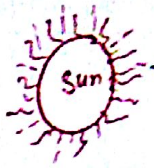
HEAT

|1| → CALORIMETRY
|2| → K.T.G
|3| → THERMODYNAMICS
|4| → THERMAL EXPANSION



← ultimate soure of Energy.

Heat Transfer

|1| → CONDUCTION
|2| → CONVECTION
|3| → RADIATION

CALORIMETRY

1.→ # Internal energy(U)

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

Molecular motion. (K.E)

Molecular configuration (P.E)

- * $K.E = f(T)$
- * $P.E \propto -I.M.F$

- * I.M.F → solid > Liquid > Real gas > Ideal gas (0)
- * P.E → $\underbrace{\text{Solid} < \text{Liq} < R.G}_{-ve} < I.G$ (0)

* T = const ⇒ K.E ⇒ const.

$\boxed{U_{solid} < U_{Liq} < U_{R.G} < U_{I.G}}$

Eg → $\boxed{U_{0°C\,Ice} < U_{0°C\,H_2O}}$

Internal Energy of Gas

Ideal Gas (I.G)

- * I.M.F = 0
- * P.E = 0
- * $U = K.E = f(T)$

Real Gas (R.G)

- * I.M.F ≠ 0 $\left(IMF \propto \frac{1}{I.M.D}\right)$
- * P.E ≠ 0
- * $U = f(T, I.M.D)$

AIR ** [
- * I.M.D ↑ (Expansion) ⇒ I.M.F ↓ ⇒ PE ↑ ⇒ U ↑
- * I.M.D ↓ (compression) ⇒ I.M.F ↑ ⇒ PE ↓ ⇒ U ↓

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NOTE • Applicable for both I.G & R.G.

- * In isothermal process of I.G Internal energy remain same but in case of Real gas it will change with Intermolecular distance.
- * In a isometric (or, Isochoric) process when gas absorb Heat internal energ ↑ & when it is reject Heat its energy ↓.

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- * Phase consrsion takes place at const. temp but change in internal energy is not equal to zero.

$\text{Solid} \xrightarrow[M.P]{T=C} \text{Liq} \xrightarrow{T_{B.P}=C} \text{vapour}$

- * T = C ⇒ K.E ⇒ same ⇒ Δ.K.E = 0
- * V ↑ ⇒ I.M.D ↑ ⇒ I.M.F ↓ ⇒ P.E ↑ ⇒ U

***** EXEPTION

$\text{Ice} \xrightarrow{Tmp = 0°C = C} \text{Water}$

- * $V_{Ice} > V_{Water}$ → due to H-bonding
- * V ↓ ⇒ I.M.D ↓ ⇒ I.M.F ↑, P.E ↓ ⇒ U ↓

Manitude of Heat

Heat ∝ Temp. change (ΔT)
Heat ∝ (quantity) (Temp. change)
Heat ∝ $\underset{\uparrow \text{sp. heat.}}{C}$ (quantity) (Temp change)

$\Delta Q = MC\Delta T$
or,
$\Delta Q = \mu C\Delta T$

* unit of Heat = Jule/cal/ev/K.W.H.

$1\,ev = 1.6\times10^{-19}\,J$
$1\,K.W.H = 3.6\times10^{6}\,J$
⇓
1 unit

1 cal = 4.2 ~~J~~ J

$cal \underset{1/J}{\overset{\times J}{\rightleftarrows}} Jule$

$J = 4.2\ J/cal$ 2016 AMU * Mechanical equivalent of Heat
or, Jule const.

2. Specific Heat (c) →

→ gm. sp. Heat $\boxed{C_{gm} = \frac{\Delta Q}{M\Delta T}}$ * unit ⇒ $\frac{J}{gm K}$, $\frac{cal}{gm °c}$

→ Moler sp. Heat $\boxed{C_M = \frac{\Delta Q}{\mu \Delta T}}$ * unit → $\frac{J}{mole K}$, $\frac{cal}{mole c}$

* $C_M = M_W C_{gm}$

$$\boxed{C_M \underset{\times M_W}{\overset{1/M_W}{\rightleftarrows}} C_{gm}}$$

Eg → * C_{H_2O} = 1 cal/gm °c = * 18 $\frac{cal}{mol °c}$
* C_{H_2} = 7 cal/mole °c = 3.5 cal/gm °c

* HEAT —
→ c = const $\boxed{\Delta Q = MC_{gm}\Delta T \quad or, \ \Delta Q = \mu C_M \Delta T}$
→ c = variable $\Delta Q = \int_{T_i}^{T_f} MC\Delta T$ or, $\Delta Q = M\int_{T_i}^{T_f} f(T)\,dT$

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"Special point about specific heat"

|i| → sp. heat only depends on nature of substance it is independent from temp. quantity & supplied Heat.

