'THERMODYNAMICS'

Study about macroscopic variable (PVT)

\# **System** → Definite matter include in a finite boundry.

system	Energy	Mass
open	✓	✓
closed	✓	X
Isolated	X	X

|I| → Thermodynamics law

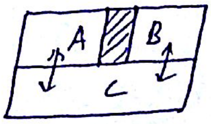
[A] → **zeroth Law of thermodynamics (Z·L·O·T)** → If two independent system ⊕nt in thermal eq^{m} cond^{n} with another common system then temp. of these system is same.

AMU 2016

$T_A = T_C$

$T_B = T_C$

$\boxed{T_A = T_B = T_C}$



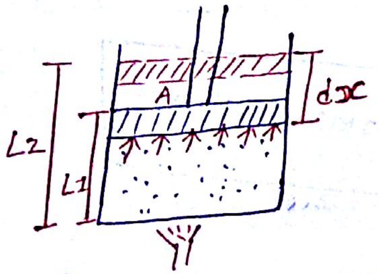
Draw back of Z·L·O·T

It explain only temp. & thermal eq^{m} cond^{n} & can't explain direction of Heat flow & How much part of suplied heat convert in work in internal Energy.

** **Sign convension**

	Phy	che
* Work done by the gas/by the system →	⊕ve	⊖ve
* Work done on the gas/by the system →	⊖ve	⊕ve.

Thermodynamics Work



$\boxed{V_1 = AL_1 \quad V_2 = AL_2}$

$\boxed{W = \vec{F}\cdot\vec{dx} = F\,dx\cos\theta}$

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

$\boxed{P = F/A \quad F = PA \quad A\,dx = dV}$

**

$$\boxed{\begin{array}{l} * \; V_i > V_f \Rightarrow dV = \oplus ve \Rightarrow W = \oplus ve \\ * \; V_f < V_i \Rightarrow dV = \ominus ve \Rightarrow W = \ominus ve \end{array}}$$

case-I → $P = \text{const.}$

$$W = P\int_{V_1}^{V_2} dV = P(V)_{V_1}^{2}$$

$$W = P(V_2 - V_1)$$

**

- * $V_2 > V_1 \Rightarrow W = \oplus ve \Rightarrow$ by the system [Expansion]
- * $V_2 < V_1 \Rightarrow W = \ominus ve \Rightarrow$ on the system [compression]
- * $V_2 = V_1 \Rightarrow \boxed{W = 0}$ → Isometric process.

EX→ In $\oplus$ce of 1 atm · press. Ice convert in H_2O.
↳ Work done by the surrounding $\oplus$ve.

$$Ice \xrightarrow[0^\circ C]{P=c} H_2O$$

$V\downarrow \Rightarrow W = \oplus ve$

[* on the Ice $= \ominus$ve
* By the surrounding $= \oplus$ve]

Case-II → P = variable

$P = f(v)$

$W = \int_{V_1}^{V_2} P \cdot dv$

$$\boxed{W = \int_{V_1}^{V_2} f(v)\, dv}$$ *

$P = f(T)$

* Replace temp. in term of 'p' & 'v' from Ideal gas eqn.

$$\boxed{P = f'(v)}$$

* $$\boxed{W = \int_{V_1}^{V_2} F'(v)\,(dv)}$$

***

Standard Result :→

$PV^\gamma = K$

$$W = \frac{\mu R (T_1 - T_2)}{n-1}$$

$$W = \frac{\mu R(-\Delta T)}{n-1}$$

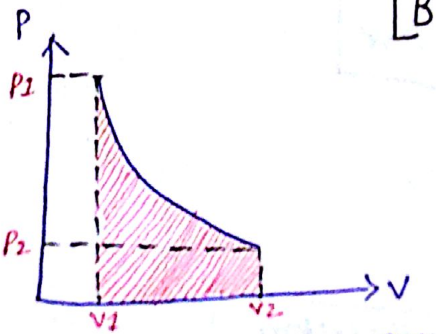
Case III → Graphical Section

Area inclose b/w PV curve & velo. axis represcent

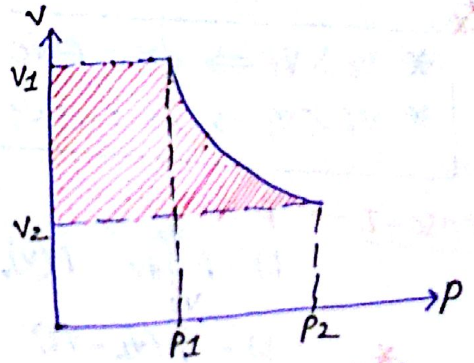
Work done in thermodynamic process.

* $$\boxed{W = \int_{V_1}^{V_2} P dv = \text{Area inclose b/w 'p-v' curve \& 'v' axis.}}$$

[A] →



[B] →



* volume ↑, W·done $= \oplus$ve

$\boxed{W = + Area}$

* volume ↓, Workdone $= \ominus$ve

$\boxed{W = - Area}$

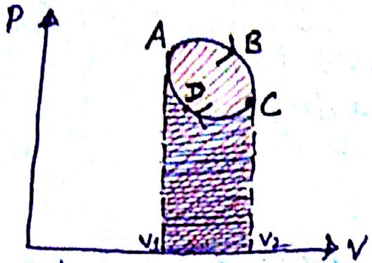
2016 AIIMS

NOTE ⇒ * Thermodynamic work done depend on path as well as initial & final point.

* Work done in two or more than two thermodynamic process is scalar addition of W. done in diff. thermodynamic process.
* In $\oplus$nce of conservative force field work done is independent from path. (Gravitational force & Electrostatic force field)

Case IV ⇒ Work done in cyclic process :→ Work done cyclic process equal to the Area of cycle (PV cycle).

[A]→ C·W →



$W_{cycle} = W_{ABC} + W_{CDA}$

$= +\text{Area}(ABC\,V_2V_1) - \text{Area}(CV_2V_1\,ADC)$

$= \text{Area}(ABCDA) = \text{Area of cycle.}$

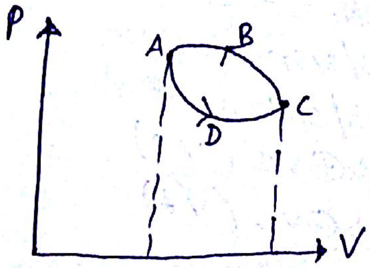
Clock Wise

$\boxed{W = \oplus ve}$

**

$$\boxed{W_{cycle} = \text{Area of cycle} \underset{\text{"P-V"}}{\downarrow}}$$

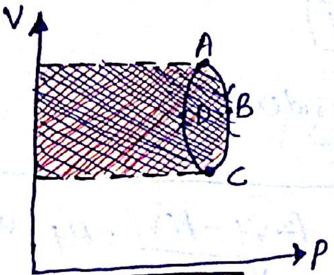
[B]→ A·C·W →



Anticlock Wise

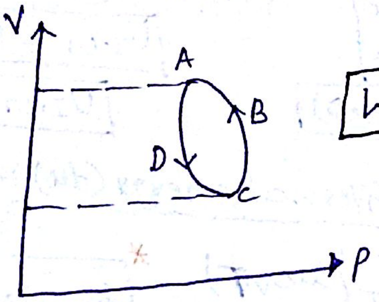
$\boxed{W = \ominus ve}$

[C]→ C·W ⇒



$\boxed{W = \ominus ve}$

[D] ⇒ A·C·W →



$\boxed{W = \oplus ve}$

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- * Vol. In x-axis
  - → C·W ⇒ W = ⊕ve
  - → A·C·W ⇒ W = ⊖ve
- * Vol. In y-axis
  - → C·W ⇒ W = ⊖ve
  - → A·C·W = W = ⊕ve.

