

Zvc MvZve`vi cŭg mĤ

fygKv

c`v_9eÁvbi th kvLiq Zvc I KvĤRi m^úK[©]m[†]Ŭ AvĤj vPbv Kiv nq ZvĤKB ZvcMvZve`v
(Thermodynamics) etj | ZvcMvZve`vi cŭg mĤ Zvc I hvšK kv³i m^úK[©]AvĤj vPbv Kiv nq | G
BDvĤU Zvc MvZve`vi cŭgmĤ, newfbvZvcMvZvq cŭvqv I MvĤmi AvĤcĤĤK Zvc AvĤj vPZ nĤe |

cW - 1

ZvcMZxq e'e-v I cwi cvk, Zvc I Aš:-'kw³, M'vm Øviv mαúwì Z KvR, weifbæZvcMZxq cµqv

Dfík

G cvfi tkfI AvciB -

- | ZvcMZxq e'e-v I cwi cvk, mαútkavi Yv w' tZ cvi teB,
- | ZvcMZxq -vbr¼, Ae-v I cµqv eYØv Ki tZ cvi teB,
- | weifbæZvcMZxq cµqv e'vL'v Ki tZ cvi teB |

13.1.1 t ZvcMZxq e'e-v ev vnt÷g I cwi cvk

c`_eÁvb mel tq e'e-v (System) ej tZ eSvq Ro RMtZi Ggb LmbKUv Ask hvi Ae-vi cwieZØ ev hvi tFŠZ atgP cwieZØ chfeY Kiv nq| e'e-vi evBti hv wKQye'e-vi AvPi tYi Dci cL'q cFve we-hi Kti ZvtK cwi cvk (environment) ej v nq|

wc÷b hY GKwU wvuj Úvti Aew-Z M'vm ZvcMZxq e'e-v ev vnt÷g vntmte wefepZ nq Ges wc÷b G t'q t' cwi cvk tZ cvi | Kvi Y wc÷b i DVvbrgvi Dci M'v tmi Ae-vi cwieZØ nq| A_Ø G t'q t' wc÷b M'v tmi A_Ø e'e-vi AvPi tYi Dci cL'q cFve we-hi Kti |

13.1.2 t ZvcMZxq cµqv

Zvc MwZwe`vq e'e-vi Ae-v Pvc (P), AvqZb (v) I cig ZvcgvTvi (T) mrvth` cKvk Kiv nq| G i vnk, vj tK ZvcMZxq -vbr¼ (Thermodynamic co-ordinate) ev ZvcMZxq Pj i vnk (Thermodynamic variables) etj | ZvcMZxq -vbr¼i mrvth` tKvb e-zev e'e-vi Ae-v cKvk Kitj tm Ae-v tK ZvcMZxq Ae-v etj | th cwieZØbi Kvi tY ZvcMZxq -vbr¼i gvb cwieZØ nq tm cwieZØ tK ZvcMZxq cµqv etj |

13.1.3 t Zvc I Aš:-'kw³ (Heat and internal Energy)

ZvcgvTvi e'ear tbi Kvi tY D'P ZvcgvTvi -vb t_tK wæ ZvcgvTvi -vtb mÁvuj Z kw³i bvgB Zvc| Avi e'e-vi gta`_vtK GKwU wvuj Ø cwi gvY Zvc kw³ hv Ab'vb` kw³ tZ ifcvi Šwì Z n tZ cvi | G kw³ tK Aš:-'kw³ etj | Aš:-'kw³ e'e-vi AYyuj i wefekw³ I MwZkw³i thvMdj |

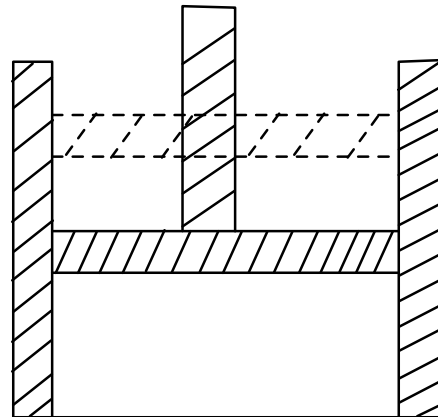
Zvc cØqvM ev Acmvi Y Kti Aš:-'kw³i cwieZØ NUVtbr hvq| Zvc cØqvM Kitj chY Zvtci wKQy Ask Øviv Aš:-'kw³ ep× cvq I evwK Ask Øviv evwK KvR mαúwì Z nq| Zvc Acmvi tY Aš:-'kw³ nvm cvq|

Avei M'v tmi Dci KvR mαúwì Z n t' A_Ø M'v tK msvngZ Kitj Aš:-'kw³ ep× cvq Ges M'v tK cÁvvi Z n t' A_Ø M'vm Øviv KvR mαúwì Z n t' Aš:-'kw³ nvm cvq|

Aš:-'kw³i cwieZØ i agvT e'e-vi cØ_ugK I Pøvš-Ae-vi Dci wbfP Kti | tKvb c t_ Pøvš-Ae-vq tcØvuj, Zvi Dci wbfP Kti bv|

13.1.4 t M'vm Øviv m'úwì Z KvR

aiv hvK, uc÷bhÿ GKUW umwj Úvtii gfa" uKQy M'vm AvtQ| uc÷tbi cŕt"Qŕi tŕŕĬdj A | M'vtmi Pvc P | AZGe, uc÷tbi Dci ej, F = PA | aiv hvK, M'vm cŕwvi Z ntq uc÷bŕK evBŕii wŕŕK Δx `i-Zj chŒ-mwiŕtq ubj | hwŕ Δx Lÿ ŕŕž² nq hvŕZ Pŕŕci Lÿ GKUv cwi eZŒ bv NŕU, Zvntj ej F tK wŕi aiv thŕZ cvŕi |



ŕŕĬ 13.1

AZGe, m'úwì Z KvRi cwi gvY,

$$\Delta W = F \Delta x = P A \Delta x$$

uKŒZA. $\Delta x = \Delta V = M'vtmi AvqZb cwi eZŒ |$

$$\therefore \Delta W = P \Delta V \dots \dots \dots (1)$$

A_ŕ M'vm Øviv m'úwì Z KvR

$$= Pvc \times AvqZb cwi eZŒ |$$

G KvRŕK em"K KvR etj |

13.1.5 t veŕfbcZvcMZvq cŕμqv

(K) mŕgvò cŕμqv (Isothermal Process)

