Heat Capacity $C \equiv \left(\frac{\delta Q_{rev}}{dT}\right)$ $\left(\frac{J}{mole\text{-}K}\right)$

$C_p > C_v$ $(C_p - C_v) > 0$

$\boxed{\text{Ideal Gas:}}$ $(C_p - C_v) = R$

$U = U(T)$ only!

indep. of P, V

$\therefore \left(\frac{\partial U}{\partial V}\right)_T = 0$, $\left(\frac{\partial U}{\partial P}\right)_T = 0$

Reversible +

Adiabati

1st Law:

☆ $\boxed{\delta W}$

Ideal Gas: dU

state 1: $(P_1, V_1,$

Heat Capacity $C \equiv \left(\frac{\delta Q_{rev}}{dT}\right)$ $\left(\frac{J}{mole\text{-}K}\right)$

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one mole Monatomic Ideal Gas

$C_v = \frac{3}{2}R$, $C_p = \frac{5}{2}R$

Reversible + Adia

"絶

Adiabatic:

1st Law: d

☆ $\boxed{\delta W_{rev} \equiv}$

Ideal Gas: $dU = -\delta$

state 1: (P_1, V_1, T_1) —

$\because$ Ideal Gas: d

$\left(\frac{Q_{rev}}{T}\right)$ $\left(\frac{J}{mole\text{-}K}\right)$

v $(C_p - C_v) > 0$

$C_v) = R$

only!

p, V

$\left(\frac{\partial U}{\partial p}\right)_T = 0$

Ideal Gas

$p = \frac{5}{2}R$

§ Reversible + Adiabatic Process

"絶熱"

Adiabatic: $\delta Q = 0$, $\Delta Q = 0$

1st Law: $dU = \cancel{\delta Q}^{\,0} - \delta W$

☆ $\boxed{\delta W_{rev} \equiv p \cdot dV}$

Ideal Gas: $dU = -\delta W = -p \cdot dV$

state 1: $(p_1, V_1, T_1) \longrightarrow$ state 2 (p_2, V_2, T_2)?

$\because$ Ideal Gas: $dU = C_v \cdot dT = -p\, dV = -\frac{RT}{V} dV$

$\therefore \int_{T_1}^{T_2} \frac{dT}{T} = \int_{V_1}^{V_2} -\frac{R}{C_v} \frac{dV}{V}$

Adiabatic Process

"絶熱"

$\delta Q = 0$, $\Delta Q = 0$

$dU = \cancel{\delta Q}^{\,0} - \delta W$

$p \cdot dV$

$\delta W = -p \cdot dV$

$\longrightarrow$ state 2 (p_2, V_2, T_2)?

$dU = C_v \cdot dT = -p\, dV = -\frac{RT}{V} dV$

$\therefore \int_{T_1}^{T_2} \frac{dT}{T} = \int_{V_1}^{V_2} -\frac{R}{C_v} \frac{dV}{V}$

$$\ln\left(\frac{T_2}{T_1}\right) = \ln\left(\frac{V_1}{V_2}\right)^{\frac{R}{C_v}}$$

$$\therefore \frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\left(\frac{R}{C_v}\right)} = \left(\frac{V_1}{V_2}\right)^{\gamma - 1}$$

$\because PV = RT$

$$\frac{p_2 V_2}{p_1 V_1} = \frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma - 1}$$

$$\therefore \left(\frac{p_2}{p_1}\right) = \left(\frac{V_1}{V_2}\right)^{\gamma} \Rightarrow p_1 V_1^{\gamma} = p_2 V_2^{\gamma}$$

$$\Rightarrow \boxed{p \cdot V^{\gamma} = \text{const.}}\ \ast$$

$$) = \ln\left(\frac{V_1}{V_2}\right)^{\frac{R}{C_V}}$$

$$= \left(\frac{V_1}{V_2}\right)^{\left(\frac{R}{C_V}\right)} = \left(\frac{V_1}{V_2}\right)^{\gamma-1}$$

$$\boxed{V = RT}\ *$$

$$\frac{V_2}{V_1} = \frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1}$$

$$\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^{\gamma} \Rightarrow P_1V_1^{\gamma} = P_2V_2^{\gamma}$$

$$\Rightarrow \boxed{P \cdot V^{\gamma} = \text{const.}}\ *$$

同理 $\left(\frac{T_2}{T_1}\right) = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$

§ Reversible Isothermal Process

等溫

$dT = 0$

state 1 $\longrightarrow$ state 2

(P_1, V_1, T_1) $\quad$ (P_2, V_2, T_2)

$T_1 = T_2 = T$

Ideal Gas: $U = U(T)$

$dT = 0$, $\therefore$ $\Delta U = 0$, $dU = 0$

$dU = 0 = \delta Q - \delta W$

$\left(\frac{T_2}{T_1}\right) = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$

rsible Isothermal Process

等溫

$dT = 0$

1 $\longrightarrow$ state 2

$T_1)$ $\quad$ (P_2, V_2, T_2)