NOTE → Result of circle & ellipse is same.

Ist LAW OF THERMODYNAMIC [F·L·O·T]

Supplied heat convert in thermodynamic work \$ change in internalenergy.

Phy	Che
$\Delta Q = \Delta W + du$ $\delta Q = \delta W + du$	$\Delta Q = -\int P dv + du$ $\Delta Q = -\Delta W + du$

Δ, δ → path dependent.

d ⇒ Final/Initial position (statefunction)

Eg → Heat, Work \$ disp.

** Remember following point before use of F·L·O·T

(i) → unit of ΔQ, ΔW \$ du is same.

(ii) → Given data used with proper sign convension.

*Signconvension
- Heat
  - Absorb = ⊕ve
  - Reject/Librate = ⊖ve
- Work
  - on the gas/system = ⊖ve
  - by the gas/system = ⊕ve
- du
  - T↑ ⇒ du ⇒ ⊕ve (V↑)
  - T↓ ⇒ du ⇒ ⊖ve (V↓)

Internal Energy (U):-

$\boxed{U = K \cdot E + P \cdot E}$

$\boxed{* \; K \cdot E = f(T)}$

$* \boxed{P \cdot E = f(I \cdot M \cdot D)}$

* Ideal Gas ⇒ $\boxed{P \cdot E = 0}$

$\boxed{U_{I \cdot G} = K \cdot E}$

$\boxed{U_{I \cdot G} = \mu c_v dT}$

change in internal energy (du) :→ Independent from path.

$$\frac{du}{dT} = \frac{d}{dt}(\mu c_v T)$$

$$\boxed{du = U_f - U_i}$$

$$* \boxed{du_{I \cdot G} = \mu c_v dT = \frac{P_f V_f - P_i V_i}{\gamma - 1} = U_f - U_i}$$

↑ For Any thermodynamic process.

AIR

Exemplar 9

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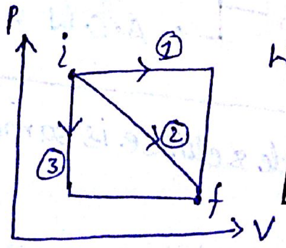
NOTE → * Internal Energy is a state function \$ change in internal energy independent from path. It only depend on final \$ Inital position.

* Thermodynamic Work \$ Heat depend on final \$ Initial position aswell as path.

$$\boxed{\begin{array}{c} du_1 = du_2 = du_3 = U_f - U_i \\ \Delta W_1 \neq \Delta W_2 \neq \Delta W_3 \\ \Delta Q_1 \neq \Delta Q_2 \neq \Delta Q_3 \end{array}}$$



Wor \$ Heat path dependent.

$$\boxed{\begin{array}{c} W_I > W_{II} > W_{III} \\ \Delta Q_1 > WQ_2 > \Delta Q_3 \end{array}}$$

* Change in Internal energy in Isothermal process of ideal gas is zero. (Internal energy const.)

A/R
* Phase conversion take place at const temp. but change in internal energy is not equal to zero. bcoz contribution of K.E is zero. but due to change in Intermolecular distance, PE is change.

* $\boxed{\begin{array}{l} U_{R.G} = K.E + P.E = \mu C_v dT + P.E \\ \Delta U_{RG} = \mu C_v dT + d(P.E) \end{array}}$

* In cyclic process change in Internal energy is zero.

$\boxed{U_f - U_i = du = 0}$

A/R
* In a Isothermal process of Ideal gas change in Internal energy zero. but in Real gas not zero.

* $\boxed{\begin{array}{l} U_{R.G} = \mu C_v dT + PE \\ dU_{R.G} = \mu C_v dT + \Delta P.E \\ \text{* Isothermal process.} \\ dU_{RG} = \Delta P.E \neq 0 \end{array}}$

APPLICATION OF F.L.O.T

|1| → Isobaric / constant pres. process →

|i| → P = const.

|ii| → Gas Law = charl's Law

|iii| → Process Eqn = $\overset{\checkmark}{P}V = \overset{\checkmark}{n}RT$

$\boxed{V \propto T}$

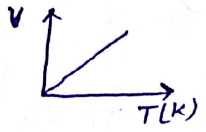
$\boxed{\frac{V}{T} = \text{const}}$

$\boxed{\frac{V_1}{T_1} = \frac{V_2}{T_2}}$ (charle's Law)

$\boxed{V \propto T}$

V v/s T(K)

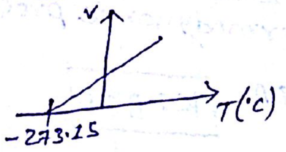
$\boxed{V = kT}$



V v/s T (°C)

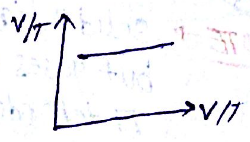
$V = k(\overset{°C}{T} + 273.15)$

$\boxed{y = mx + c}$

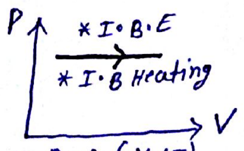


$\frac{V}{T}$ v/s V

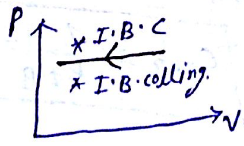
$\boxed{\frac{V}{T} = K}$



|iv| → Process curve :→



* P = C (V∝T)
* V ↑, T ↑
* ΔW = ⊕ve
* du = ⊕ve
* ΔQ = ⊕ve



* P = C, V↓, T↓
* ΔW = ⊖ve
* du = ⊖ve
* ΔQ = ⊖ve

|v| → Work

$$\Delta W = \int_{V1}^{V2} p \cdot dv$$

$$\boxed{W_{I \cdot B} = P(V_2 - V1) = Pdv}$$

$pv = \mu RT$

$$\boxed{pdv = \mu RdT}$$

$$\boxed{W_{I \cdot B} = Pdv = \mu RdT}$$

|vi| → Heat (ΔQ) →

$$\boxed{\Delta Q = Mc_p\Delta T \quad \text{or, } \Delta Q = \mu c_p \Delta T}$$

|vii| → Change in Internal Energy.

$$\boxed{du = \mu c_v dT}$$

|viii| → Apply F·L·O·T

$$\Delta Q = \Delta W + du$$

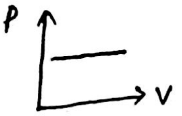
$\boxed{CP = R + CV}$ $(C_p > C_v)$

(3e) $\boxed{C_p - C_v = R}$ → Mayer eqn

*NOTE → For gases c_p is always greater than c_v but in a thermodynamic process where system absorb heat & perform ⊖ve work in this process c_v is greater than c_p.

