MAE91 Summer 2004 – Quiz 2
Dr. H. Susan Zhou

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Closed book and notes – 25 minutes

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1. Write down the Kelvin Planck and the Clausius statement of the second law and prove that the two statements are equivalent.

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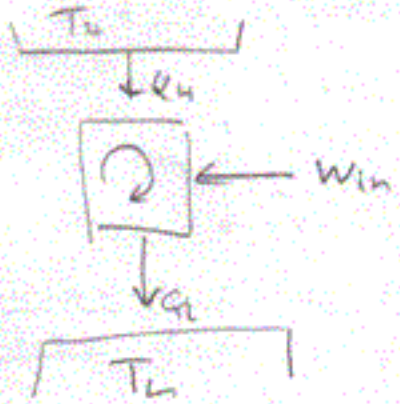
KP: impossible to have 100% efficient heat engine.

Clausius: must have 2 heat resivours of different temperatures for a cycle heat engine that produces work.

-2

-3 prove equivalent



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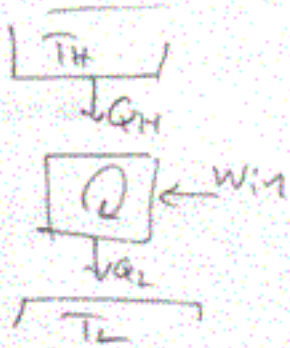
2. In Carnot engine with ammonia as the working fluid, the high temp is 60°C, and as Q_H is received, the ammonia changes from saturated liquid to saturated vapor. The ammonia pressure at low temperature is 190kPa. Find T_L, the cycle thermal efficiency, the heat added per kilogram, and entropy s at the beginning of the heat rejection process. (No numerical numbers substitution is required). (Hint: use T-s diagram to solve the problem).



Statement

$T_H = 60°C$ → Q_H

State ①	Process →	State ②
$x_1 = 0$		$x_2 = 1$
$P_1 = 190 kPa$		$v_2 = v_1$
v_1		

Find T_L, η, ΔQ per kg, s.

Assumptions

Constant mass
Carnot heat engine

Laws

$$\eta_{actual} = \frac{W_{in}}{Q_H} = \frac{Q_H - Q_L}{Q_H} = 1 - \frac{Q_L}{Q_H}, \quad \eta_{Carnot} = \frac{T_H - T_L}{T_H} = 1 - \frac{T_L}{T_H}$$

This = ΔQ under T-S curve

$$_1Q_2 - {}_1W_2 = m(u_2 - u_1) \quad \text{or} \quad {}_1q_2 - {}_1w_2 = (u_2 - u_1)$$

steps

$$_1q_2 - \cancel{{}_1w_2}^{=0} = u_2 - u_1$$

so $_1q_2 = u_2 - u_1$ ——— ①

δQ −1

area = ½(T₂+T₁)(s₂−s₁)

at state 1 find u_1 from ammonia table given (P_1, x_1)
at state 2 find u_2 from ammonia table given $(v_2 = v_1, x_2)$
so use eq ① to find $_1q_2$, this is Δq ← heat added per kg = q_H

δQ ← $\boxed{\frac{q_H - q_L}{q_H} = 1 - \frac{T_L}{T_H}}$ ⟹ $\boxed{\text{solve for } T_L}$ −1

this is area under curve of T-S

Calculated above; given

to find s_1, from table at state ① find $s = s_f + x_1 s_{fg}$ → given; → table @ P_1; → table ammonia @ P_1

to find s_2, from Table at state ② using $(P_2 = P_1, x_2 = 1)$ −2

find T_1, T_2 from Table as well → from Table $(x_1, v_2 = v_1)$