(I) Exception → H_2O
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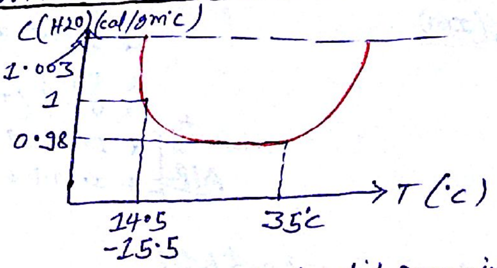
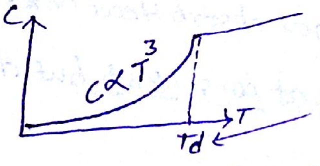


* 1 cal ⇒ Required Heat to change 1 °c temp. b/w 14.5 to 15.5 for one gm H_2O. (at NTP)

(II) Exception → Generally specific heat of solid Remain unchange $\bar{c}$ temp. but in some solid it will charge with lower temp.



Debye temp. < Room temp.

|ii| → In a substance wich is Ⓐnt in nature specific Heat is maximum for H_2.
* $\boxed{C_{H_2} = 3.5\ cal/gm °c}$

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|iii| → In Remaning solid, liquid Specific Heat is Maximum for H_2O. * (C_{H_2O} = 1 cal/gm °c)
(that's why it is used as collent.) but its ignition point is very low.

|iv| → For metals * sp. Heat = $\left(\frac{6.4}{at\,wt}\right)$ cal/gm °c * $\boxed{C_{Cu} < C_{Al}}$ ← BCECE 2014

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|V| → sp. Heat of substance max$\underline{m}$ in gaseous state & min$\underline{m}$ for solid state.
$\boxed{C_{solid} < C_{liq} < C_{gas}}$ * Reason → Require Heat to change same temp. for same quantity is max$\underline{m}$ for gaseous state due to Maximum Intermolecular distance.

***
VI → In phase conversion process sp. Heat is not define.

$\boxed{\text{Solid}} \underset{\text{Freezing}}{\overset{\text{melting}}{\rightleftharpoons}} \boxed{\text{Liq}}$ $\boxed{\text{Liq}} \underset{\text{condensation}}{\overset{\text{vaporisation}}{\rightleftharpoons}} \boxed{\text{vapour}}$

$T_{M.P} = c$ $T_{B.P} = c$

$$T = c \Rightarrow \Delta T = 0 \Rightarrow c = \frac{\Delta Q}{M\Delta T} = \infty$$

*
VII → sp. heat of gas depend on *thermodynamic process & *atomicity.

'Thermodynamic process'

$\boxed{c = \frac{\Delta Q}{M\Delta T}}$

- Isothermal process ⇒ $T = C \Rightarrow \Delta T = 0 \Rightarrow \boxed{C_{I.T} = \infty}$
- AIIMS Adiabatic process ⇒ $\Delta Q = 0 \Rightarrow \boxed{C_{A.P} = 0}$
- Isometric/Isochoric process ⇒ $\boxed{C_V = \frac{\Delta Q_V}{M\Delta T}}$ ⇒ sp. Heat at const. vol.
- Isobaric process ⇒ $\boxed{C_P = \frac{\Delta Q_P}{M\Delta T}}$ ⇒ sp. heat at const. press.
- Polytropic process ⇒ $\boxed{C = C_V + \frac{Pdv}{\mu dT}}$

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*NOTE → Solid & liquid has single value of sp. Heat but gas has ∞ value of sp. heat its value may be ⊕ve, ⊖ve or, ∞

* $\boxed{-\infty \le C_{gas} \le +\infty}$

A/R
Explain ⊖ve sp. heat of gas.

* If gas absorb Heat & Its temp ↓ sp. Heat of gas in this process is ⊖ve.

* ↑T due to expansion > T↑ due to Heat absorb.

* $\Delta T = ⊖ve$, $\Delta Q = ⊕ve$, * $C = \frac{\Delta Q}{M\Delta T} = ⊖ve$.

