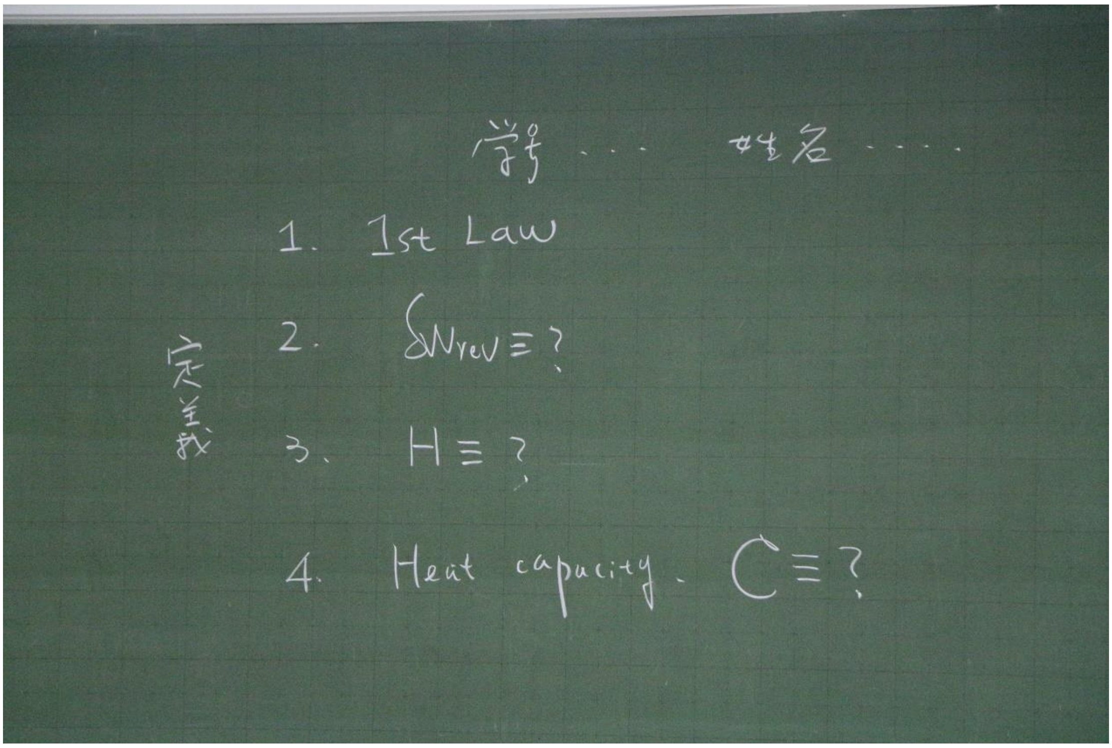
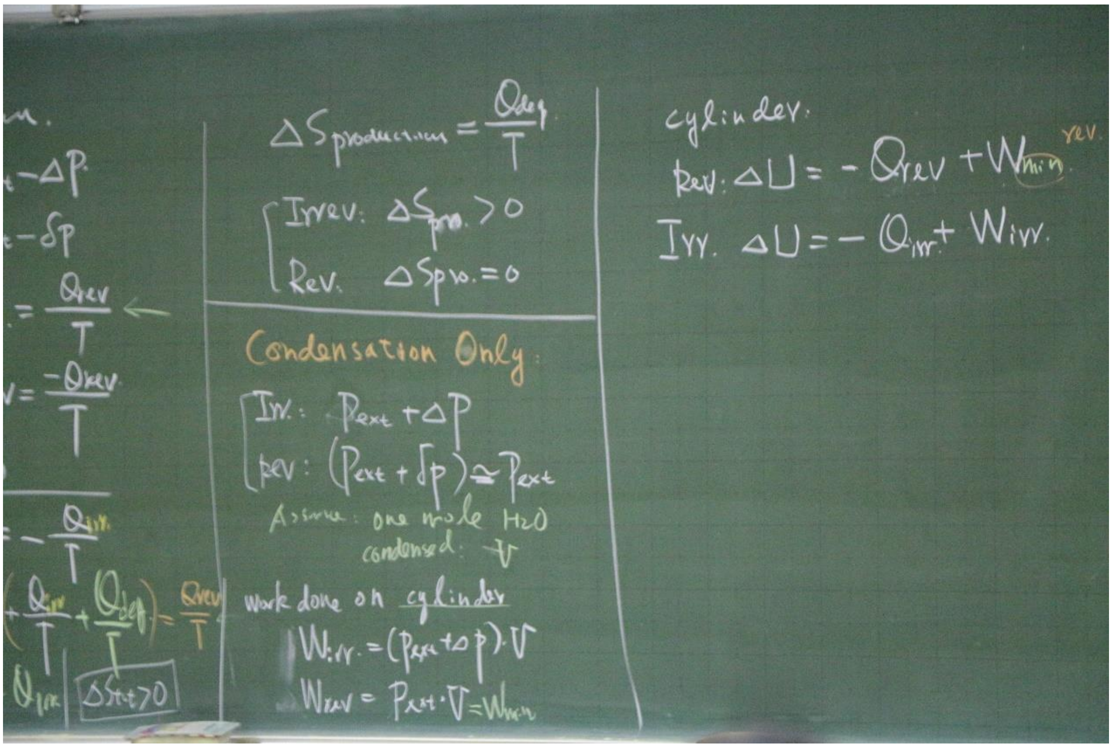
