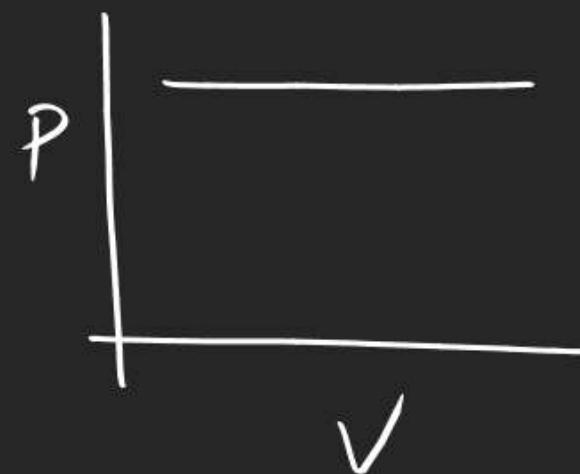


THERMODYNAMICS

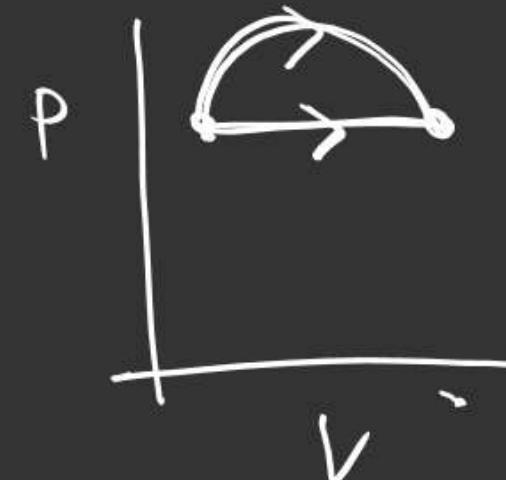


Q. 1 mol non-ideal gas is subjected to a change from (2 bar, 4 lit, 300 K) to (2 bar, 6 lit, 500 K)

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

~~$\Delta U = n C_V \Delta T$~~ $\Delta H = 1 \times 25 \times 200$
 $= 5000 \text{ J}$

$\Delta H = 5000 \text{ J}$
 $\Delta U = 4600 \text{ J}$
 $= 4600 \text{ J}$



$$\begin{aligned} 5000 &= \Delta U + (P_2 V_2 - P_1 V_1) \\ &= \underline{\Delta U + 4600 \text{ J}} \end{aligned}$$

$Q = \Delta H$ if P is constant throughout
 $= 5000 \text{ J}$

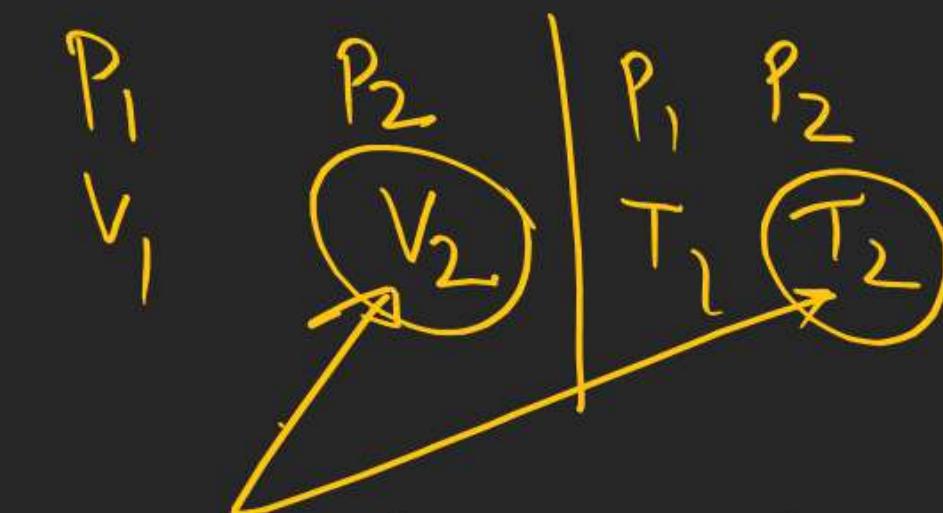
THERMODYNAMICS

Adiabatic process : \rightarrow

$q = 0$

from 1st law $q = T.D$

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



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

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

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

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

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

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

THERMODYNAMICS

expansion $V \uparrow$ $W < 0$ $\Delta U < 0$ $\Delta T < 0$ $T \downarrow$ $P \downarrow$