Pvc cwi eZŒ Kivi dtj hwŕ tKvb M'vtmi AvqZtbi cwi eZŒ nq, uKŒZvcgvĬvi tKvb cwi eZŒ nq bv, Zvntj tm cwi eZŒŕK mŕgvò cwi eZŒ etj |

th cŕμqvq G cwi eZŒ msNwUZ nq ZvŕK mŕgvò cŕμqv etj |

tKvb M'vmŕK nVvr Pvc cŕqvŕM msbgZ Kiv ntj, M'vtmi Dci KvR m'úwì Z nq etj M'vtmi AŒŕ' kŕ³ ep× cvq| dtj ZvcgvĬv ep× cvq| Avevi M'vmŕK nVvr cŕwvi Z ntZ wŕŕj, M'vtmi AŒŕ' kŕ³ eŕtq M'vm KZŕ KvR m'úwì Z nq etj AŒŕ' kŕ³ nŕm cvq| dtj ZvcgvĬv Kŕg hvq| hwŕ axŕi axŕi Pŕŕci cwi eZŒ Kiv nq Ges msbgb I cŕhviŕYi mgq h_vμŕg Zvc mwiŕtq I Zvc cŕvb Kŕi ZvcgvĬv wŕi ivLv nq, Zvntj G cwi eZŒŕK mŕgvò cwi eZŒ etj | mŕgvò cŕμqvq M'vm AYŕj AŒŕ' kŕ³ AcwievZŒ_vŕK| Zvŕci Av_vb cŕvŕbi Rb" M'vm cvĬ Zvŕci mŕwievŕx ntZ nq|

mŕgvò cwi eZŒŕ Pvc I AvqZtbi cvi_úwìK m'úK^etqj Gi mŕ t_ŕK cvlqv hvq| etqj Gi mŕ Abŕvŕŕi ZvcgvĬv wŕi_vKŕj ubwŕ Œ cwi gvY M'vtmi AvqZb cŕhÿ Pŕŕci e_v_wbŕwŕZK|

$$A_ŕ v \propto \frac{1}{P} hLb T wŕi_vŕK|$$

$$ev, PV = a^eK|$$

(L) if-Zvcxq çµqv (Adiabatic Process)

th çµqvq M'vfmî Pvc I AvqZtbi çwi eZ⁰ nq wKšZM'vm Zvc MhY ev eR⁰ KitZ çvfbv tm çµqvçK if-Zvcxq çµqv etj |

if-Zvcxq çµqvq M'vmçK msbuqZ Kitj ZvcgvÎv tetô hvq Ges çhmi Z Kitj ZvcgvÎv Ktg hvq | if-Zvcxq çµqvq M'vm tKvb Zvc MhY ev eR⁰ bv Kitj I M'vfmî Aš:-' kw³ w'î _vçK bv | hLb M'vfmî çhviY NtU, M'vm evn'K KvR Kti Ges M'vfmî Aš:-' kw³ nwm çvq | Avevi hLb M'vmçK msbuqZ Kiv nq, M'vfmî Dci KvR m'úwî Z nq dtj M'vfmî Aš:-' kw³ epx çvq |

(M) a'e AvqZb çµqv (Isochoric Process)

th çµqvq e^{-z} AvqZb Acwi ewZ² _vçK wKšZPvc I ZvcgvÎvi çwi eZ⁰ nq, ZvçK a'e AvqZb çµqv ejv nq |

AvqZb w'î _vçK etj GB çµqvq M'vm KZ² m'úwî Z KvR, $\Delta W = 0$

(N) a'e Pvc çµqv (Isobaric Process)

th çµqvq Pvc w'î ivLv nq, ZvçK a'ç Pvc çµqv ejv nq |

a'e Pvc P Gi Aaxtb hv M'vfmî AvqZb çwi eZ⁰ ΔV nq, Zvntj M'vm KZ² m'úwî Z KvR, $\Delta W = P\Delta V$

D`niY

1 | $2.0 \times 10^5 \text{ N m}^{-2}$ w'î Pvc tKvb M'vfmî AvqZb 12 cm^3 t_çK 15 cm^3 ntjv | evn: ' KvçRi çwi gvY wYç Ki "b |

evn: ' KvçRi çwi gvY, $\Delta W = P \cdot \Delta V$

GLvçb, $P = 2.0 \times 10^5 \text{ N m}^{-2}$ ($\therefore 1 \text{ m}^3 = 10^6 \text{ cm}^3$)

$$\begin{aligned} \Delta V &= (15-12) \times 10^{-6} \text{ m}^3 \\ &= 3 \times 10^{-6} \text{ m}^3 \end{aligned}$$

$$\begin{aligned} \therefore \text{evn: ' KvçR,} &= 2.0 \times 10^5 \times 3 \times 10^{-6} \text{ Joule} \\ &= 6 \times 10^{-1} \text{ Joule} \\ &= 0.6 \text{ J} \end{aligned}$$

mvi mstçç

ZvcMZxq Ae^{-v} t ZvcMZxq vçvççi mrvvçh' tKvb e'e^{-vi} Ae^{-v} çKvk Kitj tm Ae^{-v}çK ZvcMZxq Ae^{-v} ejv nq |

Pvc (P), AvqZb (V), ZvcgvÎv (T) GB i wK çµqvçK ZvcMZxq vçvççi ejv nq |

ZvcMZxq çµqv t th çµqvî dtj ZvcMZxq vçvççi gv çwi ewZ² nq tm çµqvçK ZvcMZxq çµqv etj |

Zvc I Aš:-' kú³ t ZvcgvÎv Zvi Ztg`i Rb` D`P ZvcgvÎvi `vb t_†K vb`eZvcgvÎvi `v†b mÁwj Z kú³ i bvgB Zvc |