Eg → * Plastic, Rubber $(c_v > c_p)$
* H_2O b/w 0°c to 4°c

|ix| → slope of 'p-v' curve



slope = $\tan\theta = \frac{dy}{dx}$

$$\boxed{\theta = 0^\circ}$$

* $\boxed{\left(\frac{dp}{dv}\right)_{IB} = 0}$

|x| → volume elasticity co-efficient (K) or, Bulk modulas of Elasticity (B): →

***NOTE → Liquid & gases ~~as~~ have only volume elasticity co-efficienty b/c due to de-forming force only volume of gas is change.

$$K = \frac{\text{volumetric stress}}{\text{volumetric strain}}$$

* $\boxed{K = -\frac{\Delta P}{\left(\frac{\Delta V}{V}\right)} = -V\left(\frac{\Delta P}{\Delta V}\right)}$

* $\boxed{K = -V(\text{slope of 'p-v' curve})}$

BHU AIIMS NOTE → Solid & Liquid has single value of volume elasticity co-efficient but gases has ∞ value of volume elasticity co-efficient. It dependent thermodynamic process. (Always ⊕ve).

$K_{I \cdot B} = -V\left(\frac{dp}{dv}\right)_{I \cdot B}$ $\boxed{K_{I \cdot B} = 0}$

$= -V(0)$

|xi| → compressibility (C): →

$\boxed{C = \frac{1}{K}}$ * $\boxed{C_{I \cdot B} = \frac{1}{K_{I \cdot B}} = \frac{1}{0} = \infty}$

|xii| → EX → phase conversion

|a| → Melting process

$$\underset{T_{m.p}}{\boxed{\text{Solid}}} \xrightarrow[\substack{T_{m.p}=c \\ V\uparrow}]{P=c} \underset{T_{m.p}}{\boxed{\text{Liquid}}}$$

- * $\Delta W = P(V_L - V_S)$
- * $\Delta Q = +M_S L_f$
- * $du = \Delta Q - \Delta W \neq 0$

|b| → vaporisation press

$$\boxed{\text{Liquid}} \xrightarrow[\substack{T_{B.P}=c \\ V\uparrow}]{P=c} \boxed{\text{vapour}}$$

$\Delta W = +P(V_V - V_L)$

$\Delta Q = +ML_V$

$du = \Delta Q - \Delta W \neq 0$

*** Standard Result for gases in I.B process

$\boxed{\Delta Q = \mu c_p \Delta T}$ $\boxed{\Delta W = \mu R \Delta T}$ $\boxed{du = \mu c_v \Delta T}$

gama.

γ or, y

|a| → Part of Heat, convert in Work

$$\frac{\Delta W}{\Delta Q} = 1 - \frac{1}{y}$$

|i| → ΔQ = same ⇒ $\boxed{\Delta W = \Delta Q\left(1 - \frac{1}{y}\right)}$

* $\boxed{\Delta W_{mono} > \Delta W_{Di} > \Delta W_{Tri}}$

|ii| → ΔW = same ⇒ $\boxed{\Delta Q = \dfrac{\Delta W}{1 - \frac{1}{y}}}$ *

* $\boxed{\Delta Q_{Mono} < \Delta Q_{Di} < \Delta Q_{Tri}}$

|b| → Part of Heat, convert in a Internal Energy

$$\frac{du}{\Delta Q} = \frac{\mu c_v \Delta T}{\mu c_p \Delta T} = \frac{1}{y}$$

$$\boxed{\frac{du}{\Delta Q} = \frac{1}{y}}$$

*** # → Part of supplied Heat convert in Work & change in I.E →

Gas	Monoatomic ($y = 5/3$)	Di-atomic ($y = 7/5$)	Triatomic ($y = 4/3$) (Non-Linear)
$\Delta W = \boxed{1 - \frac{1}{y}}$ *	$1 - 1/5/3$ $1 - 3/5$ $= \boxed{2/5}$ * $\approx \boxed{40\%}$	$1 - 1/7/5$ $1 - 5/7$ $= \boxed{2/7}$ * $\approx \boxed{(30\%)}$	$1 - 1/4/3$ $1 - 3/4$ $= \boxed{1/4}$ * $\boxed{\approx 25\%}$
$\frac{du}{dQ} = \boxed{\frac{1}{y}}$ *	$\frac{1}{5/3} = \boxed{3/5}$ * $\boxed{\approx 60\%}$	$\frac{1}{\frac{7}{5}} = \boxed{5/7}$ * $\boxed{\approx 70\%}$	$\frac{1}{\frac{4}{3}} = \boxed{3/4}$ * $\boxed{\approx 75\%}$

|2|→ Isometric/Isochoric/const-vol process→

|i|→ V=const.

|ii|→ Gas Law ⇒ Gaylussac law

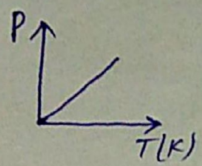
|iii|→ Process eqn ⇒ $PV=\mu RT$

$$\boxed{\frac{P}{T}=K_1=\frac{\mu R}{V} \Rightarrow \frac{P_1}{T_1}=\frac{P_2}{T_2}}$$

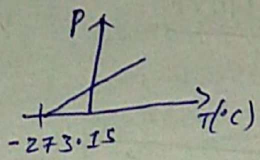
|iv|→ Process eqn → $PV=\mu RT$

$\boxed{P \propto T}$ $\frac{P}{T}=K$ $\boxed{\frac{P_1}{T_1}=\frac{P_2}{T_2}}$

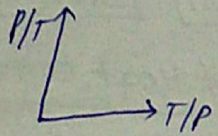
P v/s T(K)



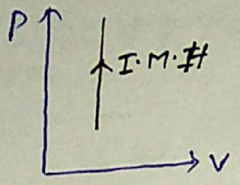
P v/s T(°C)



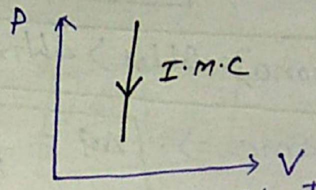
P/T v/s T



|v|→ Process curve:→



- * V=const, P↑, T↑
- * $\Delta W=0$
- * $du=\oplus ve$
- * $\Delta q=\oplus ve$



- * V=const, P↓, T↓
- * $\Delta W=0$
- * $du=\ominus ve$
- * $\Delta q=\ominus ve$

|vi|→ Work

$\boxed{\Delta W_{I.M}=0}$

|vii|→ Heat

$\boxed{\Delta q=\mu C_v \Delta T \text{ or, } mC_v\Delta T}$

|viii|→ change in Internal Energy (du)

$\boxed{du=\mu C_v \Delta T}$

|ix|→ Apply F.L.O.T

$\boxed{\Delta q=du=\mu C_v \Delta T}$

|x|→ slope of 'P-V' curve

$\boxed{\left(\frac{dP}{dV}\right)_{IM}=\tan 90^\circ=\infty}$

|xi|→ volume elasticity cofficient (K)

$\boxed{K_{IM}=\infty}$

|xii|→ compressibility (C)

$C_{I.M}=\frac{1}{K_{IM}}=\frac{1}{\infty}=0$

|xiii|→ Ex→ Heating & colling of salid & liquid.

|3| → const. temp / Isothermal process: →

|i| → T = const. |iii| → Gas law = Boyles Law

|iii| → Process eq^n

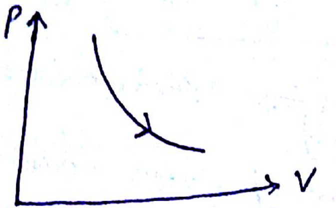
$PV = \mu RT$

$PV = K$

$\boxed{P \propto \frac{1}{V}}$ → Rectengular Hyperbola.