A/R
For gases $C_P > C_V$ Why.?

* At const press supplied Heat to change same temp for same quantity of gas is greater than from const. vol. process ~~process~~ bcoz Work is also perform at const. press.

* $\Delta Q_P > \Delta Q_V \Rightarrow \boxed{C_P > C_V}$

Relation b/w C_P & C_V.

|a| → If C_P & C_V Molar sp. Heat → $\left[\frac{cal}{mole\,°C}, J/mole\,°K\right]$

Mayer equation → AIEEE, PMT $\boxed{C_P - C_V = R}$ → same for all gases.

* R = gas const = 8.31 J/mole = 1.98 cal/mole K ≃ $2 \frac{cal}{mole\,°K}$

|b| → If C_P & C_V gm. Sp Heat → $\left[\frac{cal}{gm\,°C}, J/gm\,K\right]$

$$\boxed{C_P - C_V = R/MW}$$

Atomicity :→ Sp. heat of gas in a fix thermodynamics process ↑ with atomicity.

*

$$\boxed{\underbrace{f}_{\text{Degree of freedom}} = 3\underbrace{N}_{\text{No. of atom}} - \underbrace{B}_{\text{No. of BOND}}}$$

***

$$C_V = \frac{f}{2}R = \frac{R}{\gamma - 1}$$

$$C_P = C_V + R = \left(\frac{f}{2} + 1\right)R = \frac{\gamma R}{\gamma - 1}$$

γ = Sp. heat Ratio = $C_P/C_V = 1 + \frac{2}{f}$
or,
Adiabatic const.

$$\boxed{f = \frac{2}{\gamma - 1}} \;*$$

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Atomicity	$f = 3N - B$	$C_V = \frac{f}{2}R$	$C_P = \left(\frac{f}{2}+1\right)R$	$\gamma = C_P/C_V$
* Monoatomic Ex → He, Ne, Ar, Kr Rn, Xn	* $N = 1, B = 0$ $f = 3 \times 1 = 3$ $\boxed{f = 3}$	$C_V = \frac{3}{2}R$	* $C_P = \frac{5}{2}R$	* $\gamma = \frac{5}{3} = 1.67$
* Diatomic Eg → H_2, N_2, O_2, CO	* $N = 2, B = 1$ $f = 3 \times 2 - 1$ $\boxed{f = 5}$	$C_V = \frac{5}{2}R$	* $C_P = \frac{7}{2}R$	* $\gamma = \frac{7}{5} = 1.4$
* TRIATOMIC * Linear Eg → CO_2 $O=C=O$	* $N = 3, B = 2$ $f = 3 \times 3 - 2$ $\boxed{f = 7}$	* $C_V = \frac{7}{2}R$	$C_P = \frac{9}{2}R$	$\gamma = \frac{9}{7} = 1.285$
* Non-Linear Eg → O_3, * H_2O vapour or, H_2O	* $N = 3, B = 3$ $\boxed{f = 6}$	$C_V = 3R$	$C_P = 4R$	* $\gamma = 4/3 = 1.33$

*→ on ↑ atomicity, value of C_P & C_V ↑ & γ ↓.

$$\boxed{\begin{gathered}\gamma_{max} = 1.67 \text{ (Monoatomic)} \\ \gamma < \gamma \le 1.67\end{gathered}}$$

NOTE→ If shape of triatomic gas is not define, always consider non-linear

$$\left[\begin{aligned} &* \text{ At const press. } \Delta Q = MC_P\Delta T \text{ or, } \mu C_P \Delta T \\ &* \text{ At const vol. } \Delta Q = MC_V\Delta T \text{ or, } \mu C_V \Delta T\end{aligned}\right]$$

Gaseous Mix

(a) → Sp. heat of mix. at const vol.

$$(C_V)_{mix} = \frac{\mu_1 C_{V1} + \mu_2 C_{V2} + \cdots + \mu_N C_{VN}}{\mu_1 + \mu_2 + \cdots + \mu_N}$$

(b) → Sp. heat of mix at const. press.

$$(C_P)_{mix} = \frac{\mu_1 C_{P1} + \mu_2 C_{P2} + \cdots + \mu_N C_{PN}}{\mu_1 + \mu_2 + \cdots + \mu_N} = C_{Vmix} + R$$

|c| → Sp. heat Ratio of Mix

$$\gamma = \frac{(C_p)_{mix}}{(C_v)_{mix}} = \frac{\mu_1 C_{P1} + \mu_2 C_{P2} + \cdots\cdots \mu_N C_{PN}}{\mu_1 C_{V1} + \mu_2 C_{V2} + \cdots\cdots \mu_N C_{VN}}$$