Avi Aš:-' kú³ ntjv M`im AYyj i efe kú³ I MúZkú³ i thvMdj |

m†gvò cġuqv t P†ci cwi eZ†bi dtj hLb †Kvb M`v†mi AvqZ†bi cwi eZ† nq, †KšzZvcgvÎvi cwi eZ† nq bv, tm cwi eZ††K m†gvò cwi eZ† etj |

ifxZvcxq cġuqv t th cġuqvq M`v†mi Pvc I AvqZ†bi cwi eZ† nq †Kšz M`im Zvc MhY ev eR† K†z c††i bv, tm cġuqv†K ifxZvcxq cġuqv etj |

c†VvĒi gj`vqb

K. `be††K c†kæ

m†K DĒ†i i c†k †K (√) †Pý w b

- 1/ th ZvcMZxq cġuqvq ZvcgvÎv w`i _v†K Zv†K †K etj ?
 (K) a`e AvqZb cġuqv (L) m†gvò cġuqv
 (M) a`e Pvc cġuqv (N) ifxZvcxq cġuqv
- 2/ th ZvcMZxq cġuqvq e`e`vi m†_ Zv†ci Av`vb c†vb nq bv Zv†K †K etj ?
 (K) m†gvò cġuqv (L) a`e Pvc cġuqv
 (M) ifxZvcxq cġuqv (N) a`e AvqZb cġuqv
- 3/ ifxZvcxq c††vi †Y M`im A†c††vKZ.kxZj nq| Kvi Y -
 (K) Aš:-' kú³ n†m cvq| (L) Aš:-' kú³ e††x cvq|
 (M) ZvcgvÎv Acwi e†Z† _v†K| (N) e`e`v Zvc eR† K†i |
- 4/ m†gvò cġuqvq M`im AYj Aš:-' kú³
 (K) e††x cvq (L) n†m cvq
 (M) Acwi e†Z† _v†K| (N) m†gvb` n†m ev e††x cvq|

L. msv††B c†kæ

- (K) msÁv †j L† t ZvcMZxq `vbv¼, ZvcMZxq Ae`v, ZvcMZxq cġuqv|
- (L) i`xZvc cġuqvq M`v††K msv††Z K††j Gi ZvcgvÎv e††x cvq|

cW - 2

ZvcMuzie`vi cög mF; M'vfmí Avtçw¶K Zvc, tgvj vi Zvc aviY ¶lgZv, Av`kM'vfmí t¶¶t C_p I C_v Gi gta`cv_R`|

Dt'ik`

G cW tktl Avcib -

- | ZvcMuzie`vi cög mF eYØv Kitz cri`teb,
- | a`e Pttc M'vfmí Avtçw¶K Zvc (C_p) I a`e AvqZtb M'vfmí Avtçw¶K Zvc (C_v) Gi msAv wj LtZ cri`teb,
- | tgvj vi ZvcaviY ¶lgZv eYØv Kitz cri`teb,
- | GK tgvj Av`kM'vfmí t¶¶t C_p - C_v = R mgxKiY cözcv`b Kitz cri`teb|

13.2.1 t ZvcMuzie`vi cög mF

hLb tKvb e`e`vq Zvc mieivn Kiv nq GB Zvtci wKQyAsk e`q nq Gi Aš`-`kiv³ e¶x`tZ Ges evKx Ask e`q nq ein: `KvR m`úv`tb|

hiv` ΔQ Zvc MhY Kivi dtj e`e`vi Aš`-`kiv³ e¶x` ΔU I ein: `KvRi cwi gvY ΔW nq, Zvtj Avgiv wj LtZ cwi,

$$\Delta Q = \Delta U + \Delta W \dots \dots \dots (1)$$

mgxKi YwUtk ZvcMuzie`vi cög mF ejv nq|

¶z`cwieZ¶bi t¶¶t wj LtZ cwi -

$$\Delta Q = dU + dW \dots \dots \dots (2)$$

w`i Pvc P Gi weifx` dv AvqZb cñvi`Yi Rb` tKvb M'vm th ewnt `KvR m`úv`b Kti Zvi cwi gvY, dW = pdv

∴ 2 bs mgxKi Ytk tj Lv hvq,

$$\Delta Q = dU + PDV \dots \dots \dots (3)$$

Zvc tkvml Z ntj aQ avvZK I ewRZ ntj FYvZK nte|

Aveni e`e`v Øviv KvR m`úv` Z ntj avvZK I e`e`vi Dci KvR m`úv` Z ntj w FYvZK nte| e`e`vi Aš`-`kiv³ e¶x` tctj dU avvZK I Aš`-`kiv³ nvm tctj dU FYvZK nte|

Zvc Muzie`vi cög mF t`tk Avgiv eš`tZ cwi th, tKvb e`e`vi hZUKzZvc mieivn Kiv nq tm AbgvfZ KvR cvl qv hvq| KvR tctZ ntj Aek`B Zvc mieivn Kitz nte| kiv³i mieivn Qrov KvR cvl qv m`e` bq| GK kiv³ t`tk mgZ` Ab` kiv³i Avwef`e nte| A_¶ tgvU kiv³i cwi gvY GKB _vKte| AZGe, t`Lv hv`Q th, Zvc Muzie`vi cög mF kiv³i msi ¶Y mF`i GKwU wtkl ifc gvU|

13-2-2 t M'v̄mi Av̄tcūŋK Zvc

GKK f̄t̄i i tKvb e^{-z} Zvcgv̄ŋv GK W̄W̄M̄ evov̄tZ th cui gvY Zv̄tci c̄q̄vRb nq, Zv̄tK H e^{-z} Dcv̄v̄tbi Av̄tcūŋK Zvc etj |

h̄v̄ m f̄t̄i i tKvb e^{-z} ΔQ cui gvY Zvc c̄q̄vM Ki t̄j Gi Zvcgv̄ŋv ΔT cui gvY ēv̄x̄ cv̄q, Zv̄t̄j e^{-z} Av̄tcūŋK Zvc,

$$C = \frac{1}{m} \frac{\Delta Q}{\Delta T} \dots \dots \dots (4)$$

W̄KŠZ M'v̄m̄t̄K Zvc w̄ t̄j Zvcgv̄ŋv ēv̄x̄ i m̄v̄t̄_ m̄v̄t̄_ Gi Av̄qZb I Pvc Df̄qB ēv̄x̄ cv̄q | Zv̄B M'v̄m̄i t̄ŋt̄ŋ KLbI Av̄qZb̄t̄K, Avevi KLbI Pvc̄t̄K w̄ i i vL̄v nq | dt̄j M'v̄m̄i `B̄ c̄k̄vi Av̄tcūŋK Zvc cv̄l qv̄ h̄v̄q-