$\boxed{P_1V_1 = P_2V_2}$ *

|iv| → Process curve →

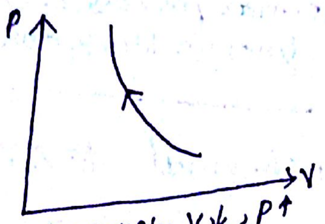


T = const, V↑, P↓

du = 0

ΔW = ⊕ve

Δq = ⊕ve

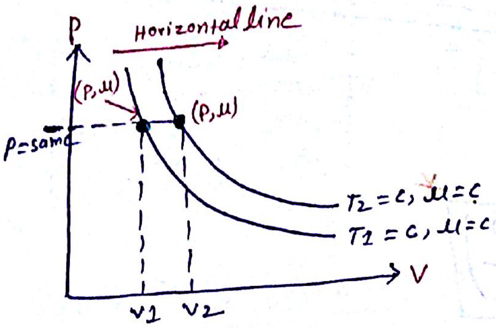


T = const, V↓, P↑

du = 0

ΔW = ⊖ve

Δq = ⊖ve.

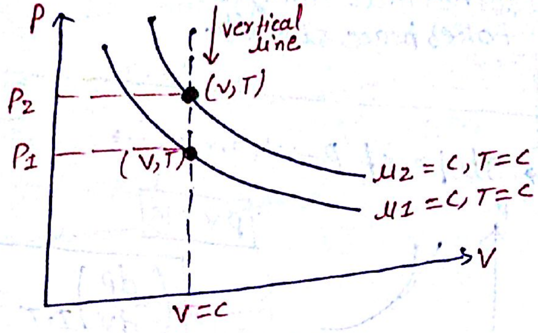


$PV = \mu RT$

* $\boxed{V \propto T}$

$\boxed{V_2 > V_1}$ *

$\boxed{T_2 > T_1}$ *



$PV = \mu RT$

* $\boxed{P \propto \mu}$ *

$\boxed{P_2 > P_1}$ *

$\boxed{\mu_2 > \mu_1}$

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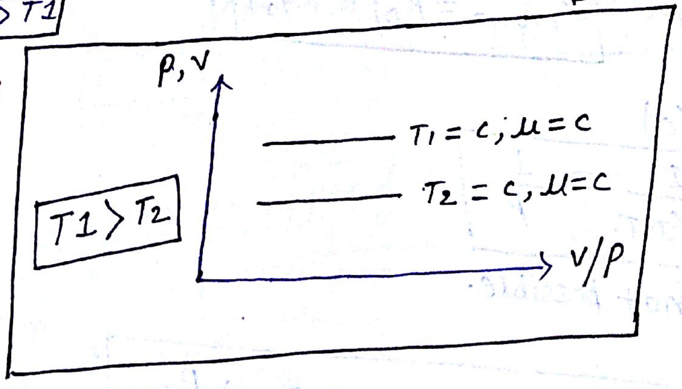
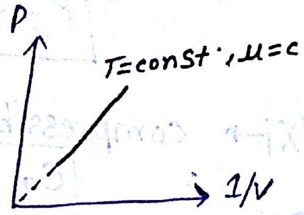




|V| → Work done (ΔW) → *

$$\boxed{W_{I.T} = 2.303 K \log_{10} V_2/V_1}$$

$$\boxed{K = P_1V_1 = P_2V_2 = \mu RT}$$

$$\boxed{\frac{V_2}{V_1} = \frac{P_1}{P_2}}$$

* $$\boxed{W_{I.T} = 2.303 \log_{10}(P_1/P_2)}$$

|vi|→ change in Internal energy (du)

$$T = \text{const} \Rightarrow u = \mu C_v T = \text{const}.$$

$$\boxed{du = 0}$$

|vii|→ F.L.O.T

$$\Delta Q = \Delta W + \underset{0}{du}$$

$$\boxed{I.W = du = 0}$$

*
$$\boxed{\Delta Q = \Delta W = 2.303 k_3 \log_{10}\left(\frac{V_2}{V_1}\right) = 2.303 k \log_{10}(P_1/P_2)}$$

NOTE → In Isothermal process 100% part is supplied heat convert in thermodynamic Work done, practically Impossible.

***

Assumption for Isothermal process

|i|→ container is perfecetelly conducting.

$k = \infty$, $c = 0$

Thermal conductivity

|ii|→ Isothermal change takes place slowelly..

Assumption for Adiabatic process.

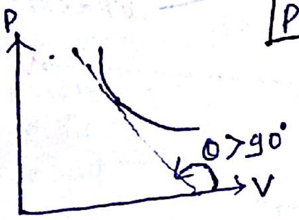
$\boxed{\Delta Q = 0}$

|i|→ conductor is perfectelly insulating.

$K = 0$, $c = \infty$

|ii|→ Adiabatic change takes place suddenly or, very fast.

|viii|→ slope of 'p–v' curve →



$$\boxed{PV = K}$$

*
$$\boxed{\left(\frac{dp}{dv}\right)_{I.T} = -\left(\frac{P}{V}\right)}$$

|ix|→ volume elasticity const (K) :→ Independent from atomicity & Molecular wt. = Process of gas.

$$\boxed{K_{I.T} = P}$$

$$\boxed{K_{Mono} = K_{Di} = K_{Tri}} \quad (P = \text{same})$$

|X|→ compressibility (c)

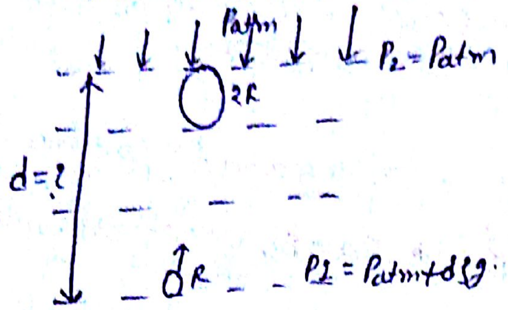
$$\boxed{C_{I.T} = \frac{1}{K_{I.T}} = \frac{1}{P}}$$

|xi|→ Ex → Practically not possible.

