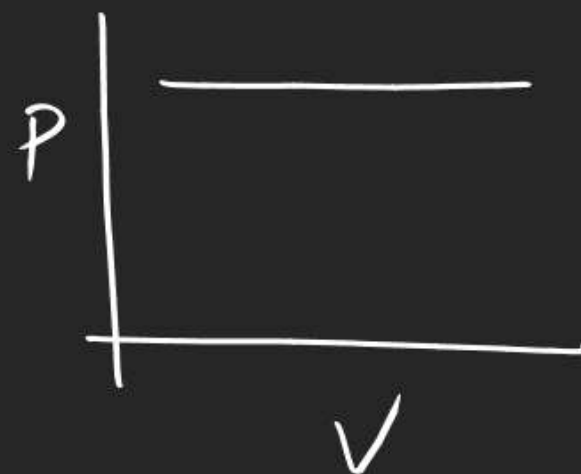
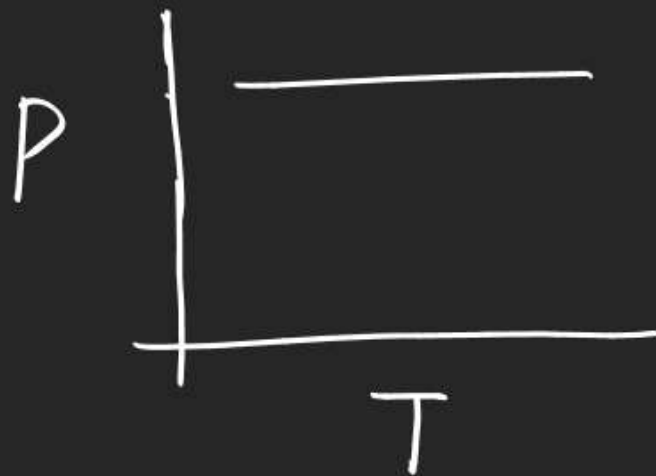