(1) w̄ i Av̄qZb̄ M'v̄m̄i Av̄tcūŋK Zvc, C_v

(2) w̄ i Pvc̄ M'v̄m̄i Av̄tcūŋK Zvc, C_p

(1) w̄ i Av̄qZb̄ M'v̄m̄i Av̄tcūŋK Zvc (Specific heat at constant volume)

w̄ i Av̄qZb̄ GKK f̄t̄i i tKvb M'v̄m̄i Zvcgv̄ŋv 1 W̄W̄M̄ evov̄tZ th cui gvY Zv̄tci c̄q̄vRb nq, Zv̄tK w̄ i Av̄qZb̄ M'v̄m̄i Av̄tcūŋK Zvc ēj v nq | Gt̄K C_v Ø̄v̄v c̄k̄v̄k Kiv nq |

(2) w̄ i Pvc̄ M'v̄m̄i Av̄tcūŋK Zvc (Specific heat at constant pressure)

Pvc̄ w̄ i t̄i t̄L GKK f̄t̄i i tKvb M'v̄m̄i Zvcgv̄ŋv 1 W̄W̄M̄ evov̄tZ th cui gvY Zv̄tci c̄q̄vRb nq, Zv̄tK w̄ i Pvc̄ M'v̄m̄i Av̄tcūŋK Zvc ēj v nq | Gt̄K C_p Ø̄v̄v c̄k̄v̄k Kiv nq |

13-2-3 t t̄gv̄j vi Zvc aviY ŋ̄gZv

GK t̄gv̄j M'v̄m̄i Zvcgv̄ŋv GK W̄W̄M̄ evov̄tZ th cui gvY Zv̄tci c̄q̄vRb Zv̄tK t̄gv̄j vi Zvc aviY ŋ̄gZv etj | Gt̄K t̄gv̄j vi Av̄tcūŋK ZvcI ēj v nq |

tKvb M'v̄m̄i n m̄sL̄K t̄gv̄t̄j i Zvcgv̄ŋv ΔT cui gvY evov̄tZ h̄v̄ ΔQ Zv̄tci c̄q̄vRb nq, Zv̄t̄j

$$\begin{aligned} \text{t̄gv̄j vi Zvc aviY ŋ̄gZv, } C' &= \frac{\Delta Q \text{ Joule}}{n\Delta T \text{ mole. Kelvin}} \\ &= \frac{\Delta Q}{n\Delta T} \text{ J mole}^{-1} \text{ K}^{-1} \end{aligned}$$

$$\text{GLv̄t̄b } n = \text{t̄gv̄j } m̄sL̄v = \frac{m}{M} = \frac{e^{-i} fi}{e^{-i} GK t̄gv̄t̄j i fi}$$

$$\therefore C' = \frac{\Delta Q}{\frac{m}{M}\Delta T} = M \cdot \frac{\Delta Q}{m \cdot \Delta T}$$

ev, C' = M × C (c̄v̄v Av̄tcūŋK Zvc Principal specific heat)

A_ŋ̄ t̄gv̄j vi Zvc aviY ŋ̄gZv = Av̄Ȳv̄eK fi (M) × M'v̄m̄i c̄v̄v Av̄tcūŋK Zvc

A_ev t̄gv̄j vi Av̄t Zvc = Av̄Ȳv̄eK fi × c̄v̄v Av̄t Zvc

AvqZb w-í tiþL GK tgvj M'vþmi ZvcgvÎv GK tKj wfb eþx KiþZ th Zvtci cðqvRb ZvþK w-í AvqZþb tgvj vi Zvc avi Y ¶lgZv etj | GþK C_v ðviv cðvik Kiv nq|

$$C_v = M \times c_v$$

A_# w-í AvqZþb tgvj vi Zvc avi Y ¶lgZv = AvYueK fi × Avtci¶¶K Zvc

A_ev, Avgiv wj LtZ cwi, w-í AvqZþb tgvj vi Avtci¶¶K Zvc = AvYueK fi × cðvb Avtci¶¶K Zvc | Pvc w-í tiþL GK tgvj M'vþmi ZvcgvÎv GK tKj wfb eþx KiþZ th Zvtci cðqvRb nq ZvþK w-í Pvc tgvj vi Zvc avi Y ¶lgZv etj | GþK C_p ðviv cðvik Kiv nq|

$$C_p = M \times c_p$$

A_# w-í Pvc tgvj vi Zvc avi Y ¶lgZv = AvYueK fi × Av:Zvc |

A_ev, w-í Pvc tgvj vi Avt Zvc = AvYueK fi × cðvb Avt Zvc |

13.2.4 t C_v Atc¶¶v C_p eo

AvqZb Acwi ewZZ tiþL tKvb M'vþm hw ðKQyZvc cðvb Kiv nq, Zvntj H M'vþmi Aš÷- kú³ eþx cvte| dtj M'vþmi ZvcgvÎv I Pvc eþx cvte| ðKšZM'vm tKvb ew: -' KúR KiþZ cvte bv thþnZz AvqZb w-í |

Avevi, Pvc w-í tiþL hw M'vþm cwi gvY Zvc cðvb Kiv nq, Zvntj H Zvc G t¶¶t I M'vþmi ZvcgvÎv eþx Kiþe| Zte Gt¶¶t M'vm ew: -' KúRI Kiþe| G KúR mðúv`b Kivi Rb` G t¶¶t ðKQyZvc e`q nte| dtj M'vþmi ZvcgvÎv cteP mgcwi gvY eþx nte bv| mgcwi gvY ZvcgvÎv eþxi Rb` G t¶¶t M'vþm Avi I ðKQyZvc cðqvM KiþZ nte|