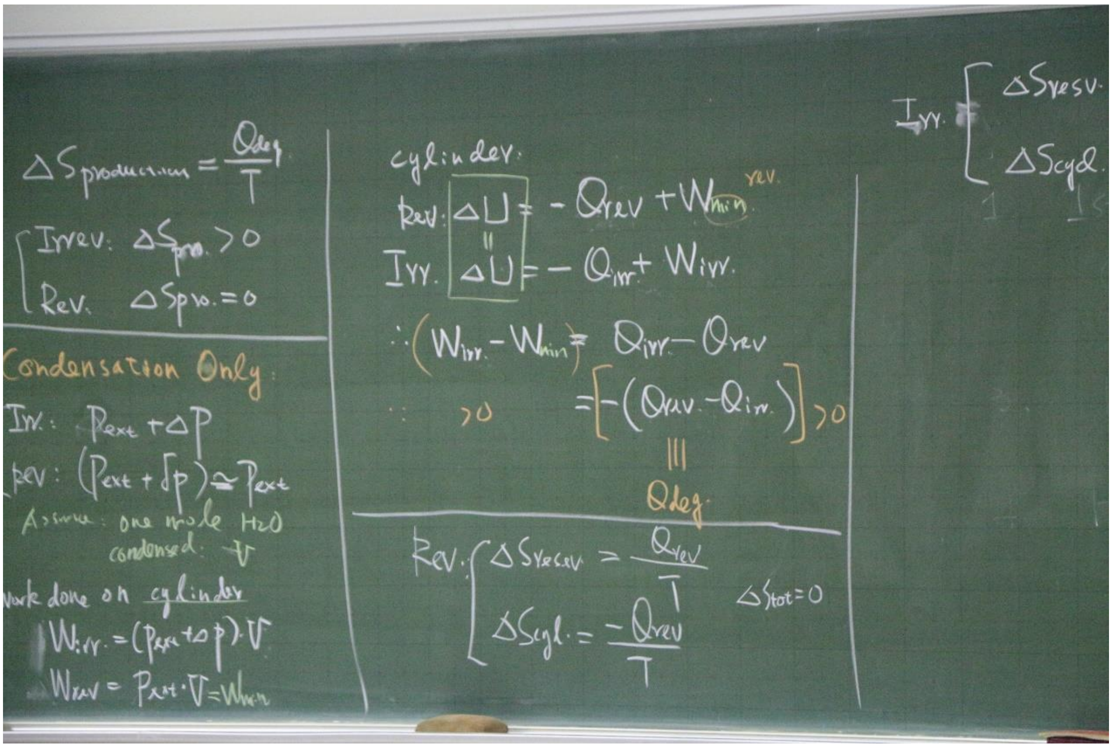