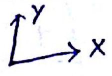
$$\boxed{\frac{\mu_1 + \mu_2 + \cdots \mu_N}{\gamma_{mix} - 1} = \frac{\mu_1}{\gamma_1 - 1} + \frac{\mu_2}{\gamma_2 - 1} + \cdots\cdots \frac{\mu_N}{\gamma_N - 1}}$$

NOTE →
- * Result of mix. found b/w Max & Min value.
- * If same atomicity gases mix in a same or, different amount result of mix remain same.

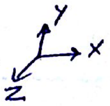
DEGREE OF FREEDOM [D.OF]

MOTION →
- Translational motion
- Rotational motion
- vibrational motion.

* Translational motion →
- If point object move in a st. line ⇒ $\boxed{f_t = 1}$ → X
- If point object move in a plane ⇒ $\boxed{f_t = 2}$ →



- If point object move in free space ⇒ $\boxed{f_t = 3}$ →

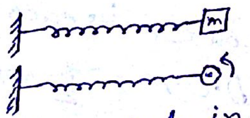


- If point object

* Rotational motion → f_r = No. of axis of Rotation

* vibrational motion → $f_r = 2 = 1(K.E) + 1(P.E)$

******
EX →
- |i| → particle projected vertically upward → D.O.F ⇒ 1
- |ii| → Particle projected at 'θ' from Horizontal → ⇒ 2
- * |iii| → e^- Rotate around nucleus → 3
  $\boxed{f_T = 3 = 2(t) + 1(r)}$
- |iv| →



  $f = 2(v)$
  $f = 3, (2v) + 1(r)$
- *|v| → coin rotate in a horizontal frictional surface.
  $f = 2 \Rightarrow 1(t) + 1(r)$

- (VI) → coin or, Wheal rotate at frictionless horizontal surface.
  $\boxed{f = 1(r)}$
- * |vii| → If coin or, Wheal placed at Inclined surface.
  - If friction Ⓟnt ⇒ $f = 2 = 1(r) + 1(t)$
  - If friction Ⓐnt ⇒ $f = 1(t)$
- *** |viii| → Kite or, butterfly or, Insect flying in a freespace → 3 (t)

D.O.F OF GAS

|a| → Monoatomic Eg → He, Ne, Ar, Kr, Xn, Rn

$N = 1, B = 0 \Rightarrow f_T = 3 \times 1 = 3$

f_T →
- $T_{trans} = 3$
- $f_{rotn} = 0$
- $f_{vib} = 0$

$\boxed{He}$

* $\boxed{R_{K.E} = \frac{1}{2} I\omega^2}$

NOTE→ * Rotational K·E of Monoatomic gas Molecule is zero that's why Rotational D·O·F is zero
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* vibrational energy transfer b/w gas Molecule due to bond which is not present in Monoatomic gas.

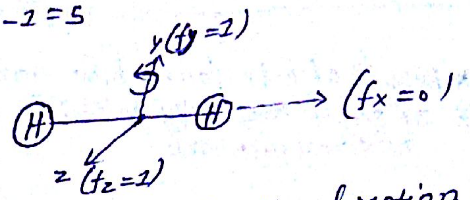
$$\boxed{R_{K\cdot E} = \frac{1}{2}I\omega = 10^{-44} J}$$

|b|→ Diatomic gas:→

Eg → H_2, N_2, O_2, CO

$N = 2, B = 1 \Rightarrow f_T = 3 \times 2 - 1 = 5$

$\boxed{f_T = 5}$
→ $f_{Trans} = 3$
→ $f_{rot} = 2$
→ $f_{vib} = 0$



NOTE→ Diatomic gas Molecule represent vibrational Motion at high temp.