compⁿ $V \downarrow$ $W > 0$ $\Delta U > 0$ $\Delta T > 0$ $T \uparrow$ $P \uparrow$

$$P = \frac{n R \bigcirc T \downarrow}{\bigcirc V \uparrow}$$

600K 300K
10 atm < 5 atm

THERMODYNAMICS

for reversible adiabatic process

from 1st

$$dU = w$$

$$nC_V dT = - \underline{P_{ext} dV}$$

[for a reversible

$$\underline{P_{ext}} \simeq P = \frac{nRT}{V}$$

$$\cancel{\cancel{w dT}} = - \frac{nRT}{V} dV$$

$$\int \frac{dT}{T} = - \frac{R}{C_V} \int \frac{dV}{V}$$

for
rev
adiabatic
only

$$\boxed{\begin{aligned} TV^{r-1} &= \text{const} \\ PV^r &= \text{const} \\ P^{1-r} T^r &= \text{const} \end{aligned}}$$

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

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

$$T_2 V_2^{r-1} = T_1 V_1^{r-1}$$

THERMODYNAMICS

for irrever adiabatic procen

$$dU = w$$

$$nC_V dT = - P_{ext} \int dV$$

$$nC_V(T_2 - T_1) = - P_{ext}(V_2 - V_1)$$

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

$$\Delta U = \underline{w} = nC_V \underline{\Delta T}$$

Q. Calculate W for 1mol non-linear triatomic ideal gas

undergoing adiabatic process from (16 atm, 300 K) to (1 atm,)

(a) Reversibly

$$\gamma = \frac{C_P}{C_V} = \frac{4R}{3R} = \frac{4}{3}$$

(b) Irreversibly

(a)

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

(c) free expansion

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

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

$$\underline{\underline{T_2 = 150K}}$$

$$W = n C_V (T_2 - T_1)$$

$$= 1 \times 3R (-150)$$

$$W = -450R$$

THERMODYNAMICS

②

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

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

$$T_2 = 229.68 \\ \approx 230 \text{ K}$$

$$W = 1 \times 3 R (230 - 300) \\ = -210 R$$

$$③ n C_V (T_2 - T_1) = -0(V_2 - V_1)$$

$$T_2 = T_1 = 300$$

$$W = 0$$

$\Delta U = 0$
 $\Delta H = 0$

THERMODYNAMICS

Q. Calculate w for 1 mol non-linear triatomic ideal gas undergoing adiabatic process from (1 atm, 300 K) to (16 atm) ① Rev ② Isover

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

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

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

$$= 900R$$

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

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

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

$$= 3375R$$

=====

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

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

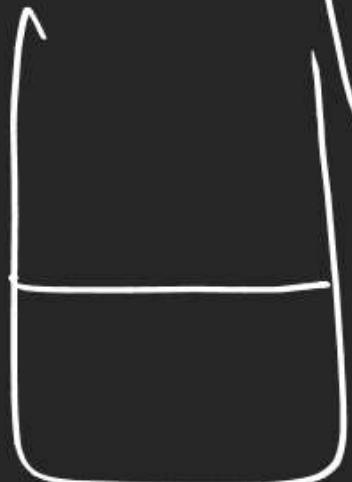
$$\underline{W} = n C_V \Delta T$$

Rev

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

$$T = \underline{600 \text{ K}}$$

$$n = 1$$

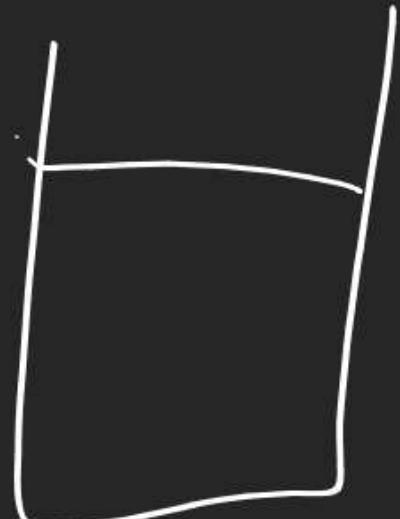
 V_{rev} 

Irrev

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

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

$$n = 1$$

 V_{irr} 

for exp as well compⁿ

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

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

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

S-L 27-34