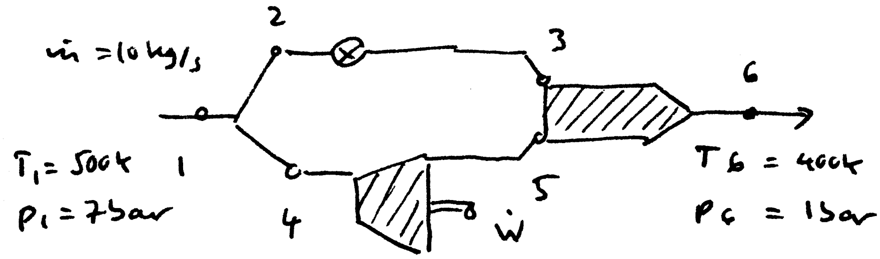
Unified Engineering **MIT ID# (last four digits):**
Thermo Quiz 3 **Fall 2007**

(Extra page for solutions)

- all components adiabatic
- steady operation
- neglect ΔKE, ΔPE
- assume perfect gas



equal flow split, $p_3 = p_5$

a)

1st law: $\frac{dE_{cv}}{dt} = \Sigma \dot{Q} + \Sigma \dot{W} + \Sigma \dot{m}(h + \frac{c^2}{2} + gz)$

$0 = 0 + 0 + \dot{m}(h_2 - h_3)$

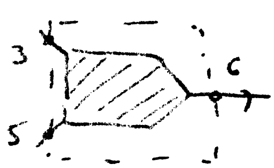
$\rightarrow h_2 = h_3$, $dh = c_p dT$

$dh = 0 \rightarrow dT = 0$

$\underline{T_3 = T_2 = 500K}$

no shaft or piston work, but <u>flow work</u>

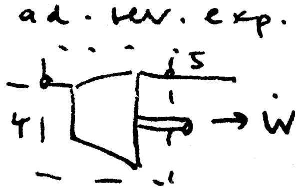
b)



1st law: $0 = 0 + 0 + \frac{1}{2}\dot{m}h_3 + \frac{1}{2}\dot{m}h_5 - \dot{m}h_6$

$h_6 = \frac{1}{2}h_3 + \frac{1}{2}h_5 \longrightarrow \underline{T_5 = 2(T_6 - \frac{1}{2}T_3) = 300K}$

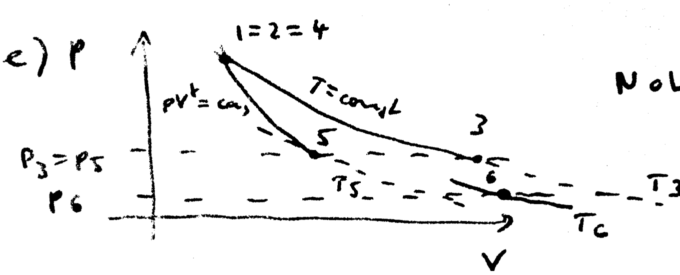
c) ad. rev. exp., 1st law: $0 = 0 - \dot{W} + \frac{\dot{m}}{2}h_4 - \frac{\dot{m}}{2}h_5$



$\dot{W} = \frac{\dot{m}}{2}c_p(T_4 - T_5)$, $\underline{\dot{W} = 1.0\ MW}$

d) ad. rev. exp. through turbine: $\frac{p_5}{p_4} = \left(\frac{T_5}{T_4}\right)^{\gamma/\gamma-1}$, $\underline{p_5 = p_3 = 1.17\ bar}$

e)



Note: $T_5 < T_6 < T_3$

f) throttle valve: irreversible — have unrestrained expansion of flow (free expansion) – to restore initial state would have to pump air back to high pressure → would leave mark on environment

mixing chamber: irreversible — flow mixing – air would not un-mix to hot and cold by itself – would have to separate molecules and restore situation to higher pressure → clearly leave mark on environment