THERMODYNAMICS

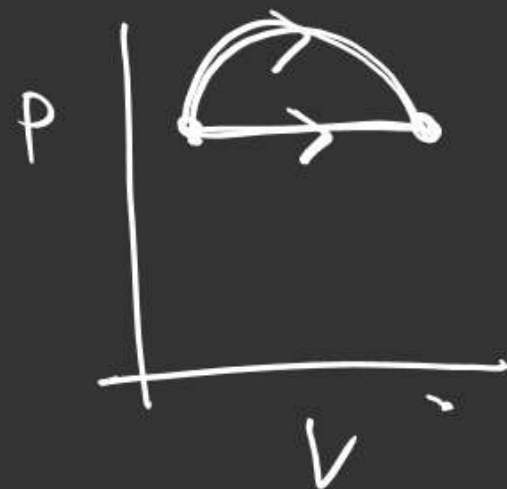


THERMODYNAMICS

Q. 1 mol non-ideal gas is subjected to a change from (2 bar, 4 Lit, 300 K) to (2 bar, 6 Lit, 500 K)

Given $C_v = 20 \text{ J/K/mol}$ find ΔU & ΔH
 $C_p = 25 \text{ J/K/mol}$

~~$\Delta U = n C_v \Delta T$~~



$$\Delta H = 1 \times 25 \times 200$$

$$= 5000 \text{ J}$$

$$\Delta H = 5000$$

$$\Delta U = 4600$$

$$= 4000$$

$$5000 = \Delta U + (P_2 V_2 - P_1 V_1)$$

$$= \Delta U + 4000 \text{ J}$$

$Q = \Delta H$ if P is constant throughout

$$= 5000 \text{ J}$$

THERMODYNAMICS

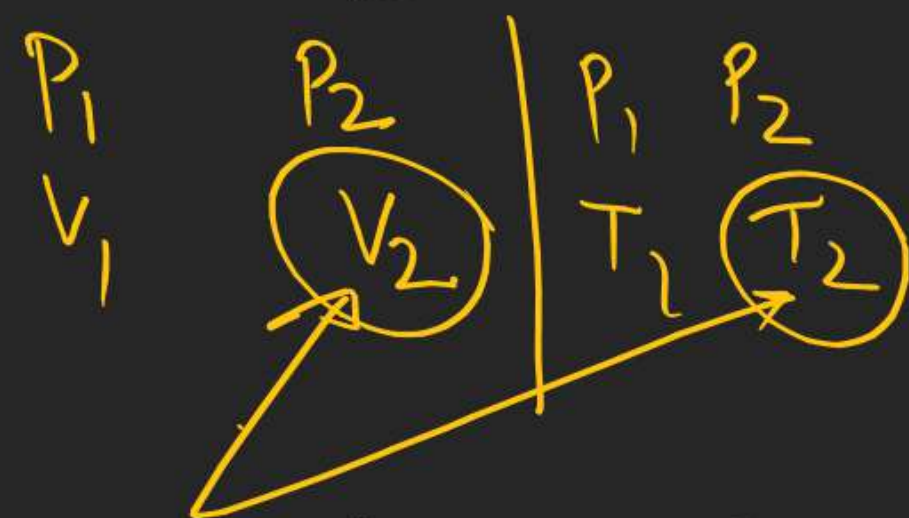
Adiabatic process! →

$q = 0$

from 1st law of T.D
 $\Delta U = w = n C_V \Delta T$ (for ideal gas)

$$\frac{C_p}{C_v} = \frac{C_v}{C_v} + \frac{R}{C_v}$$

$$\gamma = 1 + \frac{R}{C_v}$$



$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\Delta H = n C_p \Delta T \quad (\text{for ideal gas})$$

$$= n \frac{R}{\gamma - 1} \Delta T$$

$$= \frac{n R T_2 - n R T_1}{\gamma - 1} = \frac{P_2 V_2 - P_1 V_1}{\gamma - 1}$$

THERMODYNAMICS

<u>expansion</u>	$V \uparrow$	$w < 0$	$\Delta U < 0$	$\Delta T < 0$	$T \downarrow$	$P \downarrow$
<u>compⁿ</u>	$V \downarrow$	$w > 0$	$\Delta U > 0$	$\Delta T > 0$	$T \uparrow$	$P \uparrow$

$$P = \frac{nR \textcircled{T} \downarrow}{\textcircled{V} \uparrow}$$

600K 300K
10 atm < 5 atm

THERMODYNAMICS

for reversible adiabatic process

from 1st

$$dU = w$$

$$nC_v dT = -P_{\text{ext}} dv$$

[for a reversible

$$P_{\text{ext}} = P = \frac{nRT}{V}$$

$$nC_v dT = -\frac{nRT}{V} dv$$

$$\int \frac{dT}{T} = -\frac{R}{C_v} \int \frac{dv}{V}$$

for
rev
adiabatic
only

$$\begin{aligned} TV^{\gamma-1} &= \text{Const} \\ PV^{\gamma} &= \text{Const} \\ P^{1-\gamma} T^{\gamma} &= \text{Const} \end{aligned}$$

$$\ln \frac{T_2}{T_1} = -(\gamma-1) \ln \frac{V_2}{V_1}$$

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

$$T_2 V_2^{\gamma-1} = T_1 V_1^{\gamma-1}$$

THERMODYNAMICS

for irrevers adiabatic process

$$\Delta U = \underline{w} = n C_v \underline{\Delta T}$$

$$dU = w$$
$$nC_v dT = -P_{\text{ext}} dv$$

$$nC_v (T_2 - T_1) = -P_{\text{ext}} (V_2 - V_1)$$

$$\boxed{nC_v (T_2 - T_1) = -\underline{P_{\text{ext}}} \left(\frac{nRT_2}{P_2} - \frac{nRT_1}{P_1} \right)}$$

Q. Calculate w for 1 mol non-linear triatomic ideal gas undergoing adiabatic process from (16 atm, 300 K) to (1 atm,)

(a) Reversibly

(b) Irreversibly

(c) free expansion

$$\gamma = \frac{C_p}{C_v} = \frac{4R}{3R} = \frac{4}{3}$$

(a) $P_1^{1-\gamma} T_1^\gamma = P_2^{1-\gamma} T_2^\gamma$

$$\left(\frac{T_2}{T_1}\right) = \left(\frac{P_1}{P_2}\right)^{\frac{1-\gamma}{\gamma}} = \left(\frac{16}{1}\right)^{\frac{1-\frac{4}{3}}{\frac{4}{3}}} = (16)^{-\frac{1}{4}}$$

$$\frac{T_2}{300} = \left(\frac{1}{16}\right)^{\frac{1}{4}} = \frac{1}{2}$$

$T_2 = 150 \text{ K}$

$$\begin{aligned} W &= n C_v (T_2 - T_1) \\ &= 1 \times 3R (-150) \\ W &= -450R \end{aligned}$$

