Note:

The compression from point 1 to point 2 is ~~said~~ said to be a polytropic transformation. No information is given about the reversibility of said transformation.
As a consequence two interpretation should be allowed ~~~~ ~~~~ for the solution of the exercise (Note that this effects only ~~~~ the answer to point 1)

First case

The transformation is considered irreversible.
As a consequence, ~~~~ the condition $dS > \dfrac{\delta Q}{T}$ should be satisfied during the transformation.
No information is given about the heat exchanged during the compression.
The fluid could be (i) cooled, (ii) heated or (III) exchange no heat with the surrounding.
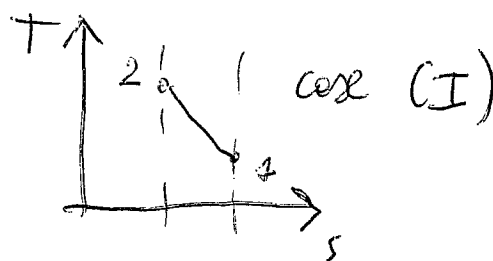Hence, the entropy can ~~~~ increase during the transformation ~~~~
(cases II and III).
However, it can also decrease (case I) although it is not obliged to ~~~~.
The sign (>) applying.
As a consequence these two graphs should be considered ~~~~, provided an explanation is given, allowable.

case (II & III)

case (I)
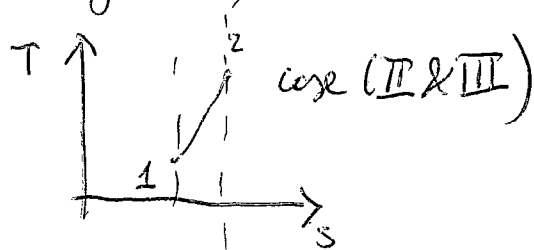
To be given good by default | To be accepted provided

Second case

The assumption ~~that the~~ of a reversible Transformation is made.

Only in this case, the relation :

$$ds = \frac{\delta q}{T}$$

applies and should be therefore satisfied during the Transformation.
A direct consequence of such a relation is that, for a thermally and calorically perfect gas, $\int ds$ is given by :

$$\int_1^2 ds = c_p \ln \frac{T_2}{T_1} - R \ln \frac{P_2}{P_1} \qquad (1)$$

or in the infinitesimal form $ds = c_p \frac{dT}{T} - R \frac{dP}{P}$

From (1) we conclude that, if the Transf. is $\underline{reversible}$ and polytropic of exponent n, the entropy variation is given by:

$$\int_1^2 ds = c_p \ln \left[\frac{P_2}{P_1} \right]^{\frac{n-1}{n}} - R \ln \frac{P_2}{P_1}$$
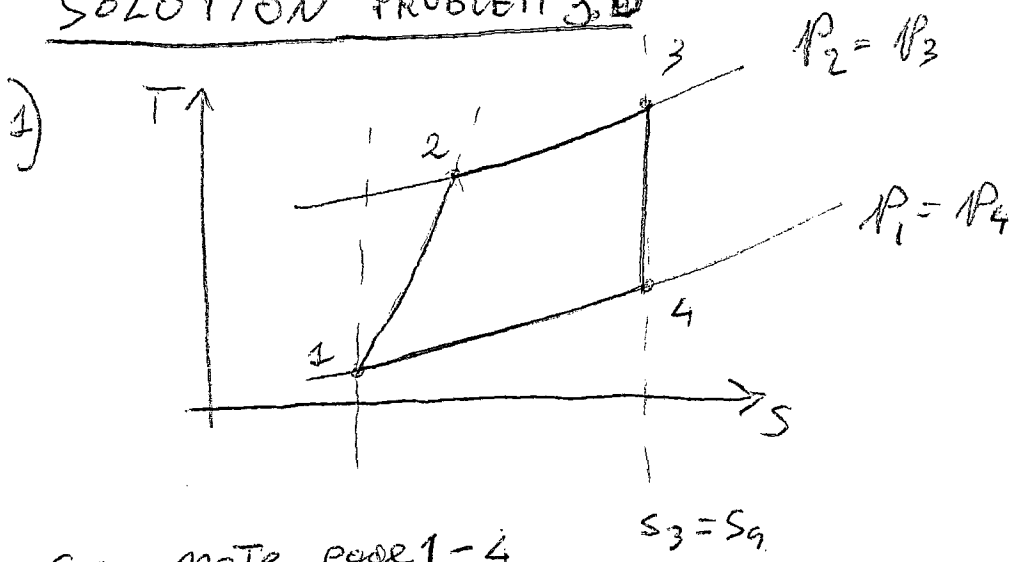
$$S_2 - S_1 = c_p \ln \left(\frac{P_2}{P_1} \right) \left[\frac{n-1}{n} - \frac{\gamma-1}{\gamma} \right] \begin{cases} > 0 \text{ if } n > \gamma \\ < 0 \text{ if } n < \gamma \end{cases}$$