A_# GK tgvj M'vþmi ZvcgvÎv 1K eþx KiþZ w-í AvqZþbi t¶¶t th Zvc j vMte, w-í Pvc t¶¶t Zvi tþtq teuk Zvc j vMte|

e`z GK tgvj i fi = M Mög, thLvþb M = AvYueK fi

A_# C_p = C_v + q GLvþb q ntj v M'vmþK th KúR KiþZ nq Zvi mgZj` Zvc|

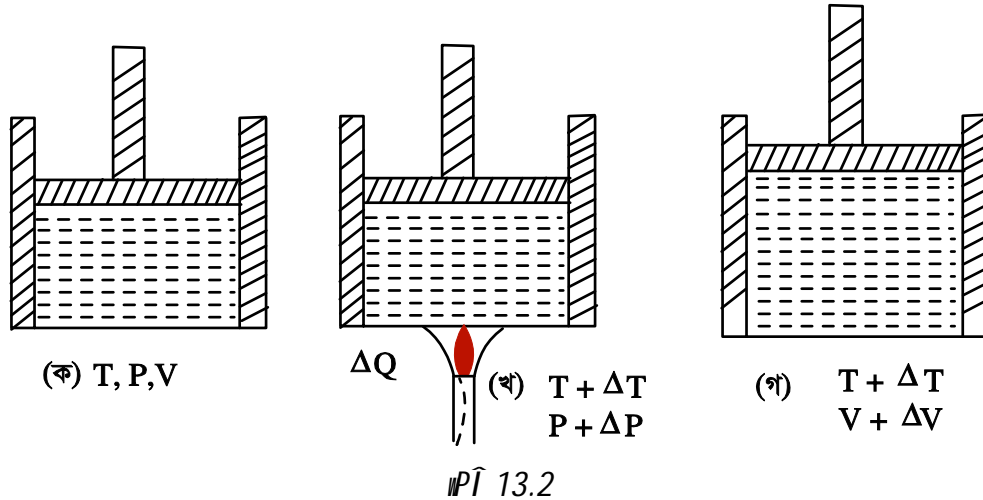
$$\therefore C_p > C_v$$

13.2.5 : Av`kM'vþmi t¶¶t

aiv hvK, ðc÷bhþ GKúU wmwj Úvti i gta` P Pvc, T ZvcgvÎvq, V AvqZb ðeukó 1 tgvj Av`kM'vm AvtQ (wPÎ 13-2K)|

Gevi M'vþm ðKQyZvc cðvb Kiv ntj v| G Zvc M'vþmi ZvcgvÎv I Pvc eþx Kiþe Ges AvqZb I eþx tctZ Pvþe| dtj ðc÷bþK Dcti i wþK DVtZ tPóv Kiþe|

ðc÷bþK cteP Ae`vq ivLþZ ntj A_# AvqZb w-í ivLvi Rb` ðc÷þbi Dci Avi I ðKQy Rb PvcvþZ nte|



ain hvk, ΔQ Zvc c`qM Kiv ntjv Ges M'vfmî AvqZb v AcwiewZ` ivLv ntjv| Gi dtj M'vfmî ZvcgvÎv hv` ΔT cwi gvY epx` cvq, Zvntj ,

$$\Delta Q = C_v \cdot \Delta T$$

Avevi, ZvcMwZwe`vi c`g mF` t`K tj Lv hvq,

$$\Delta Q = \Delta U + \Delta W$$

$$\text{ev, } \Delta Q = \Delta U + 0$$

Gt`qÎ AvqZb w`i etj ewn: `KvRi cwi gvY ΔW = 0

$$\therefore C_v \Delta T = \Delta U \dots \dots \dots (5)$$

Gevi Pvc w`i ivL`Z wc`tbi Dci t`K AwZwi³ I Rb Ztj wbtj, wc`b Dcti i w`K DVtZ`vKte, A` M'vfmî AvqZb epx` cvte (॥PÎ 13-2M)| AvqZb epx`i Rb` M'vmtK ewn: `KvR Ki`Z nte| M'vfmî Aš`-k³ e`q G KvR m`ubonq etj Aš`-k³ nwm cvq| dtj ZvcgvÎv Ktg hvq|

w`i Pvc M'vfmî ZvcgvÎv cte` mgcwi gvY A` ΔT cwi gvY epx`i Rb` Avil wKQyZvc w`Z nte| G AwZwi³ Zvtci cwi gvY nte w`i Pvc m`uvw` Z KvRi mgZ` Zvc| Gi cwi gvY = PΔV (GLv`b ΔV M'vfmî AvqZb epx` I P c`E w`i Pvc)|

$$G \text{ t`qÎ c`E tgvU Zvc, } \Delta Q = C_p \Delta T$$

ZvcMwZwe`vi c`g mF` t`K tj Lv hvq,

$$C_p \Delta T = \Delta U + P\Delta V \dots \dots \dots (6)$$

5 bs mgvKi Y t`K cvB, ΔU = C_v ΔT

$$\therefore C_p \Delta T = C_v \Delta T + P\Delta V \dots \dots \dots (7)$$

$$\text{ev, } (C_p - C_v) \Delta T = P\Delta V \dots \dots \dots (8)$$

M'vfmî c`gk ZvcgvÎv T I AvqZb v ntj 1 tgvj Av`k M'vfmî Rb`

$$PV = RT$$

W⁻i P₁t_c, A_vqZ_b e₁x ΔV I Z_vcgv₁v e₁x ΔT n_tj

$$P(V + \Delta V) = R(T + \Delta T)$$

GB mgxKi Y₁U t₋t_K c₁e₁^{β3} mgxKi Y₁e₁t_qv₁M K_ti c_vB,

$$P\Delta V = R\Delta T \dots \dots \dots (9)$$

mgxKi Y (8) I (9) t₋t_K t_j L_v h_vq,

$$(C_p - C_v) \Delta T = R\Delta T$$

$$e_v, C_p - C_v = R \dots \dots \dots (10)$$

mve_Rub_b M_ivm a^eK R GK₁U a_viZ₁K i_vnk, m_zi_vs c_p > c_v |

C_p I C_v Gi A_bg_vZ_tK γ θ_vi_v c₁K_vk K_iv n_q|

$$A_{\text{#}}, \gamma = \frac{C_p}{C_v}$$

γ Gi , i'Z_i

$$\gamma = \frac{C_p}{C_v}$$

γ Gi g_vb t₋t_K M_iv_tm_i A_vY₁e₁K M_Vb m₁ú_tK₁g_j-¹e_vb Z₋ c_vl q_v h_vq | GK c_ig_vY₁e₁nkó M_iv_tm_i t₁q₁t₁ Gi g_vb 1.66; θ-c_ig_vY₁K M_iv_tm_i t₁q₁t₁ 1.4 I w¹ c_ig_vY₁K M_iv_tm_i t₁q₁t₁ Gi g_vb 1.33 |

