u = -gz, \quad \Delta u = mc(T_2 - T_1)$

$\therefore -gz = mc(T_2 - T_1) \rightarrow T_2 = \frac{-gz}{mc} + T_1$

$T_2 = \frac{-9.8 \frac{m}{s^2} \cdot 100\,m}{1\,kg \cdot 4.2 \frac{kJ}{kg\,K}} + 15^\circ C$

UNITS

$T_1 = 288.15\,K$

$c = 4200 \frac{J}{kg\,K}$

$\therefore T_2 = \frac{-9.8 \frac{m}{s^2} \cdot 100\,m}{1\,kg \cdot 4200 \frac{J}{kg\,K}} + 288.15\,K$

$\rightarrow T_2 = \frac{-980}{4200} + 288.15 = 287.92\,K = \boxed{14.77^\circ C}$

Thermo HW 2

4.) $T_1 = 600°C$, $P_1 = 1.8 MPa$
$T_2 = 250°C$, $P_2 = 0.40 MPa$

$m\Delta(u + \cancel{\frac{v^2}{2}} + \cancel{gz}) = W_s$, $m = 1$ kg

$m\Delta u =$ work
$\Delta u =$ work $\rightarrow u_1 = 3292.7$
$u_2 = 2726.4$
$u_2 - u_1 = 3292.7 - 2726.4 = \boxed{566.3 \frac{kJ}{kg}}$

5.) $T_1 = 800°C$, $T_2 = 250°C$, $P = 0.101 MPa$, $m = 1$ kg

$\cancel{m\Delta(u + \frac{v^2}{2} + gz) = Q + W_{EC} + W_s}$

$\cancel{W_s = m\Delta(u) = \Delta u}$
$W = P \cdot \Delta V$ $PV = nRT$, $V = \frac{nRT}{P}$, $n = \frac{m}{M}$, $M = 0.02897$

$V_1 = \frac{\left(\frac{1 kg}{0.02897 \frac{kg}{mol}}\right) \cdot 8.3145 \frac{kg\, m^2}{s^2\, mol\, K} \cdot 1073.15 K}{101000 \frac{kg}{m s^2}} = 3.049\ m^3$

$V_2 = \frac{\frac{1 kg}{0.02897 \frac{kg}{mol}} \cdot 8.3145 \frac{kg\, m^2}{s^2\, mol\, K} \cdot 523.15 K}{101000 \frac{kg}{m s^2}} = 1.487\ m^3$

$\Delta V = |1.487 - 3.049|\ m^3 = 1.563\ m^3$

$W = 100000\ Pa \cdot 1.563\ m^3 = 157852.1\ J = \boxed{157.9\ kJ}$

Thermo HW#2

6.) $P = 0.075\,MPa$, $V = \pi r^2 h = \pi 100 \cdot 5 = 500\pi\,cm^3 = 0.001571\,m^3$

$r = 10\,cm$, want: $\frac{Q}{\Delta t}$ (Power)

$$m\Delta\left(u + \cancel{\frac{v^2}{2}} + \cancel{gz}\right) = \underline{Q} + \underline{W}_{EC} + \cancel{W_s} \rightarrow \underline{Q} = m\Delta u - \underline{W}_{EC}$$

$$W_{EC} = -m\int_{V_1}^{V_2} P\,dV = -m(PV_2 - PV_1) = -mP(V_2 - V_1)$$

$$\therefore \underline{Q} = m\Delta u + mP\Delta V = m(\Delta u + P\Delta V)$$

Since $\Delta H = \Delta u + P\Delta V$, $\underline{Q} = m\Delta H$

$$m = \frac{V}{V_{spec}} = \frac{0.001571\,m^3}{0.001038\,\frac{m^3}{kg}}$$

$$\left(V@0.075\,MPa = \frac{V@0.07\,MPa + V@0.08\,MPa}{2}\right)$$

$\therefore m = 1.51402\,kg$

$$\left(\Delta H@0.075\,MPa = \frac{\Delta H@0.07 + \Delta H@0.08}{2}\right)$$

$\Delta H@0.075\,MPa = 2278.07\,\frac{kJ}{kg}$

$$\therefore \underline{Q} = 1.51402\,\cancel{kg} \cdot 2278.07\,\frac{kJ}{\cancel{kg}} = 3449.044\,kJ$$

$$\text{Power} = \frac{Q}{\Delta t} = \frac{3449.044\,kJ}{1200\,sec} = \boxed{2.874\,kW}$$