First Law of Thermodynamics:

$$dU = \bar{d}Q + \bar{d}W$$

$$\bar{d}W = -p\,dV$$

$$\Rightarrow \boxed{\bar{d}Q = dU + p\,dV}$$

$$U = U(T, V)$$

$$dU = \left(\frac{\partial U}{\partial T}\right)_V dT + \left(\frac{\partial U}{\partial V}\right)_T dV$$

$$\bar{d}Q = \left(\frac{\partial U}{\partial T}\right)_V dT + \left[\left(\frac{\partial U}{\partial V}\right)_T + p\right] dV$$

$$\Rightarrow \frac{\bar{d}Q}{dT} = \left(\frac{\partial U}{\partial T}\right)_V + \left[\left(\frac{\partial U}{\partial V}\right)_T + p\right] \frac{dV}{dT}$$

$$\boxed{\begin{array}{l} \bar{d}Q \propto dT \\ \bar{d}Q = C\,dT \end{array}}$$

$$C_V = \left(\frac{\bar{d}Q}{dT}\right)_V = \left(\frac{\partial U}{\partial T}\right)_V$$

$$C_p = C_V + \left[\left(\frac{\partial U}{\partial V}\right)_T + p\right] \left(\frac{\partial V}{\partial T}\right)_p$$

$$U = U(P,V)$$

$$đQ = \left(\frac{\partial U}{\partial P}\right)_V dP + \left[\left(\frac{\partial U}{\partial V}\right)_P + P\right] dV$$

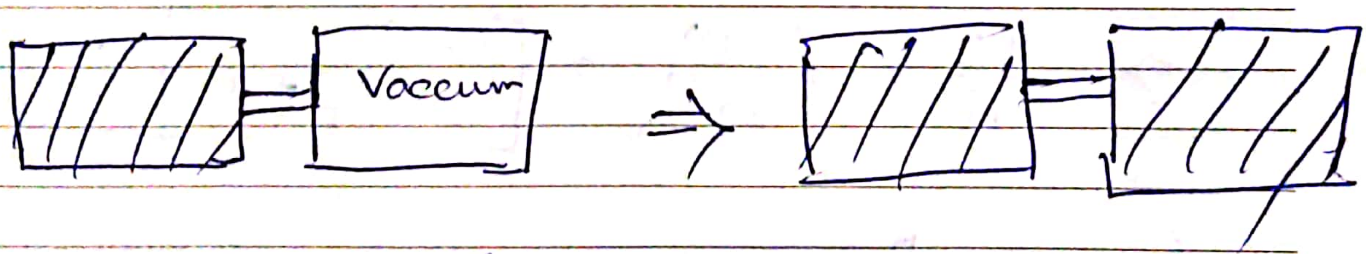
$$U = U(P,T) \quad , \quad V = V(P,T)$$

$$đQ = \left[\left(\frac{\partial U}{\partial P}\right)_T + P\left(\frac{\partial V}{\partial P}\right)_T\right] dP + \left[\left(\frac{\partial U}{\partial T}\right)_P + P\left(\frac{\partial V}{\partial T}\right)_P\right] dT$$

$$C_P = \left(\frac{dQ}{dT}\right)_P = \frac{\partial}{\partial T}\left(U + PV\right)_P = dQ_P$$

$H = U + PV$ = Enthalpy.

① Joule Expansion: perfect gas + free exp.



Expt finding $T_1 = T_2$

$đW = 0$

$đQ = 0$ since $T_1 = T_2$

$\Rightarrow dU = 0$.

$\Rightarrow \left(\frac{\partial U}{\partial V}\right)_T = 0$.

② $\Rightarrow dU = C_v dT$

$đQ = C_v dT + PdV$.

3) - $C_p - C_v = P\left(\frac{\partial V}{\partial T}\right)_P$

8

9 $\Rightarrow \boxed{C_p - C_v = nR}$

10 **Isothermal & Adiabatic process:**

11 **Isothermal:** $dT = 0$.

12 $\Rightarrow dU = 0$.

1 $\Rightarrow dQ = -dW$

$= \int_{V_1}^{V_2} P\,dV$

2

3 $= RT \ln\left(\frac{V_2}{V_1}\right)$

4 $V_2 > V_1 \Rightarrow dW < 0 \;,\; dQ > 0$

5 **Adiabatic:** $dQ = 0$.

6 $\Rightarrow dU = dW$.

$\Rightarrow C_v\,dT = -P\,dV = -\frac{RT}{V}dV$

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

$C_p = C_v + R \Rightarrow \frac{R}{C_v} = \frac{C_p}{C_v} - 1 = \gamma - 1$

$\Rightarrow \boxed{TV^{\gamma-1} = \text{Const}} \Rightarrow \boxed{PV^{\gamma} = \text{Const}}$

Isothermal Process: $PV = RT$

$$\Rightarrow PdV + VdP = 0$$

$$\Rightarrow \left(\frac{\partial P}{\partial V}\right)_T = -\left(\frac{P}{V}\right)$$

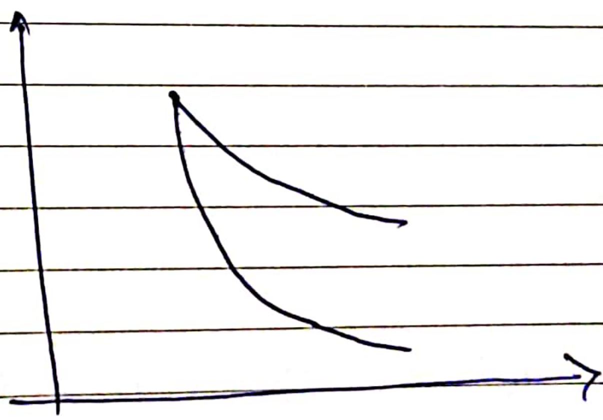
Adiabatic Process: $PV^\gamma = \text{const}$

$$\Rightarrow \gamma P V^{\gamma-1} dV + V^\gamma dP = 0.$$

$$\Rightarrow \left(\frac{\partial P}{\partial V}\right) = -\gamma\left(\frac{P}{V}\right)$$

$\gamma > 1.$

$\gamma = 1 + 2/f$



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1st Law ⇒ Conservation of Energy
⇒ Yet never happen

2nd Law of Thermodynamics:

Kelvin statement: There exists no thermodynamic transformation whose sole effect is to extract a quantity of heat from a given reservoir and convert it entirely into work.

Clausius statement: There exists no ~~thermodyn~~ thermodynamic transformation whose sole effect is to extract a quantity of heat from a ~~given heat reservoir~~ colder reservoir and ~~convert~~ to deliver it to a hotter reservoir.

Ideal gas ⇒ reversible + isothermal expansion

⇒ work done by the gas.

⇒ $dU = 0$.

⇒ $đQ = -đW$?

Kelvin statement & Clausious statement are equivalent