*

High temp

$\boxed{f_T = 7}$
→ $f_T = 3$
→ $f_r = 2$
→ $f_v = 2$

|c|→ Triatomic gas:→

|i|→ Linear shape→

Eg → CO_2

$N = 3,\ B = 2 \Rightarrow \boxed{f_T = 7}$

$\boxed{f_T = 7}$
→ $f_t = 3$
→ $f_r = 3$
→ $f_v = 1$

|ii|→ Non-Linear shape/Polyatomic gas

Eg → O_3, H_2 vapour, NH_3 vapour

$N = 3,\ B = 3\ \boxed{f = 6}$

$\boxed{f_T = 6}$
→ $f_t = 3$
→ $f_r = 3$
→ $f_v = 0$

*

At High temp

$\boxed{f_T = 8}$
→ $f_t = 3$
→ $f_r = 3$
→ $f_v = 2$

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'MAXWELL'S ENERGY EQUIPARATION LAW' *

Total energy of gas molecule equally distribute in its each D·O·F. Energy of one molecule crossponding to single D·O·F $= \frac{1}{2}KT$

**

- * Energy of one molecule for 'f' D·O·F $= \frac{f}{2}KT$
- * Energy of one mole for 'f' D·O·F $= N_A\left(\frac{f}{2}KT\right) = N_A\left(\frac{f}{2}\frac{R}{N_A}T\right) = \boxed{\frac{f}{2}RT}$ *
- * Energy of one gm for 'f' D·O·F $= \frac{f}{2}\frac{RT}{M_W}$

$$\left[\begin{array}{l} K = \text{boltzman const} \\ K = \frac{R}{N_A} = 1.38 \times 10^{-23} J/K \end{array}\right]$$

**

- * Molar K·E (one mole) $= \frac{f}{R}RT$
- * Molecular K·E (one molecule) $= \frac{f}{2}KT$
- * gm K·E (one gm) $= \frac{f}{2}\frac{RT}{M_W}$
- * $E = \mu\left(\frac{f}{2}RT\right) = N\left(\frac{f}{2}KT\right) = m\left(\frac{f}{2}\frac{RT}{M_W}\right)$

* —

Avg./Mean/Total K·E

|i|→ Gas given = Total K·E
|ii|→ Gas NOT define = Translational K·E

3. TEMPERATURE

* Thermometry → not in syllabous (बच्चों के लिए रखा है!)

* Temp. scale → °C, K, F, R, Ra

R ← Reumer; Ra ← Rankine.

**

$$\boxed{\begin{array}{l} * \text{ U.F.P} = \text{B.P of } H_2O \rightarrow 100^\circ C / 373.15K / 212^\circ F / 80^\circ R / 672 Ra \\ * \text{ L.F.P} = \text{Freezing point} \rightarrow 0^\circ C / 273.15K / 32^\circ F / 0^\circ R / 460^\circ Ra. \end{array}}$$

|a| → No. of Division → U.F.P − L.F.P

$$\boxed{\begin{array}{ccccccccc} Ra & > & F & > & C & = & K & > & R \\ \downarrow & & \downarrow & & \downarrow & & \downarrow & & \downarrow \\ 212 & & 180^\circ & & 100 & & 100^\circ & & 80 \end{array}}$$

|b| → Reading of division $\propto \frac{1}{\text{no. of division}}$

$$\boxed{1^\circ \Delta Ra < 1 \Delta F < 1^\circ \Delta C = 1 \Delta K < 1^\circ \Delta R}$$

|c| → Numerical value of sp. heat in diff. temp scale.

$c = \frac{\Delta Q}{m \Delta T} = \text{const.}$

$$\boxed{c \propto \Delta Q \propto \Delta T}$$

$$\boxed{C_{Ra} < C_F < C_C \leftrightarrows C_K < C_R} \; *$$

Relation b/w Reading of temp. scale:

$\frac{L_1}{L_2} = \text{const}$ $\quad \frac{\text{Reading} - \text{L.F.P}}{\text{U.F.P} - \text{L.F.P}}$

Imaginary scale ↓

$$\frac{^\circ C - 0}{100^\circ - 0} = \frac{K - 273.15}{373.15 - 273.15} = \frac{F - 32}{212 - 32} = \frac{R - 0}{80 - 0} = \frac{Ra - 460}{672 - 460} = \frac{PMPsir - X}{Y - X}$$

*

$$\boxed{\frac{C}{100} = \frac{K - 273.15}{100} = \frac{F - 32}{180} = \frac{R}{80} = \frac{Ra - 460}{212} = \frac{PMPsir - X}{Y - X}}$$

$C = K - 273.15$

$K = C + 273.15$

Imp
- * $0^\circ C = 273.15\ K$
- * Tribble point of water $= 0.01^\circ C = \overset{*}{273.16} K$
- * $0^\circ K = -273.15 C$ (Absolute 0°c temp.