*** Standard Result.

#
$$\boxed{\begin{aligned} r_2 = n r_1 &= d\,(n^3 - 1)\,(10\,m) = (n^3 - 1)\frac{P_{atm}}{\rho g} \\ V_2 = n V_1 &= d\,(n - 1)\,(10\,m) = (n - 1)\frac{P_{atm}}{\rho g} \end{aligned}}$$

Ex→ Air bubble Rise from bottom to top in a pond at surface of water its radius becomes double. Find out depth of pond.



$$d = (n^3-1)\frac{P_{atm}}{\rho g}$$

$$=(2^3-1)\frac{10^5}{1000\times 10}$$

$$=(8-1)\times 10^1$$

$$= 70m.$$

(4) → Adiabatic process →

(i) → $\boxed{\Delta q = 0}$ q = const.

(ii) → Process eqn.

(a) → P v/s V →

(γ=gama)

$\boxed{PV^\gamma = K}$ *

$\boxed{P_1V_1^\gamma = P_2V_2^\gamma}$ *

γ = sp. heat Ratio or Adiabatic co-efficient.

$\gamma = \frac{C_p}{C_v} = 1+\frac{2}{f}$

(b) → P v/s T →

* $\boxed{PV^\gamma = K}$ V ∝ T/P (gas eqn.)

* $\boxed{P \propto T^{\gamma/\gamma-1}}$

(c) → V v/s T →

$\boxed{PV^\gamma = K}$

$\boxed{TV^{\gamma-1} = K}$

* $\boxed{T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}}$

(d) → P v/s ρ (density) →

$PV^\gamma = K$ / $V = \frac{M}{\rho}$

$\frac{P}{\rho^\gamma} = K1$

$\boxed{P \propto \rho^\gamma}$

→ Adiabatic process.

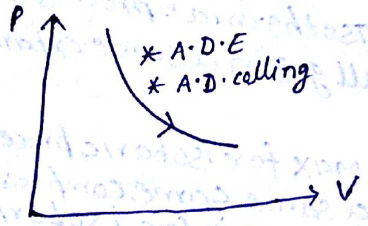
Isothermal process.

$PV = K$

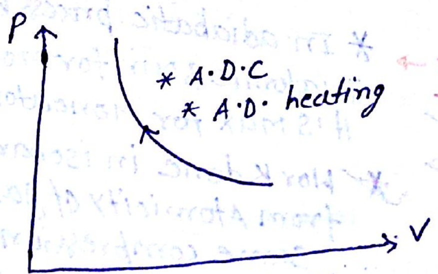
$P\left(\frac{M}{\rho}\right) = K$

$\boxed{P \propto \rho}$ *

(iii) → Process curve: → $\boxed{P \propto \frac{1}{V^\gamma}}$



* V↑, P↓, T↓, ⇒ u↓
* ΔW = ⊕ve
* du = ⊖ve
* Δq = 0



* V↓, P↑, T↑ ⇒ u↑
* ΔW = ⊖ve
* du = ⊕ve
* Δq = 0

(iv) → Work →

$$\boxed{W_{A \cdot D} = \frac{P_1V_1 - P_2V_2}{\gamma - 1}}$$

NOTE → In a adiabatic process W. done depend on atomicity of gas but it is independent in isobaric & Isothermal process for same Expansion or, same compression.

***** # comparision of W. done, case-I → In Adiabatic process.

[A] → In same Expansion →

$V_1 \longrightarrow V_2 \quad (V_2 > V_1) \quad \left(\frac{V_1}{V_2} < 1\right)$

$P_1 \longrightarrow \boxed{P_2 = P_1\left(\frac{V_1}{V_2}\right)^\gamma}$

$* \ \boxed{\underset{5/3}{\gamma_{Mono}} > \underset{7/5}{\gamma_{Di}} > \underset{4/3}{\gamma_{Tri}}}$

$* \ \boxed{(P_2)_{mono} < (P_2)_{DI} < (P_2)_{Tri}}$

$* \ \boxed{W_{Mono} < W_{Di} < W_{Tri}}$

[B] → Same compression →

$V_2 \rightarrow V_1 \quad (V_1 < V_2) \Rightarrow \frac{V_2}{V_1} > 1)$

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

$* \ \boxed{(P_1)_{mono} > (P_1)_{Dia} > (P_1)_{Tri}}$

$* \ \boxed{W_{mono} > W_{Di} > W_{Tri}}$

** **NOTE** →
- * In a same adiabatic expansion Work done by the gas is min for monoatomic gas & ↑ with atomicity.
- * In a same adiabatic compression Work done on the gas is max for monoatomic gas & it is ↓ with atomicity of gas.

*** case II → In a diff thermodynamic process.

[A] → Same Expansion.

$\boxed{(P_2)_{I \cdot B} > (P_2)_{I \cdot T} > (P_2)_{A \cdot B}}$

$\boxed{W_{I \cdot B \cdot E} > W_{I \cdot T \cdot E} > W_{A \cdot B \cdot E}}$

[B] → In same compression.

$\boxed{(P_1)_{A \cdot B} > (P_1)_{I \cdot T} > (P_1)_{I \cdot B}}$

$\boxed{W_{A \cdot B \cdot C} > W_{I \cdot T \cdot C} > W_{I \cdot B \cdot C}}$

***** **NOTE** →
AIIMS
A/R

- * In adiabatic process Work in same expansion is max for Triatomic & min for monoatomic gas. but in same compression it is max for monoatomic & min for triatomic.
- * Work done in isobaric process & Isothermal process Independent from Atomicity of gas (same for all gas in a same expansion or same compression.)
- * In same expansion Work done is max for isobaric process & min for adiabatic process but in a same same compression Work done Max for Adiabatic process & min for Isobaric process.
- * Two Isothermal curve never cut to each other.
- * Two adiabatic or, one adiabatic or, one isothermal cut to each other.

|V| → change in internal Energy

$du = \mu c_v dT$

$$\boxed{du = \frac{\mu R dT}{\gamma - 1} = -\Delta W}$$

$$\boxed{du = \mu c_v dT = \frac{\mu R(T_2 - T_1)}{\gamma - 1}}$$

|vi| → Heat

$\boxed{\Delta q = 0} \Rightarrow$ const.

|vii| → F·L·O·T

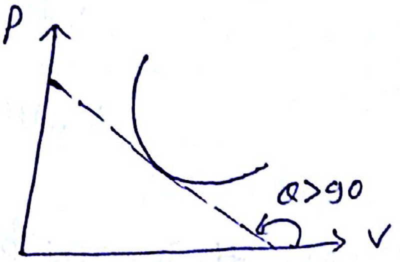
$$\underset{\substack{\Downarrow \\ 0}}{\Delta q} = \Delta W + du$$

$$\boxed{du = -\Delta W}$$

|viii| → Slope of 'P-V' curve

$PV^{\gamma} = K$

$$\boxed{\begin{gathered} \left(\frac{dP}{dV}\right)_{A \cdot B} = -\gamma \left(P/V\right) \\ \left(\frac{dP}{dV}\right)_{I \cdot T} = -\left(P/V\right) \\ \left(\frac{dP}{dV}\right)_{A \cdot B} > \left(\frac{dP}{dV}\right)_{I \cdot T} \\ \left(\frac{dP}{dV}\right)_{A \cdot B} = \gamma \left(\frac{dP}{dV}\right)_{I \cdot T} \end{gathered}}$$