学号 . . .   姓名 . . . .
1. 1st Law
2. δW_rev ≡ ?
定义
3. H ≡ ?
4. Heat capacity. C ≡ ?


ΔS_production = Q_deg / T
Irrev: ΔS_pro. > 0
Rev. ΔS_pro. = 0
Condensation Only:
Irr.: P_ext + ΔP
Rev: (P_ext + δp) ≅ P_ext
Assume: one mole H2O condensed: V
work done on cylinder
W_irr. = (P_ext + Δp)·V
W_rev = P_ext·V = W_min
ΔS_tot > 0
cylinder:
Rev: ΔU = − Q_rev + W_min^rev
Irr. ΔU = − Q_irr + W_irr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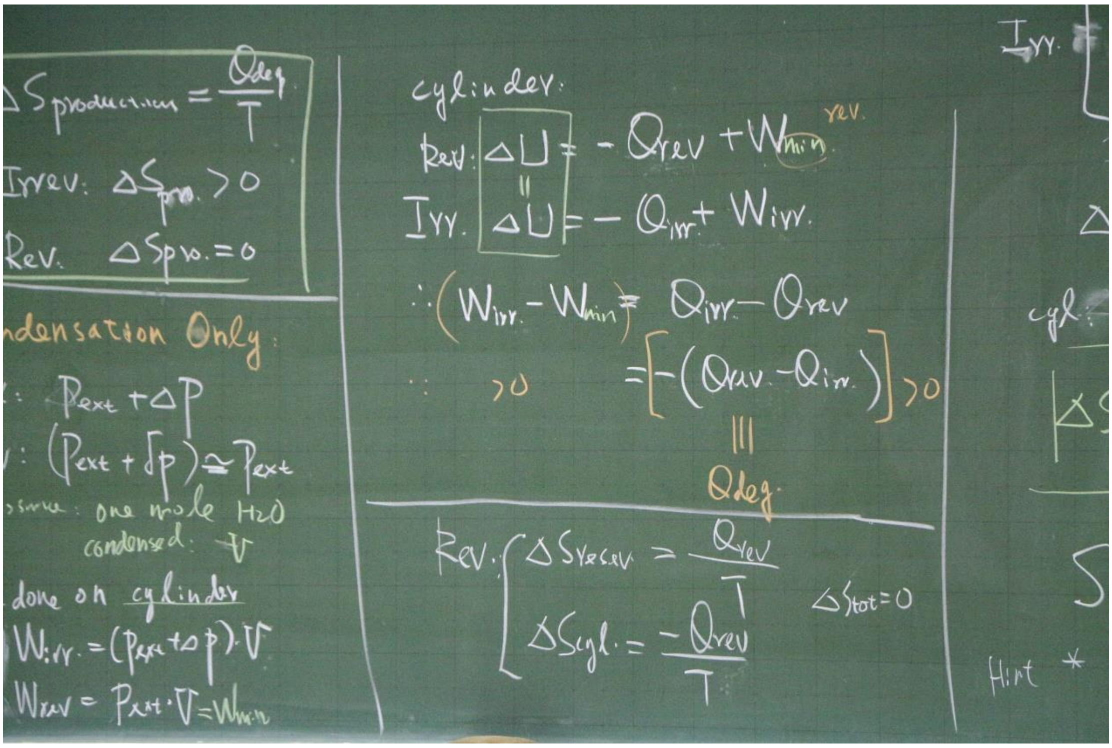
Assume: one mole H2O condensed: V
Work done on cylinder
W_irr. = (Pext + Δp)·V
W_rev = Pext·V = W_min
