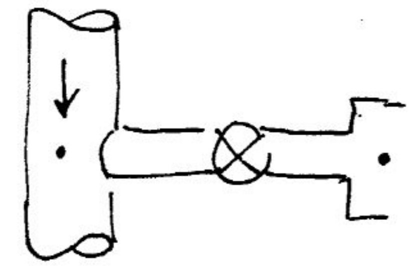
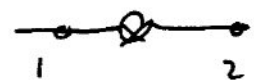
Thermo Quiz 1 16. Unified Sp 08

1.



know: $p_1 = 7$ bar
$T_1 = 165°C$

measure: $p_2 = 0.1$ bar
$T_2 = 75°C$

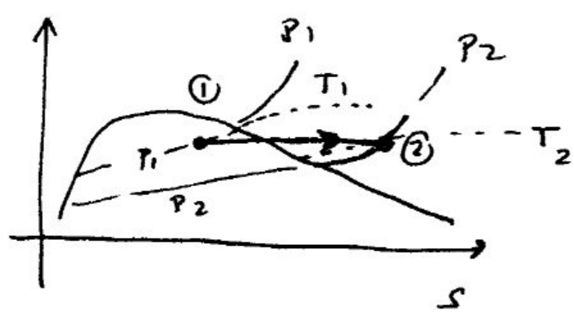
a) 

- 1st law : $0 = 0 + 0 + \dot{m}_s (h_1 - h_2)$

(no work by moving walls,
no heat x-fer, steady, no ΔKE → $\underline{h_1 = h_2 = \text{const}}$

- caloric eqn. of state : 2 phase : $h = h(p, T)$
so if $h = \text{const}$ → T not const necessarily
- Gibbs : $Tds = dh - vdp$ → $Tds = -\frac{1}{\rho} dp = d\varphi > 0$
so <u>p drops</u> as entropy is generated (<u>s increases</u>)
- hence <u>T drops</u> due to change in quality / phase (see data also)

→ process is <u>isenthalpic</u> ($h = \text{const}$)

b) 

2 phase mixture throttled to superheated steam where T and p <u>independent</u>

c) $h_1 = x_1 h_g(T_1) + (1 - x_1) h_f(T_1) = h_2(p_2, T_2)$

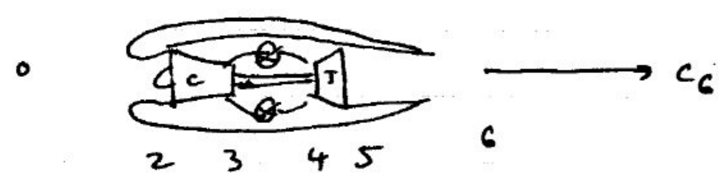
$$x_1 = \frac{h_2(p_2, T_2) - h_f(T_1)}{h_g(T_1) - h_f(T_1)}$$

$h_f(T_1) = 697.34$ kJ/kg
$h_g(T_1) = 2763.5$ kJ/kg
$h_2(p_2, T_2) = 2640.1$ kJ/kg

$\underline{x_1 = 0.94}$

2.

16.Unified Sp 08



engine on the ground

know: T_0, p_0

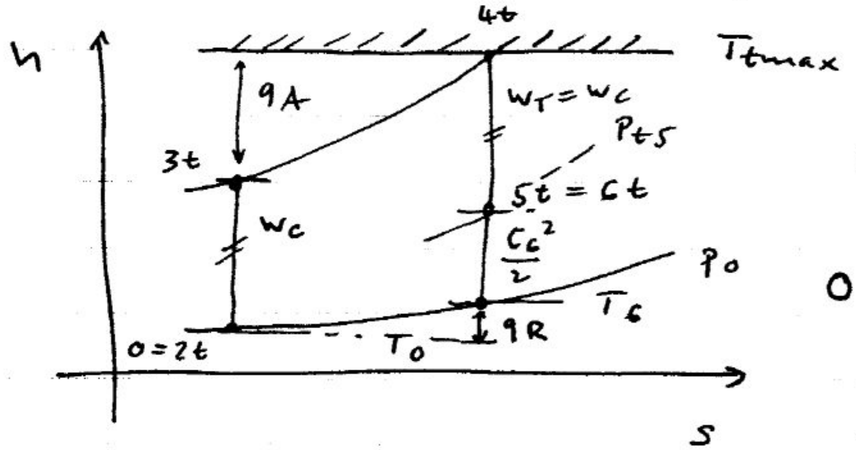
T_{tmax}

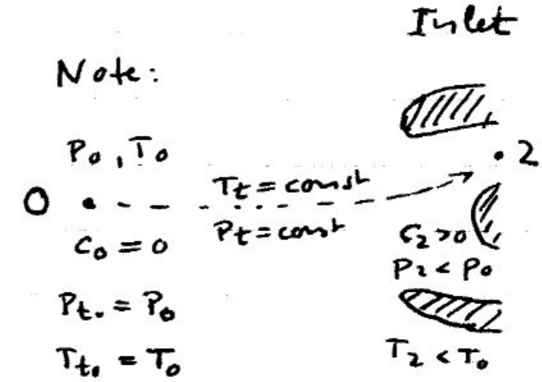
T_6

assume air throughout

a)

ideal cycle!





b) $T ds = dq$

$= dh - v dp$ so $6 \to 1$ $p = const$ $q_R = h_6 - h_0 = c_p(T_6 - T_0)$

$ds = c_p \frac{dT}{T} \to \underline{\Delta s_R = c_p \ln\left(\frac{T_0}{T_6}\right) < 0}$

c) ditto for heat addition, so $3 \to 4$ $p = const$ $q_A = c_p(T_{tmax} - T_{t3})$

$ds = c_p \frac{dT}{T} \to \underline{\Delta s_A = c_p \ln\left(\frac{T_{tmax}}{T_{t3}}\right) > 0}$

d) $\Delta s_R + \Delta s_A = \Delta s_{cycle} = 0$ so $\frac{T_{t3}}{T_{tmax}} = \frac{T_0}{T_6}$, $(T_{tmax} = T_{t4})$

$\ln\left(\frac{T_0}{T_6}\right) = \ln\left(\frac{T_{t3}}{T_{tmax}}\right)$

(or: same PR $\to$ same TR) $\underline{\underline{T_{t3} = T_{tmax} \cdot \frac{T_0}{T_6}}}$

e) $\eta_{th} = 1 - \frac{q_R}{q_A} = 1 - \frac{T_6 - T_0}{T_{tmax}(1 - T_0/T_6)}$; $\underline{\underline{\eta_{th} = 1 - \frac{T_6}{T_{tmax}}}}$

f) $w_{net} = q_A - q_R = \frac{c_6^2}{2} = c_p\left[T_{tmax}(1 - T_0/T_6) - (T_6 - T_0)\right]$

$\underline{\underline{c_6 = \sqrt{2 c_p (T_{tmax} - T_6)(1 - T_0/T_6)}}}$