if $n < \gamma$, as in the present case, $S_2 < S_1$ which means that the compression is not adiabatic and moreover the fluid is $\underline{cooled}$ ($\delta q < 0$).
As a consequence, the only drawing coherent with such an assumption [reversible Transformation] is :
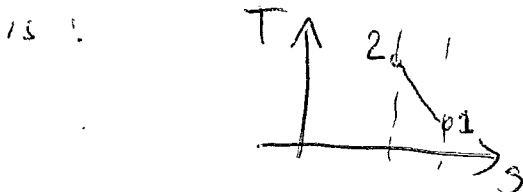
SOLUTION PROBLEM 3b

1)

$P_2 = P_3$

$P_1 = P_4$

$S_3 = S_4$

<u>See note page 1-4</u>

2) Network $\overset{def.}{\Longrightarrow}$ | Work produced by The Turbine — Work received by The compressor |

<u>Turbine:</u> $_3 q_4 + _3 W_4 = h_4 - h_3$

isentropic $\Rightarrow$ $\eta_s = 1$ $\Rightarrow$ $S_4 = S_3$ $\quad dS \geq \dfrac{\delta q}{T} \Rightarrow \dfrac{\delta q}{T} \leq 0$
efficiency

$\downarrow$

The Transformation
is isentropic and
hence adiabatic
and reversible $\longrightarrow$ $\Rightarrow \dfrac{\delta q}{T} = 0 \Rightarrow _3 q_4 = 0$

The Transform.
is adiabatic

$\boxed{_3 W_4 = h_4 - h_3}$

<u>compressor:</u> $_1 q_2 + _1 W_2 = h_2 - h_1$

No information is given <u>explicitly</u> in The Text about The heat exchange
d processes Taking place during The compression.
However in The <u>class</u> we've always considered
adiabatic compression within cycles like The one herein. proposed

iT is Therefore ~~so~~ easy for The student To make This
assumption. ~~By~~ ~~these~~
if such an assumption is not made, The evolution of
The answer should be based on The reasoning proposed

SOLUTION PROBLEM 3.9

Piston - cylinder device
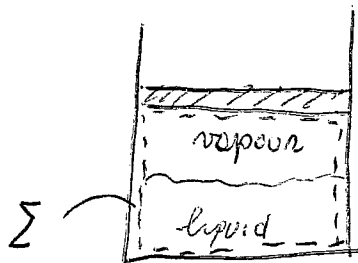
1: INITIAL STATE

$m_1 = m = $ constant during the transf. since the system Σ is closed.