t₁K_vb M_iv_tm γ Gi g_vb R_vb_v __vK_tj Gi A_Yt_z K_qU c_ig_vY₁Av_tQ Z_v R_vb_v h_vq | G Q_vo_v M_iv_tm_i ga¹ w¹ t_q k_tāi t_eM₁b_f¹ K_ti γ Gi g_vt_bi D_ci |

D`niY

1| t₁K_vb e⁻v 900J Z_vc t₁k_vl_Y K_ti Ges 300J K_vR m₁ú_v b K_ti | e⁻v_i A_š-¹ k₁³i c₁w₁e₁Z₁ b₁Y₁q K_i b |

Z_vc M_iZ₁e⁻ v_i c₁g m₁ t₋t_K,

$$dQ = dU + dW$$

$$G_Lv_tb, dQ = + 900J$$

$$dW = + 300 J$$

$$\therefore dU = dQ - dW \\ = (900 - 300)J \\ = 600 J$$

Dt 600 J

2| t₁K_vb e⁻v 1000J Z_vc t₁k_vl_Y K_ti Ges e⁻v_i D_ci 500J K_vR m₁ú_v Z n_q | e⁻v_i A_š-¹ k₁³i c₁w₁e₁Z₁ b₁Y₁q K_i b |

Z_vc M_iZ₁e⁻ v_i c₁g m₁ t₋t_K,

$$dQ = dU + dW$$

GLıtb, $dQ = +1000J$

$dW = - 500J$

$\therefore dU = dQ - dW$
 $= 1000 - (-500)$
 $= 1000 + 500$
 $= 1500 J$

Dt 1500 J

3/ tKıv e`e`v`ı w`ı AvqZıb 800 J Zıv eRb Ktı / e`e`v`ı AŞ:-`kır³ i cııeZb ıbyq Ki`b/ ZıvMıZıe`ıı cıg mF t`tk,

$dQ = dU + dW$

GLıtb, $dQ = - 800J$

$dW = p.dv = 0$

$\therefore dU = dQ$
 $= -800J$

Dt- 800J, FYıZk ıPy ıbt`R KıtQ th, GLıtb AŞ:-`kır³ nım 800J

4/ acb cı tKıv e`e`v`ıK a t`tk b tZ tbqv ntj 150J Zıv e`e`v`ı KZR.tkım Z nq Ges e`e`v`ı 50J Kır m`úv`b Ktı /

adb cı Kır m`úv`ıbi cııgvY hı 80 J nq, Zıvtj adb cı ıK cııgvY Zıv tkım Z nte?

gıb Kıı, a l b ıe`ıZ AŞ:-`kır³ U_a l U_b
 acb cı e`e`v`ı KZR.m`úv`ı Z Kır W_{acb} Ges
 e`e`v`ı KZR.tkım Z Zıv Q_{acb} Zıvtj ,

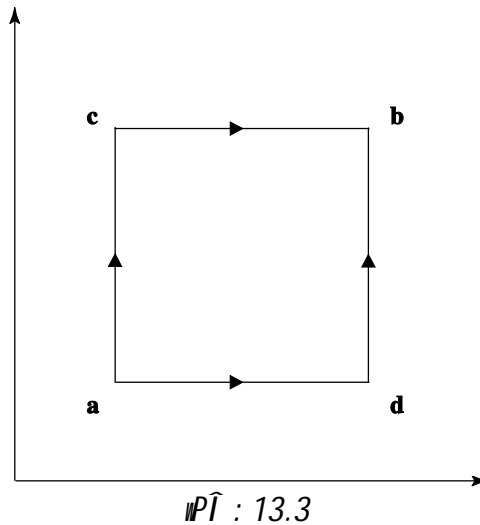
$Q_{acb} = U_b - U_a + W_{acb}$

GLıtb, $Q_{acb} = 150 J$

$W_{acb} = 50 J$

$\therefore 150 = U_b - U_a + 50$

eı, $U_b - U_a = 150 - 50 = 100 J$



AŞ:-`kır³ cııeZb cıı Dci ıbfP Ktı bı/

adb cı e`e`v`ı KZR tkım Z Zıv Q_{adb} l m`úv`ı Z KıtRı cııgvY W_{adb} ntj ,

$\therefore Q_{adb} = U_b - U_a + W_{adb}$

$W_{adb} = 80 J$

$Q_{adb} = 100 + 80 = 180 J$

mvi mst¶c

Zvc Mzve`vi cög mF t tKvb e`e`v KZR MpxZ Zvtci uKQyAsk e`q nq e`e`vi Aš:-` k13
cwi eZ¶b Ges evKx Ask ein: `KvR m`uv`tb| hw` e`e`v KZR.MpxZ Zvc ΔQ, Aš:-` k13 cwi eZ¶
ΔU Ges ein: `KvR = ΔW nq, Zvt¶j ,

$$\Delta Q = \Delta U + \Delta W$$

tgj vi Zvc aviY ¶gZv t 1 tgj Mivtmi Zvcgv¶v 1 WMM evovtZ th cwi gvY Zvtci c¶qvRb ZvtK
tgj vi Zvc aviY ¶gZv etj |

$$C_p - C_v = R$$

$$GLv¶b, C_p = w`i Pvtc tgj vi Zvc aviY ¶gZv,$$

$$C_v = w`i AvqZtb tgj vi Zvc aviY ¶gZv Ges$$

$$R = 1 tgj Mivtmi Rb` M`vm a`eK|$$

cúVvĚi gj`vqb

K. `be9PZ cĕæ

mWk DĚti i cĕk Wk (√) wPý w b|

1/ C_p | C_v Gi gĕa` mĕúK[©]

(K) $C_p = C_v + R$

(L) $C_v = C_p + R$

(M) $C_p = C_v - R$

(N) $C_v = R - C_p$

2/ wĕPi tKvbW = γ ?