(Minus sign ko magnitude में include नहीं करना)

|ix| → volume elasticity coff (K)

$K_{A \cdot B} = -V\left(\frac{dP}{dV}\right)_{AD} = -V\left(\frac{-\gamma P}{V}\right)$

$K_{A \cdot B} = \gamma P \Rightarrow \boxed{K_{mono} > K_{Di} > K_{Tri}}$

$K_{I \cdot T} = P \Rightarrow \boxed{K_{mono} = K_{Di} = K_{Tri}}$

Imp #

$$\begin{tikzcd} & K_{mono} = K_{Di} = K_{Tri} \\ P \arrow[ur, "I \cdot T"] \arrow[dr, "A \cdot D"'] & \\ & K_{mono} > K_{Di} > K_{Tri} \end{tikzcd}$$

NOTE → Adiabatic vol elasticity co-efficient depend on atomicity of gas.

|X| → compressibility (c)

$C_{AB} = \frac{1}{K_{AB}} = 1/\gamma P$

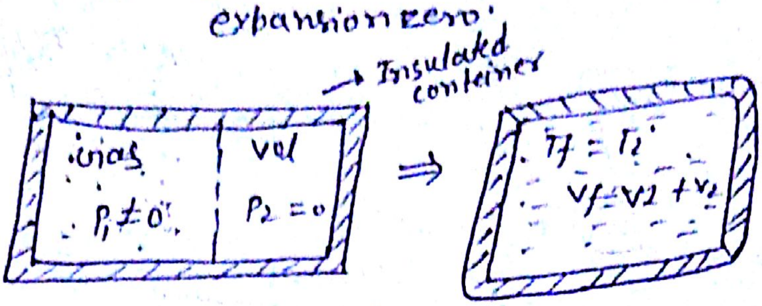
$$\boxed{C_{A \cdot D} = \frac{C_{I \cdot T}}{\gamma}}$$

$* \boxed{C_{I \cdot T} = 1/P}$

|xi| → Eg → Exemplar

- * Propagation of sound in gaseous medium.
- * suddenly blasting of tube.
- * Fast Expansion & compression of gas.

|5| → **Free Expansion of gas** → If Work done by the gas in a expansion zero.



I·G

* $\Delta q = 0$

* $\Delta W = 0$

$\Delta W_{ext} \Rightarrow 0$ $\Delta W_{int} \Rightarrow 0$

* $du = \Delta q - \Delta W$

$du = 0$ $U = const.$

* $\boxed{T_f = T_i}$ * Exam

* $\boxed{V_f = V_1 + V_2}$ Final vol.

* $\boxed{P_f = \frac{P_1 P_2}{V_1 + V_2}}$

R·G

* $\Delta q = 0$

* $I \cdot M \cdot D \Rightarrow \uparrow \Rightarrow I \cdot M \cdot F \downarrow \Rightarrow |P.E| \Rightarrow \downarrow \Rightarrow U \uparrow \Rightarrow du = \oplus ve$

* $\Delta W = \underset{0}{\Delta q} - \underset{\oplus ve}{du} = \ominus ve.$

Draw back of F·L·O·T

|i| → ~~FLOT~~ Never explain direction of Heat flow.

|ii| → How Much part of Supplied heat convert in a thermodynamic work we can't explain without information thermodynamics.

Second Law of Thermodynamic [S·L·O·T]

|a| → **Classious Statement** :→ Direction of Heat flow NOT possible low temp. to high temp. Without perform some ext. Work

|b| → **Kelvin Statement** → Temp. of body is not less than from surrounding temp. Without extract some heat.

Statement 1 & 2 explain direction of Heat flow it is normally flow High temp. to low temp.

* Low temp. to high temp. only possible When Ext. Work extract heat from system.

|c| → **Kelvin-plank Statement** → Efficiency of Heat engine is always Less than 1. It Means 100% part of supplied Heat not convert in a Mechanical Work. * $\boxed{\eta < 1}$

HEAT ENGINE

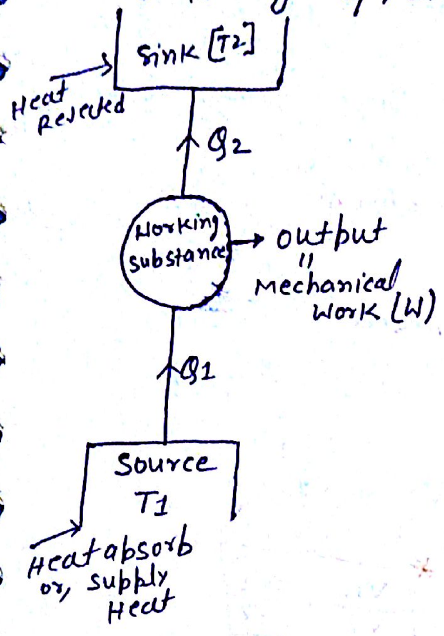
Input = Heat
Output = Mechanical Work

Scanned by CamScanner

* Source → supp Heat

* Working substance → convert heat into mechanical work.

* sink → gain/Rejected Heat.



$\boxed{Q_1 = W + Q_2}$ $(Q_1 > Q_2 \Rightarrow T_1 > T_2)$

Here,

Q_1 = Heat absorb by Heat engine or, Heat supplied by the source

or, Heat absorb by Heat engine at High temp.

Q_2 = Heat Rejected by Heat engine.

or, Heat absorb by sink

or, Heat absorb by Heat engine at low temp.

Mechanical Work (output of Heat engine) →

$$\boxed{\begin{aligned} W &= Q_1 - Q_2 \\ W &= Q_{absorb} - Q_{rejected} \end{aligned}}$$

Efficiency of Heat engine (η) :→

$$\eta = \frac{\text{output}}{\text{Input}} = \frac{\text{M. Work}}{\text{Heat}} = \frac{W}{Q_1}$$

** $$\boxed{\eta = \frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1} = 1 - \frac{Q_2}{Q_1}}$$

* $\boxed{Q \propto T}$ $$\boxed{\frac{Q_2}{Q_1} = \frac{T_2}{T_1}}$$

$$\eta_{H.E} = \frac{W}{Q_1} = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T_1}$$

↑ Ideal Efficiency

Imp * $\eta_{H.E} = 100\% = ①$ —

- $\frac{Q_2}{Q_1} = 0 \Rightarrow Q_2 = 0 / Q_1 = \infty$
- $\frac{T_2}{T_1} = 0 \Rightarrow T_2 = 0K / T_1 = \infty$

** NOTE → Temp. of sink (T_2) is not equal to zero kelvin (0K) and amount of supplied Heat is not equal to ∞ i.e efficiency of Heat engine is not ≠ to 1.

Imp ** * $\eta_{H.E} = \uparrow$ —

- $\left(\frac{Q_2}{Q_1}\right)\downarrow \Rightarrow Q_2\downarrow / Q_1\uparrow$
- $\left(\frac{T_2}{T_1}\right)\downarrow \Rightarrow T_2\downarrow$ (Sink) / $T_1\uparrow$ (Source)

NOTE → * Heat engine Work b/w same Reservior of Heat · Efficiency of Heat engine is Independent from Atomicity of gas.