$T_1 = T_2 = T$

al Gas: $U = U(T)$

$dT = 0$, $\therefore$ $\Delta U = 0$, $dU = 0$

$dU = 0 = \delta Q - \delta W$

$$\therefore \int \delta Q = \int \delta W = \int P \, dV$$

$$\therefore \underline{\Delta Q = \Delta W} = \int_{V_1}^{V_2} P \, dV$$

$$= \int_{V_1}^{V_2} \frac{RT}{V} \, dV$$

$$= RT \ln\left(\frac{V_2}{V_1}\right)$$

$$= RT \ln\left(\frac{P_1}{P_2}\right)$$

C.p. Ideal Gas

- Reversible Isthe
- Reversible Adi

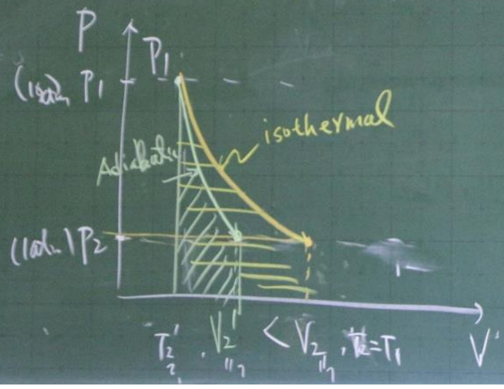
$P_1 \longrightarrow P$

c.p. Ideal Gas

Reversible Isothermal Expansion (V_2, T_2) : $PV = RT = \text{const}$

Reversible Adiabatic Expansion (V_2', T_2') : $PV^{\gamma} = (\text{const})$

$P_1 \longrightarrow P_2 (< P_1)$



$$\boxed{\Delta W_{adia.} < \Delta W_{isothermal}}$$

Isothermal Expansion:

吸熱 $\longrightarrow$ 做功

Adiabatic. $\Delta Q = 0$

$\Delta U \downarrow \longrightarrow$ 做功

T = const

nst)

Wisothermal

→ 做功

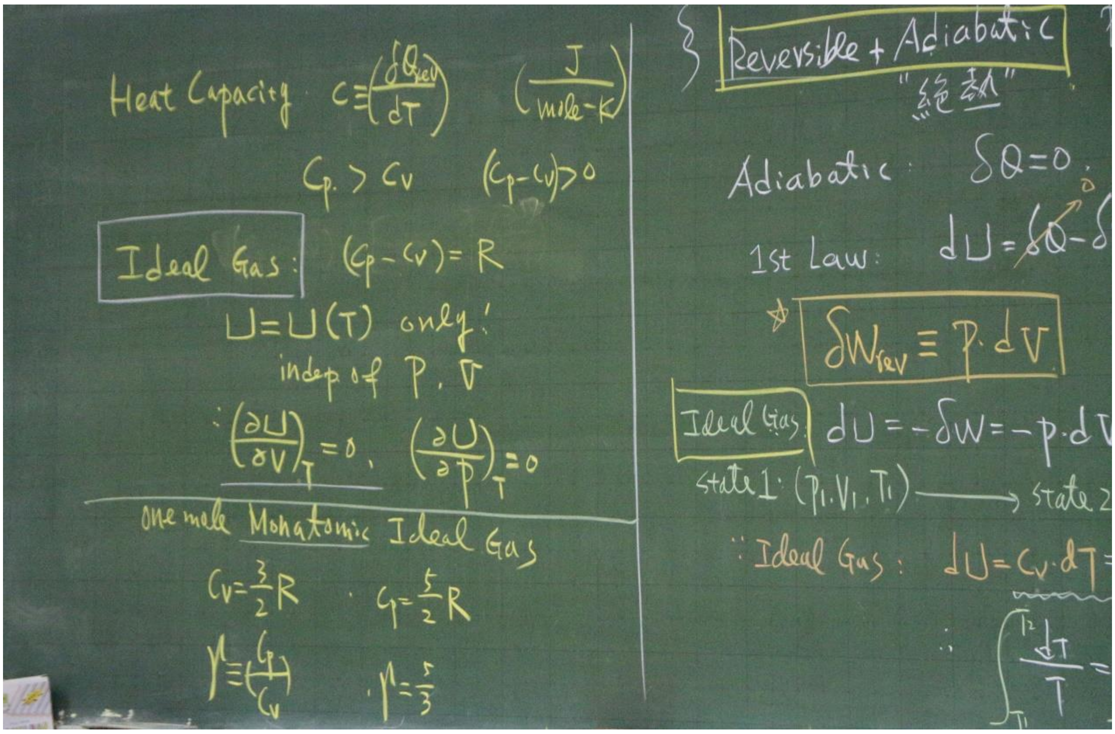
→ 做功

EX: state a $\longrightarrow$ state b

$P_a = 10\,atm$	$\longrightarrow$ $P_b = 1\,atm$
$V_a = 10\,l$	$V_b = ?$
$T_a = 298\,K$	$V_b' = ?$

$\boxed{\Delta W, \Delta Q, \Delta U, \Delta H.}$?

$\Delta U(T)$: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