V_1 is known

P_1 is known

i)

Two independent state variables are needed to uniquely identify (determine) the state of Σ.

$$P_1 \quad and \quad N_1 = \frac{V_1}{m_1} = \frac{0,1 \, m^3}{0,5 \, kg} = 0,2 \, \frac{m^3}{kg}$$

NOTE: $N_1 = 0,2 \, \frac{m^3}{kg} = 0,2 \, \frac{m^3}{10^{-3} Mg} = 0,2 \, 10^3 \frac{m^3}{Mg} = 200 \, \frac{m^3}{Mg}$

$$\Rightarrow N_1 = 200 \, \frac{m^3}{Mg}$$

From Table 1: $P = 0,4 \, MPa \Rightarrow N_\ell = 1,084 \, m^3/Mg$

$$N_g = 462,4 \, m^3/Mg$$

$$\Rightarrow \quad N_\ell < N_1 < N_g \Rightarrow The \, \Sigma \, is \, a \, mixture \, !$$

$$\Rightarrow Both \, liquid \, and \, vapour \, phase \, are$$
present in the system.

GRAPHICAL INTERPRETATION $\Rightarrow$
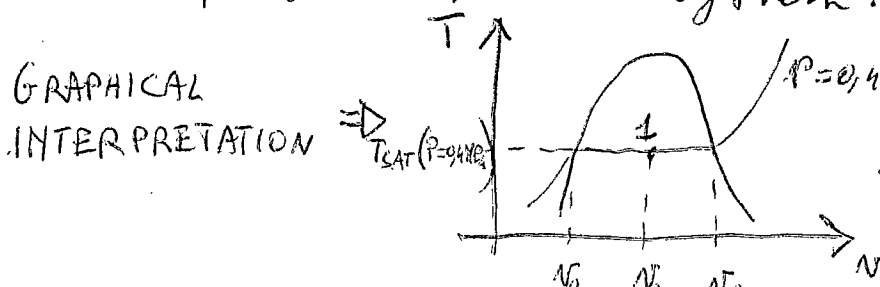
$$\Rightarrow T_1 = T_{SAT}(P = 0,4 \, MPa)$$
$$= 416,8 \, K = 143,6 \, °C$$

From the definition of work we have that the work done by the system Σ to expand during the transformation is:

$$d\overline{w} = -p\,dV$$

$$_1W_2 = \int_1^2 d\overline{w} = -\int_1^2 p\,dV = -P_1 \int_1^2 dV$$

$$= -P_1(V_2 - V_1) = -P_2 V_2 + P_1 V_1$$

since $P_1 = P_2$

Hence,

$$_1Q_2 + {}_1W_2 = U_2 - U_1$$

$$_1Q_2 - P_2 V_2 + P_1 V_1 = U_2 - U_1$$

$$_1Q_2 = U_2 + P_2 V_2 - (U_1 + P_1 V_1)$$

$$_1Q_2 = H_2 - H_1 \qquad \text{dividing by the system mess } m$$

$$_1q_2 = h_2 - h_1$$

where $q_2 = {}_1Q_2/m$ and $\dfrac{H_{1,2}}{m} = h_{1,2}$

So the amount of heat transferred to Σ is

$$_1Q_2 = m\,{}_1q_2 = m\cdot(h_2 - h_1)$$

both values of h_2 and h_1 are available from the tables.

$$v^{PGL} = \frac{Ru}{M_{mol}} \frac{T}{P}$$

$$Ru = 8,314\ \frac{J}{mol\ K}$$

$$M_{mol} = 18\ \frac{Kg}{mol}$$

So v_2^{PGL} can be computed as:

$$v_2^{PGL} = \frac{Ru}{M_{mol\ H_2O}} \frac{T_2}{P_2}$$

5

$$= \frac{8,314\ \ J/mol\ K}{18\ \ \ Kg/mol} \quad \frac{573,15\ K}{0,4\ 10^6\ \frac{N}{m^2}}$$

$$v_2^{PGL} = 662\ \frac{m^3}{Kg}$$

$$where\ 1N = 1\ Kg\ \frac{m}{s^2}$$

$$1J = 1N \cdot m$$

Therefore the accuracy of the Perfect gas model can be computed as:

$$\frac{||v_2^{PGL} - v_2||}{v_2^{PGL}} \sim 0,45\%$$