(K) $\frac{C_p}{C_v}$

(L) $C_p - C_v$

(M) $C_p + C_v$

(N) $\frac{C_v}{C_p}$

L. msvŕB cĕæ

(1) ZvcMwZwe``vi cĕg mĕ eYŕv Ki`b|

(2) c_p | c_v KvĕK eĕj wj Lĕ|

cW-3

**ifxZvcxq cwieZfb M'v̄tmi Pvc (P) I AvqZtbi (V) gta" m̄úK[⊙],
ifxZvcxq cwieZfb AvqZb I Zvcgv̄ivi gta" m̄úK[⊙], ifxZvc tiLv I
m̄tgvò tiLv|**

Dt̄ik"

G cW tk̄tI Avcib -

- | ifxZvcxq cwieZfb t̄q̄t̄I M'v̄tmi Pvc I AvqZtbi gta" m̄úK[⊙]A_ŕ PV^Y = mgxKi YuU c̄ZÖv
KīZ cvīteb,
- | ifxZvcxq cwieZfb t̄q̄t̄I Zvcgv̄iv I AvqZtbi gta" m̄úK[⊙]bifcb KīZ cvīteb,
- | ifxZvcxq tiLv m̄tgvò tiLv Ātc̄q̄v γ , Y Lvov c̄ḡvY KīZ cvīteb|

**13.3.1 t ifxZvcxq cwieZfb M'v̄tmi Pvc (P) I AvqZb (V)-Gi gta" m̄úK[⊙] PV^Y =
āæK**

ḡtb Kwi, GKiu umuj Övti 1 tgvj Av`k[⊙]M'vm AvtQ| aiv hvK, dQ cwigvY Zvc t`qvi dtj M'v̄tmi
AvqZb I Zvcgv̄ivi cwieZfb nt̄jv h_vμtg dV I dT. Avgiv Rmb, 1 tgvj Av`k[⊙]M'v̄tmi Aš:-' kw³
eμx, dU = w`i AvqZtb 1 tgvj M'v̄tmi Zvcgv̄iv dT cwigvY eμx KīZ c̄q̄vRbxq Zvc = C_v dT

$$AZGe, dQ = C_v dT + PdV \text{ ----- (1)}$$

$$ifxZvcxq c̄q̄vq dQ = 0$$

$$\therefore C_v dT + PdV = 0 \text{ ----- (2)}$$

$$e\text{v} C_v dT = -PdV \text{ ----- (3)}$$

$$Av`k[⊙]M'v̄tmi t̄q̄t̄I, PV = RT$$

$$e`eKj b K̄ti cıB, PdV + VdP = RdT$$

$$e\text{v}, PdV = RdT - VdP \text{ ----- (4)}$$

AZGe, mgxKi Y (2) tK wj L̄Z cwi,

$$C_v dT + RdT - VdP = 0$$

$$C_v dT + (C_p - C_v) dT - VdP = 0 \quad (\because C_p - C_v = R)$$

$$C_v dT + C_p dT - C_v dT - VdP = 0$$

$$C_p dT - VdP = 0$$

$$C_p dT = VdP \text{ ----- (5)}$$

mgxKi Y (5) tK mgxKi Y (3) ðivi fVM Kti civB,

$$\frac{C_p}{C_v} = - \frac{Vdp}{PdV}$$

$$\frac{C_p}{C_v} \frac{dV}{V} = - \frac{dP}{P}$$

$$\text{ev } \gamma \frac{dV}{V} + \frac{dP}{P} = 0$$

GtK mgxKj b Kti civB,

$$\gamma \log_e V + \log_e P = a^eK$$

$$\log_e PV^\gamma = a^eK = \log_e K [GLv\text{t}b \text{ K Avi GKw} a^eK]$$

$$PV^\gamma = K \text{ ----- (6)}$$

$$\therefore PV^\gamma = a^eK$$

GiUB ifxZvixq c\muq Pvc I AvqZtbi gta" m\acute{u}K h\` M'v\text{t}mi c\`ugK Pvc I AvqZb h_v\text{t}g P_1 I V_1 nq Ges ifxZvixq cwi eZ\text{t}bi dtj h\` Pev\text{t}-Pvc I AvqZb h_v\text{t}g P_2 I V_2 nq Zvntj

$$P_1 V_1^\gamma = P_2 V_2^\gamma \text{ ----- (7)}$$

13.3.2 t ifxZvixq cwi eZ\text{t}bi AvqZb I Zvcgv\text{t}vi gta" m\acute{u}K

Avgiv Rwb, Av`k M'v\text{t}mi t\text{t}t\text{t}

$$PV = RT$$

$$\text{ev, } P = \frac{RT}{V}$$

ifxZvixq cwi eZ\text{t}bi t\text{t}t\text{t},

$$PV^\gamma = K$$

$$\text{ev, } \frac{RT}{V} \cdot V^\gamma = K$$

$$\text{ev, } RTV^{\gamma-1} = K$$

$$\text{ev, } TV^{\gamma-1} = \frac{K}{R} = a^eK (\because R \text{ mveRbixb M'vm } a^eK)$$

$$\therefore TV^{\gamma-1} = a^eK$$

GiUB ifxZvixq c\muq AvqZb I Zvcgv\text{t}vi gta" m\acute{u}K

h\` M'v\text{t}mi c\`ugK AvqZb I Zvcgv\text{t}vi h_v\text{t}g V_1 I T_1 nq Ges ifxZvixq c\muq dtj h\` Gi Pev\text{t}-AvqZb I Zvcgv\text{t}vi h_v\text{t}g V_2 I T_2 nq Zintj