* If Heat engine Work b/w same expansion & compression then Efficiency depend on atomicity of gas.

CARNOT CYCLE

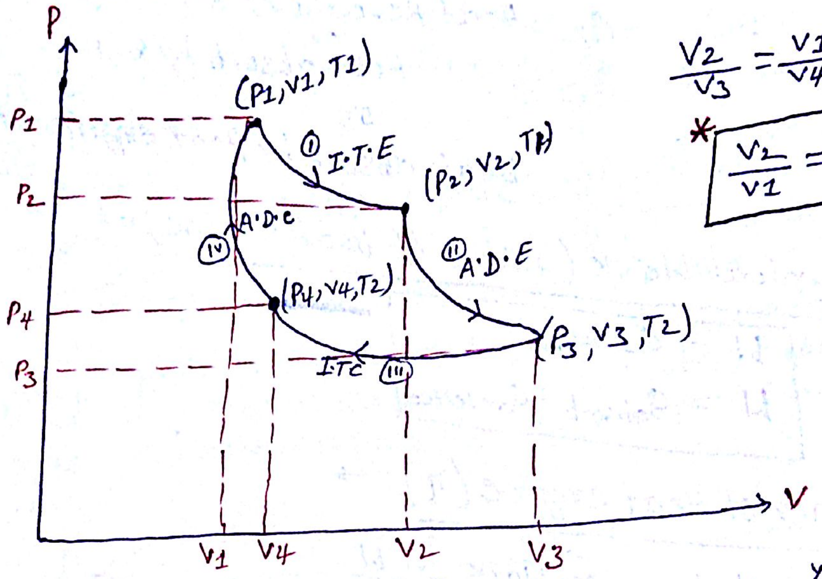
* Explain Working of Heat engine.

|a| → Isothermal Expansion (I·T·E) → Heat absorb·

|b| → Adiabatic Expansion (A·D·E) →

|c| → Isothermal compression (I·T·C) → Heat Reject·

|d| → Adiabatic compression (A·D·C) →



$$\frac{V_2}{V_3} = \frac{V_1}{V_4}$$

$$* \boxed{\frac{V_2}{V_1} = \frac{V_3}{V_4}}$$

$A \cdot D \cdot E \rightarrow T_1 V_2^{\gamma-1} = T_2 V_3^{\gamma-1} \quad \frac{T_2}{T_1} = \left(\frac{V_2}{V_3}\right)^{\gamma-1} \quad \frac{T_2}{T_1} = \left(\frac{V_2}{V_3}\right)^{\gamma-1} = \left(\frac{V_1}{V_4}\right)^{\gamma-1}$

$A \cdot D \cdot C \rightarrow T_2 V_4^{\gamma-2} = T_1 V_1^{\gamma-1} \quad \frac{T_2}{T_1} = \left(\frac{V_1}{V_4}\right)^{\gamma-1}$

$I \cdot T \cdot E \rightarrow du = 0 \Rightarrow Q_1 = W_1 = 2.303 \mu R T_1 \log_{10}\left(\frac{V_2}{V_1}\right)$

$I \cdot D \cdot E \rightarrow \Delta Q = 0 \Rightarrow W_2 = \frac{\mu R (T_1 - T_2)}{\gamma - 1}$

$I \cdot T \cdot C \rightarrow du = 0 \Rightarrow Q_2 = W_3 = 2.303 \mu R T_2 \log_{10}\left(\frac{V_4}{V_3}\right)$

$= -2.303 \mu R T_2 \log_{10}\left(\frac{V_3}{V_4}\right)$

$= 2.303 \mu R T_2 \log_{10}\left(\frac{V_2}{V_1}\right)$

$I \cdot D \cdot C \rightarrow \Delta Q = 0 \Rightarrow W_4 = \frac{\mu R (T_2 - T_1)}{\gamma - 1} = -W_2$

Work done of carnot cycle (output)

$W_{carnot} = W_1 + W_2 + W_3 + W_4$

$$\boxed{W_{carnot} = 2.303 \mu R \log_{10}\left(\frac{V_2}{V_1}\right)(T_1 - T_2)} \longrightarrow \text{Area of carnot cycle.}$$

Efficiency of carnot cycle →

$$\eta_{carnot} = \frac{W}{Q_1}$$

*

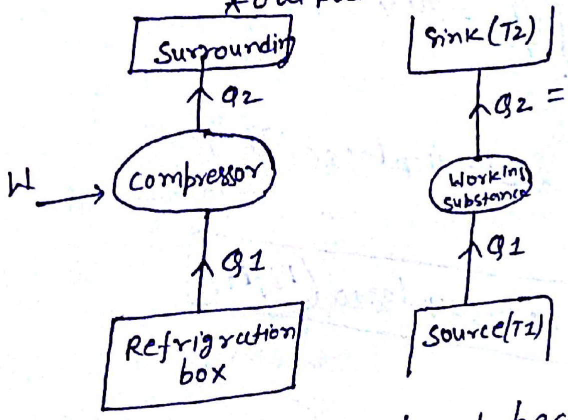
$$\eta_{carnot} = \frac{T_1 - T_2}{T_1} = 1 - \frac{T_2}{T_1} = \eta_{H \cdot E}$$

**

$$\eta_{H \cdot E} = 1 - \frac{T_2}{T_1} = 1 - \left(\frac{V_2}{V_3}\right)^{\gamma - 1} = 1 - \left(\frac{V_1}{V_4}\right)^{\gamma - 1}$$

HEAT PUMP :→

* Input = mechanical Work
* output = Heat.



$Q_2 = Q_1 + W$ ($Q_2 > Q_1 \Rightarrow T_2 > T_1$)

(i) → In a Heat pump heat flow from Low temp. to high temp.

Exemplar. (ii) → In a close room When door of freeze is open then temp. of Room ↑.

Q_1 = Heat extract by working substance. (source)

Q_2 = Heat supplied to the sink or, Heat absorb by sink.

2016 AMU

*** # In a Refrigrator, the system extract heat Q_2 from the cold Reservoir & Release Q_1 amount of Heat to the hot Reservoir With work 'W' done on the system. The cofficient of performance of Refrigrator → $\boxed{\frac{Q_2}{Q_1 - Q_2}}$ *

M. Work (W)

$$\boxed{W = Q_2 - Q_1}$$

2016 AMU

co-efficient of performance (C·O·P) →

$$C \cdot O \cdot P = \frac{\text{output}}{\text{Input}} = \frac{\text{Heat}}{\text{M} \cdot \text{Work}} = \frac{Q_1}{W}$$

***

$$(C \cdot O \cdot P)_{H \cdot P} = \frac{Q_1}{W} = \frac{Q_1}{Q_2 - Q_1} = \frac{T_1}{T_2 - T_1}$$

$$(C \cdot O \cdot P)_{H \cdot P} = \frac{1}{\frac{T_2}{T_1} - 1} = \frac{1}{\eta_{H \cdot E}}$$

*

$$\boxed{(C \cdot O \cdot P)_{H \cdot P} > 1}$$

Entropy(s)/change in entropy (ds) →

Entropy → It is state function & change in entropy independent from path. (depend on final & initial position).

$$\int ds = \int \frac{\Delta q}{T}$$

$$\int \Delta q = \int T ds$$

* $S\uparrow \Rightarrow ds \Rightarrow \oplus ve \Rightarrow \Delta q \Rightarrow \oplus ve$ (Absorb)

* $S\downarrow \Rightarrow \ominus ve \Rightarrow \Delta q \Rightarrow \ominus ve \Rightarrow$ Rejection.