THERMODYNAMICS

②

$$\cancel{n} C_v (T_2 - T_1) = -P_{\text{ext}} \left(\cancel{n} \frac{RT_2}{P_2} - \cancel{n} \frac{RT_1}{P_1} \right)$$

$$3 (T_2 - 300) = -1 \left(\frac{T_2}{1} - \frac{300}{16} \right)$$

$$T_2 = 229.68$$

$$\approx 230 \text{ K}$$

$$W = 1 \times 3R (230 - 300)$$

$$= \underline{\underline{-210R}}$$

$$\textcircled{3} \quad n C_v (T_2 - T_1) = -P (V_2 - V_1)$$

$$T_2 = T_1 = 300$$

$$W = 0$$

$$\Delta U = 0$$

$$\Delta H = 0$$

THERMODYNAMICS

Q. Calculate w for 1 mol non-linear triatomic ideal gas undergoing adiabatic process from $(1 \text{ atm}, 300 \text{ K})$ to (16 atm) (a) Rev (b) Irrev

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

$$T_2 = 600 \text{ K}$$

$$W = 1 \times 3R \times 300 \\ = 900R$$

$$\textcircled{2} \quad \cancel{\eta} \times 3R \times (T_2 - 300) = -16 \left(\frac{T_2}{16} - \frac{300}{1} \right)$$

$$T_2 = 1425 \text{ K}$$

$$W = 3R (1425 - 300) \\ = 3375R$$

Conclusions

① In case of expansion

$$|W_{rev}| \geq |W_{irr}|$$

② In case of compn

$$|W_{rev}| \leq |W_{irr}|$$

③ Reversible processes are more efficient than irreversible processes

④

$$P = 1 \text{ atm}, T = 300 \text{ K}, n = 1$$

$$\underline{W} = n C_v \underline{\Delta T}$$

Rev

$$P = 16 \text{ atm}$$

$$T_{\text{rev}} = \underline{600 \text{ K}}$$

$$n = 1$$

$$V_{\text{rev}}$$

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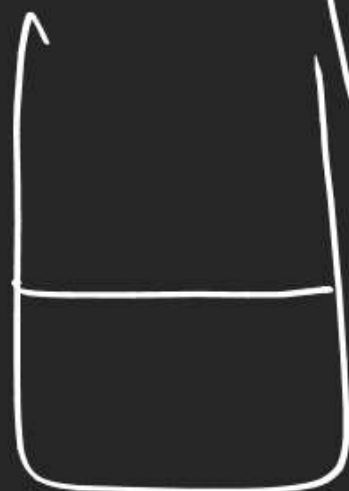
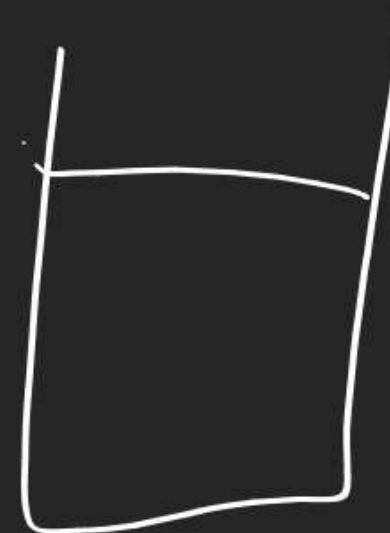
Irrev

$$P = 16 \text{ atm}$$

$$T_{\text{irr}} = 1425 \text{ K}$$

$$n = 1$$

$$V_{\text{irr}}$$



for exp as well compⁿ

$$T_{\text{rev}} < T_{\text{irr}}$$

$$\underline{|W|} = nC_v \underline{\Delta T}$$

Adiabatic rev & irr processes don't end up at the same final state if carried out against same final pressure from same initial state

S-I 27-34