$$T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1} \text{ ----- (9)}$$

13.3.3 t i f x Z v c x q t i L v m t g v o t i L v A t c q v A n a K Z i L v o v

t K v b M i v t m i c o u g K A e v b x t P P - v t j L i P t I (i P I 13-3) A n e y o v i v t L v t b v n t q t Q | a i v h v K, M i v t m K m s b u g Z K t i G i A v q Z b B C c m i g v Y K g v t b v n t e | m t g v o c i u q v q m s b u g Z K i t j m t g v o t i L v A i t i L v i g t z v G K u U t i L v n t e | I n e y M i v t m i P o v s - A e v c o k o K t i | M i v t m K i f x Z v c x q c o u q v q m s b u g Z K t i G K B c m i g v Y A v q Z b K g v t b v n t j, Z v c t e i n t Z c i t i b v e t j M i v t m i P v c t e t o h v q | G t q t I M i v t m i P o v s - A e v D n e y o v i v t L v t b v n t q t Q |

i P I t t K e s v h v t Q t h, G K B A v q Z b c m i e z b i R b m t g v o t i L v A i A t c q v i f x Z v c t i L v A D A n a K Z i L v o v (e v n e c i x z w t K X v j y) | t L v t b v h v q t h, i f x Z v c t i L v m t g v o t i L v A t c q v i g y L v o v |

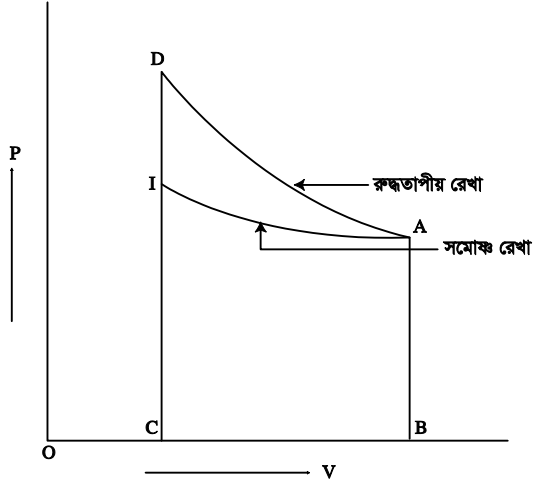
m t g v o c o u q v i t q t I,

$$P V = a^e K |$$

e e K j b K t i c i B,

$$P d V + V d P = 0$$

$$e v, V d P = - P d V$$



$$e v \left(\frac{dP}{dV} \right)_T = - \frac{P}{V} \text{ ----- (10)}$$

G L v t b \left(\frac{dP}{dV} \right)_T o v i v w i Z v c g v i v q A n e m t g v o A e v l q \left(\frac{dP}{dV} \right) e s v q |

A v e i i f x Z v c x q c o u q v i t q t I

$$P V^\gamma = a^e K |$$

e e K j b K t i c i B,

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

$$V^\gamma dP = - \gamma P V^{\gamma-1} dV$$

$$\left(\frac{dP}{dV} \right)_T = \frac{-\gamma P V^{\gamma-1}}{V^\gamma} = - \gamma \frac{P}{V} \text{ ----- (11)}$$

G L v t b \left(\frac{dP}{dV} \right)_T o v i v w i Z v c g v i v q A n e m t g v o A e v l q \frac{dP}{dV} e s v q |

$$m g x K i Y (11) t K (10) o v i v f v M K t i c i B, \frac{\left(\frac{dP}{dV} \right)_T}{\left(\frac{dP}{dV} \right)_T} = \gamma$$

$$A n e i f x Z v c x q t i L v i X v j \frac{m t g v o t i L v i X v j}{m t g v o t i L v i X v j} = \gamma$$

A Z G e i f x Z v c x q t i L v m t g v o t i L v A t c q v i g y L v o v |

mvi mst¶c

ifxZvcxq cwieZ¶b M'v¶mi Pvc (P) I AvqZ¶bi g¶a" m¶úK¶¶ PV^γ = a°eK|

ifxZvcxq cwieZ¶b M'v¶mi AvqZb I Zvcgv¶vi g¶a" m¶úK¶¶ TV^{γ-1} = a°eK|

ifxZvcxq tiLv m¶gvò tiLv A¶c¶¶v γ , Y Lvov

cv¶V¶Ei gj¶vqb

K. ¶be¶¶K c¶ke

1| ifxZvcxq cwieZ¶bi t¶¶¶¶ P I v Gi g¶a" m¶úK¶¶ tKvbwU?

(K) P^γ v = a°eK

(L) PV^γ = a°eK

(M) P^γ v^γ = a°eK

(N) PV = a°eK

L. ms¶¶B c¶kot-

(1) Av`k¶M'v¶mi ifxZvcxq cwieZ¶bi t¶¶¶¶ TV^{γ-1} = a°eK c¶gvY Ki"b|

iPbv¶j-K c¶ke

1| m¶gvò c¶¶qv I ifxZvcxq c¶¶qv eY¶v Ki"b|

2| tgv¶vi Av¶c¶¶K Zv¶ci msÁv ¶j L¶| c¶gvY Ki"b, C_p - C_v = R.

3| ifxZvcxq cwieZ¶bi t¶¶¶¶ PV^γ = a°eK c¶gvb Ki"b| -Ab¶yQ` 13.3.1 t`L¶|

4. c¶gvY Ki"b th, ifxZvcxq tiLv m¶gvò tiLv A¶c¶¶v γ , Y Lvov|

MwvZK çke

- 1/ tKvb eëv 800J Zvc tkvY Kti Ges 400J KVR mçuv`b Kti | eëvi Aš:-' kvr³i çwieZK KZ nte ?
- 2/ tKvb eëv 600J Zvc tkvY Kti Ges eëvi Dci 200J KVR mçuv`Z nq | eëvi Aš:-' kvr³i çwieZK KZ?
- 3/ tKvb eëv w`i AvqZtb 400J Zvc eRb Kti | eëvi Aš:-' kvr³i çwieZK KZ?
- 4/ acb çt_ tKvb eëv tK a t_K b Ae`vq tbqv nti 100J Zvc eëv KZR.tkvl Z nq Ges eëv 50J KVR mçuv`b Kti |

adb çt_ KVR mçuv`bi çwiçvY hw` 0J nq
Zvntj adb çt_ wK çwiçvY Zvc tkvl Z nq?