cylinder:
Rev: ΔU = − Q_rev + W_min rev.
Irr. ΔU = − Q_irr + W_irr.
∴ (W_irr. − W_min) = Q_irr − Q_rev
> 0 = [−(Q_rev − Q_irr)] > 0
Qdeg.
Rev. ΔS_resv = Q_rev / T
ΔS_cyl. = −Q_rev / T
ΔS_tot = 0
Irr. ΔS_resv.
ΔS_cyl.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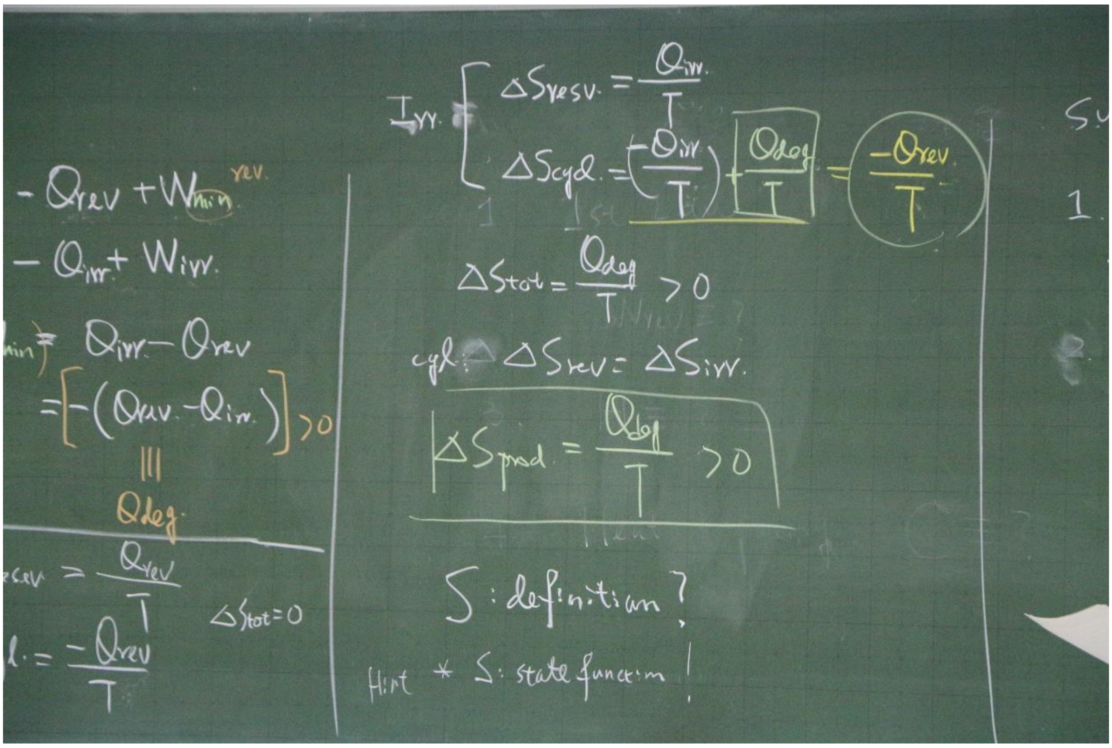
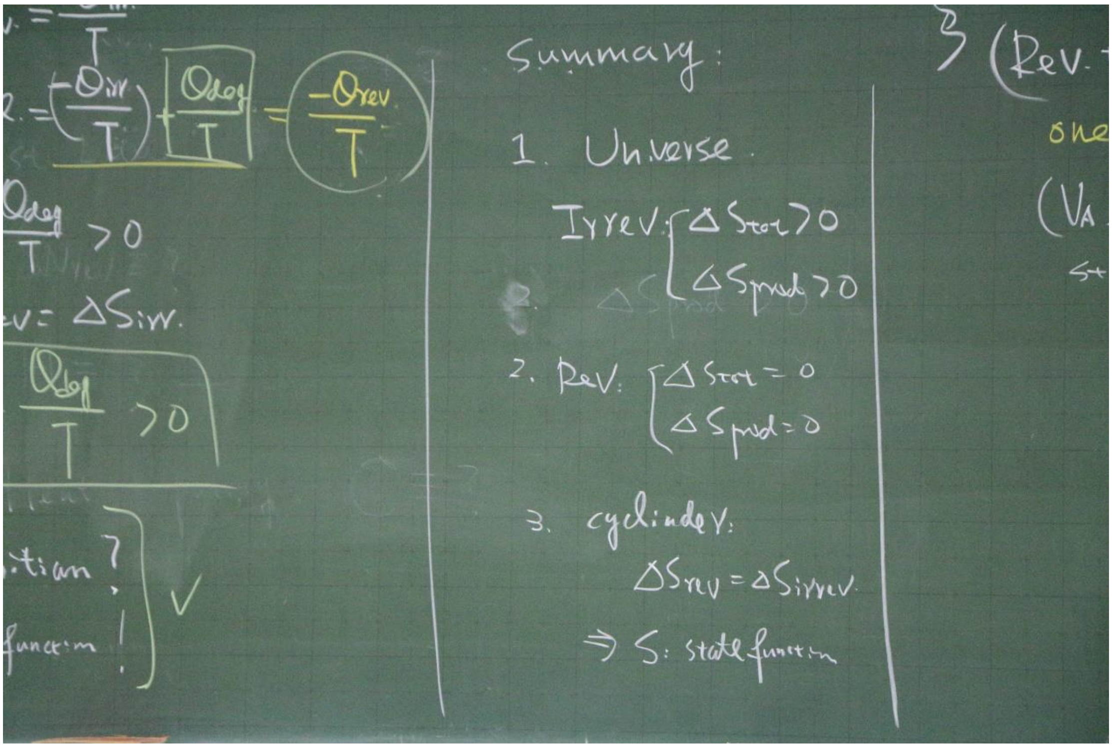
cylinder:
Rev: ΔU = − Q_rev + W_min rev.
Irr. ΔU = − Q_irr + W_irr.
∴ (W_irr. − W_min) = Q_irr − Q_rev
> 0 = [−(Q_rev − Q_irr)] > 0
Qdeg.
Rev. ΔS_resv = Q_rev / T
ΔS_cyl. = −Q_rev / T
ΔS_tot = 0
Irr.
cyl.
Hint *