* $S = C \Rightarrow ds = 0 \Rightarrow \Delta q = 0 \Rightarrow$ Adiabatic or, Isoentropic process.

Change In Entropy →

|a| → const. volume $ds = \frac{\Delta q}{T} = \mu c \int_{Ti}^{Tf} \frac{dT}{T} = \mu C_v \ln\left(\frac{Tf}{Ti}\right)$

*
|b| → const. Pressure

$$ds = \frac{\Delta q}{T} = \int_{Ti}^{Tf} \frac{\mu c_p dT}{T} = 2.303\, \mu c_p \log_{10}\left(\frac{Tf}{Ti}\right) = dS$$

|c| → const. temp

$$\boxed{ds = 2.303\, \mu R \log_{10}\left(\frac{Vf}{Vi}\right) \text{ or, } 2.303\, \mu R \log_{10}(Pi/Pf)}$$

*
|d| → Adiabatic process.

$$\boxed{ds = \frac{\Delta q}{T} = \frac{0}{T} = 0}$$

$S = $ const. $\Rightarrow$ Isoentropic process.

***
|e| → Phase conversion

$$ds = \frac{\Delta q}{T} = \frac{ML}{T}$$

→ $ds_{melting} = \boxed{\frac{M_s L_f}{T_{M.P}}}$

→ $ds_{vaporisation} = \boxed{\frac{M_L L_V}{T_{B.P}}}$

Graphical concept :→

$$ds = \frac{\Delta q}{T} = \boxed{\int \Delta q = \int T ds}$$

$\boxed{\text{Heat = Area Inclosed b/w 'T-S' curve \& 'S' axis.}}$

$S\uparrow \Rightarrow \Delta q = \oplus ve$ (Absorb)

$S\downarrow \Rightarrow \Delta q = \ominus ve$ (Reject)

'P-V' curve ($du = 0 \Rightarrow \Delta q = \Delta W$)

$\Delta W = \oplus ve$
$\Downarrow$
$\Delta q = \oplus ve$
↓
H· Energy

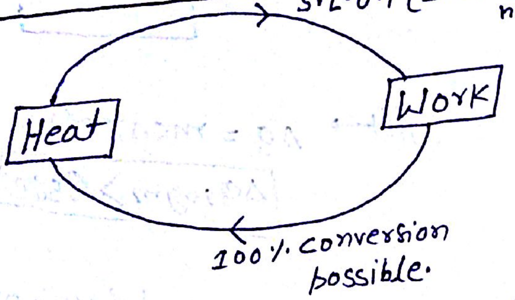
$\Delta W = \ominus ve$
$\Delta q = \ominus ve$
↓
Heat pump.

→ "T – S" curve

C·W
↓
H·E

A·C·W
↓
H· pump

conversion of Mechanical Work & Heat →



*** # Water Steam fall from 84m height. When it strike at bottom half of its K·E convert into Heat then cal. Rise in temp.

m, $u = 0$

$\boxed{PE_h = mgh = K{\cdot}E_h = 0 = T{\cdot}M{\cdot}E_h = mgh}$ *

$h = 84m$, $g = 9.8\ m/sec^2$

$c = 1\ cal/gm°c = 4.2 \times 10^3\ J/Kgm\,K.$

$\boxed{PE_B = 0,\ T{\cdot}M{\cdot}E{\cdot}B = mgh = K{\cdot}E_2 = mgh.}$ *

$Heat = \frac{1}{2}(K{\cdot}E_B) = \frac{1}{2}mgh$

$\Downarrow$

$mc\Delta T$

$mc\Delta T = \frac{1}{2}mgh$

* $\boxed{\Delta T = \frac{gh}{2c}}$

* $\boxed{\begin{aligned} C_{H_2O} &= 1\ cal/gm°c \\ &= 4.2\ KJ/Kgm°c \\ &= 4.2 \times 10^3\ J/Kg°c \end{aligned}}$

$\Delta T = \frac{2.8 \times 84}{2 \times 4.2 \times 10^{-3}}$

$= 0.098°c / 0.09K$

AIPMT 2016

A piece of ice fall from a height 'h' so that it melts completely. only one quarter of the Heat produced is absorb by the ice & all energy of Ice get converted into Heat during Its fall. The value of h.

[latent Heat of ice is → $3.4 \times 10^5 J$]

$$\boxed{\text{Heat loss} = mgh}\ *$$

$$\frac{1}{4}(mgh) = mL$$

$$h = \frac{4L}{g}$$

$$= \frac{4 \times 3.4 \times 10^5}{10}$$

$$= 13.6 \times 10^4 m$$

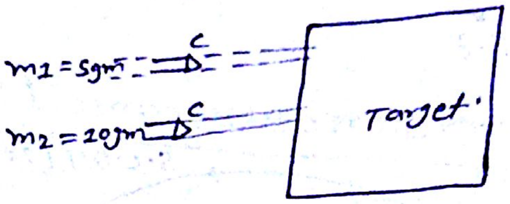
$$= \underline{136 km}$$

*
**

Two bullet Made up of Same material moves With same velocity Strike with Surface & come to Rest. Its complete K.E convert into Heat & Mass of bullet Resp 5gm & 10gm.

|a| → change in temp.

|b| → Loss in Heat.



$$Loss = \frac{1}{2}mv^2$$

||

$$Heat = mc\Delta T$$

|i| → $mc\Delta T = \frac{1}{2}mv^2$

$$*\ \boxed{\Delta T = \frac{v^2}{2c}} = \text{same}$$

$$\Delta T_{5gm} = \Delta T_{10gm}$$

NOTE → Temp. change does not depent on Mass.

|ii| → $\Delta Q = mc\Delta T \propto m$

$$\boxed{\Delta Q_{10gm} > Q_{5gm}}$$

**
***

CMC 2015

Earth suddenly stop rotation about its self axis. If 100% part of Its Rotational K.E convert in form of Heat then find out change in temp. of Earth. If Its Radius & sp. heat respectively R & C (ω ⇒ Angular velocity of Earth)

Earth ⇒ solid sphere
↳ $\frac{2}{5}MR^2$

$$Loss = \frac{1}{2}I\omega^2$$

|||

$$Heat = MC\Delta T$$

$$J(mC\Delta T) = \frac{1}{2}(2/5\, MR^2)\omega^2$$

$$\boxed{\Delta T = \frac{\omega^2 R^2}{5CJ}}$$

AIIMS.

A → Thermodynamic process in nature are Irriversible.

R → Dissipative effects can not be eliminated.

Ans → A