$-Q_{rev} + W_{min}^{rev}$
$-Q_{irr} + W_{irr}$
$= Q_{irr} - Q_{rev}$
$= [-(Q_{rev} - Q_{irr})] > 0$
Q_{deg}
$= \frac{Q_{rev}}{T}$
$\Delta S_{tot} = 0$
$= \frac{-Q_{rev}}{T}$
Irr.
$\Delta S_{resv.} = \frac{Q_{irr.}}{T}$
$\Delta S_{cyl.} = \left(\frac{-Q_{irr}}{T}\right) + \boxed{\frac{Q_{deg}}{T}} = \frac{-Q_{rev}}{T}$
$\Delta S_{tot} = \frac{Q_{deg}}{T} > 0$
cyl: $\Delta S_{rev} = \Delta S_{irr.}$
$\boxed{\Delta S_{prod} = \frac{Q_{deg}}{T} > 0}$
S: definition?
Hint * S: state function!
Su
1.


Summary:
1. Universe.
Irrev: $\Delta S_{tot} > 0$, $\Delta S_{prod} > 0$
2. Rev: $\Delta S_{tot} = 0$, $\Delta S_{prod} = 0$
3. cylinder:
$\Delta S_{rev} = \Delta S_{irrev.}$
⇒ S: state function
3 (Rev.
one
$(V_A$

Carnot Cycle (Engine)

…mary:

Universe.

Irrev: $\begin{cases} \Delta S_{tot} > 0 \\ \Delta S_{prod} > 0 \end{cases}$

Rev: $\begin{cases} \Delta S_{tot} = 0 \\ \Delta S_{prod} = 0 \end{cases}$

cylinder:

$\Delta S_{rev} = \Delta S_{irrev}$

$\Rightarrow$ S: state function

§ (Rev. + Isothermal) Compression

one mole ideal gas

$$(V_A, T) \longrightarrow (V_B, T) \quad (V_B < V_A)$$

state A $\qquad$ state B

$\because dT = 0 \quad \therefore \Delta U = 0 \quad \therefore \Delta Q = \Delta W$

$$\Delta W = \int_{V_A}^{V_B} P \cdot dV = RT \ln\left(\frac{V_B}{V_A}\right) = \Delta Q$$

$$\Delta S_{gas} = \frac{Q_{rev}}{T} = \frac{W_{rev}}{T} = R \cdot \ln\left(\frac{V_B}{V_A}\right)$$

$$\Delta S_{reser.} = -\frac{Q_{rev}}{T} = -\Delta S_{gas}$$

…Engine)

…al) Compression

…gas

$(V_B, T) \quad (V_B < V_A)$

state B

$\Delta Q = \Delta W$

$\left(\frac{V_B}{V_A}\right) = \Delta Q$

$R \cdot \ln\left(\frac{V_B}{V_A}\right)$

S_{gas}

§ (Rev + Adiabatic) Process

Expansion.

$$\text{state A} \xrightarrow{\text{Rev.}} \text{state B}$$

$$(P_A, T_A) \longrightarrow (P_B, T_B)$$

$P_A > P_B$.

$\because$ Adia. $\Delta Q = 0$. $\qquad$ Ideal gas: $PV^{\gamma} = \text{const}$

$\Downarrow$

$\Delta S = 0 \Leftrightarrow$ constant entropy (Isentropic) (Rev + Adia.)

$$(P_A, T_A) \xrightarrow{\text{Irr.}} (P_B, T_B')$$

$\because Q_{irr} > 0 \quad \therefore T_B' > T_B$

Process

...te B

(...$_B$, T_B)

...al gas: $PV^{\gamma} = \text{const}$

...nstant entropy
(Isentropic)
(Rev + Adia.)

(... T_B')

∴ $T_B' > T_B$

§ Properties of Heat Engine

Heat Reser. t_2

$\downarrow q_2$

Engine $\rightarrow W$

$\downarrow q_1$

Heat Reserv: t_1

$t_2 > t_1$

Efficiency: $\eta \equiv \dfrac{W}{q_2}$

$\rightarrow \left[\begin{array}{l} 2.\ (\text{Isothermal} + \text{Rev}) \\ 2.\ (\text{Adia.} + \text{Rev.}) \end{array} \right.$

...bstance"

B, t_2, $q=0$, t_1, C, V

$W = (W_1 + W_2 + W_3 + W_4)$
$= \text{area}$

cycle: $\Delta U = 0$

$\therefore \Delta W = \Delta Q = q_2 - q_1$

$\therefore \eta_{carnot} = \left(\dfrac{\Delta W}{q_2}\right) = \left(\dfrac{q_2 - q_1}{q_2}\right)$

Carnot Engine.

Max. efficiency !!

cylinder:

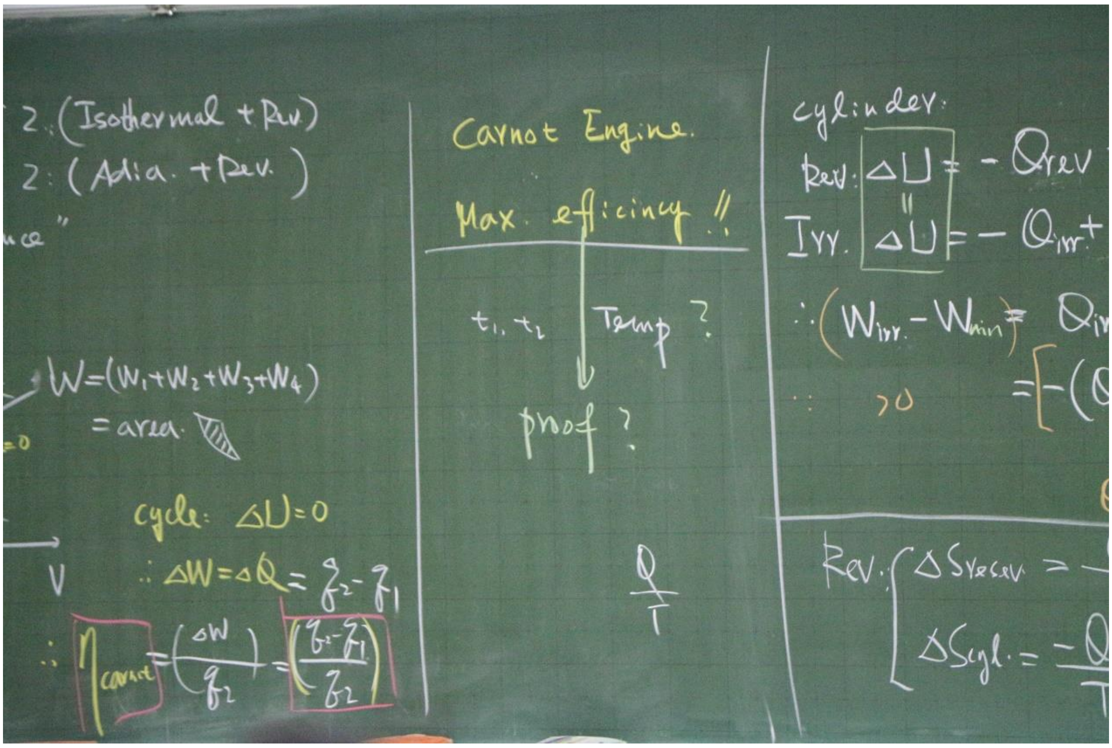
Rev: $\boxed{\Delta U} = -$ ...

Irr. $\boxed{\Delta U} = -$ ...

$\therefore (W_{irr.} - W_{rev} ...$

∴ > 0

Rev.: $\left\{ \begin{array}{l} \Delta S_{reser.} ... \\ \Delta S_{cyl.} = ... \end{array} \right.$


2: (Isothermal + Rev.)
2: (Adia. + Rev.)
W=(W1+W2+W3+W4)
=area
cycle: ΔU=0
∴ ΔW=ΔQ = q2 - q1
∴ η carnot = (ΔW / q2) = ((q2 - q1) / q2)
V
Carnot Engine.
Max. efficincy !!
t1, t2
Temp ?
proof ?
Q / T
cylinder:
Rev.: ΔU = - Qrev
Irr. ΔU = - Qirr +
∴ (Wirr. - Wmin) = Qir
>0
Rev.: ΔSrecev. =
ΔScyl. = -Q / T