Relation b/w temp. diff

$$\boxed{\frac{\Delta C}{100} = \frac{\Delta K}{100} = \frac{\Delta F}{180} = \frac{\Delta R}{80} = \frac{\Delta Ra}{212} = \frac{\Delta PMPsir}{Y - X}}$$

$* \ \frac{\Delta C}{100} = \frac{\Delta K}{100} \Rightarrow \boxed{\Delta^\circ C = \Delta K}$ Eg ⇒ $\Delta T = 10^\circ C = 10^\circ K$

NOTE → Negative value of kelvin temp. scale is not possible.

HEAT CAPACITY / THERMAL CAPACITY

Require heat to change unit temp. of body.

$$\boxed{Hc = Mc = \frac{\Delta Q}{\Delta T}}$$

* unit → J/K (S.I), $\frac{cal}{c}$

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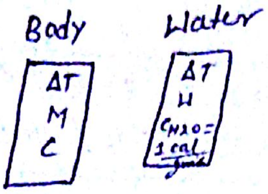
NOTE → Heat capacity & sp. heat depend on nature of material & its quantity it is Independent from supplied Heat & temp.

WATER EQUIVALENT (W)

Quantity of Water crossponding to same supplied heat to the body & H2O for same temp. change is called H2O equivalent of body.



$\Delta Q_{body} = \Delta Q_{Water}$

$Mc\Delta T = W(1)(\Delta T)$

$\boxed{W = Mc}$ → only for H2O

*unit → gm, kgm.

NOTE→ |i| → H2O equivalent & Heat capacity numerically same but unit is diff.

$Hc = W$

$\boxed{X\,\frac{cal}{c} = X\,gm}$

$y\,\frac{J}{c} = \frac{y}{4.2}\,\frac{cal}{c} = \frac{y}{4.2}\,gm$

$z\,\frac{kcal}{c} = z\,kgm$

|ii| → Heat for temp. change.

$\boxed{\Delta Q = Mc\Delta T = \Delta C\Delta T = W\Delta T}$

$\left[\begin{array}{l} gm = c/c = cal \\ kgm = c/K = kcal \end{array}\right]$

|iii| →

ΔT = Temp change

$\Delta Q_c = W\Delta T$

$\Delta Q_L = M_L C_L \Delta T$

$\boxed{\begin{array}{l}\Delta Q_{net} = \Delta Q_c + \Delta Q_L \\ = W\Delta T + M_L C_L \Delta T\end{array}}$

*Q. Excemplar

NOTE→ Sp. heat of coocking utilizer is low & thermal conductivity is high.

LATENT HEAT (L)

Require heat for phase conversion of unit quantity.

$\boxed{L = \frac{\Delta Q}{M}}$ *unit = $\frac{cal}{gm}$, J/kgm

Heat

|a| → temp. change $\Delta Q = Mc\Delta T$

|b| → phase conversion $\Delta Q = ML$

$\boxed{L = \frac{\Delta Q}{M}}$

Latent Heat of fusion (Lf)

Salid $\xrightarrow{\text{melting}}$ Liq.

Liq. $\xrightarrow{\text{Freezing}}$ Salid *

$\boxed{\begin{array}{l}\Delta Q_M = +M_S L_f \\ \Delta Q_F = -M_L L_f\end{array}}$

Latent Heat of vaporisation (Lv)

Liq. $\xrightarrow{\text{vaporisation}}$ vapour

vapour $\xrightarrow{\text{condensation}}$ Liq.

$\boxed{\begin{array}{l}\Delta Q_V = +M_L L_v \\ \Delta Q_C = -M_V L_v\end{array}}$

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NOTE→ *Latent heat of vaporisation is always greater than from Latent heat of fusion bcoz in vaporisation process maxm change take place in

I.M.D

*Sp. heat & Latent heat depend on atm. press/surrounding medium.

**

Standard

- Ice $\xrightarrow[c=\infty]{L_f}$ Water $\xrightarrow[c=\infty]{L_v}$ Stream
- $C_{Ice} = 0.5 \frac{cal}{gm^\circ c}$, $C_W = 1 gm/gm^\circ c$
- $C_{steam} = 0.47$ cal/gm°c
- 100°c steam is more painfull than 100°c boiling water boz it is extract extra ~~heat~~ amount of Heat which is equal to latent Heat.

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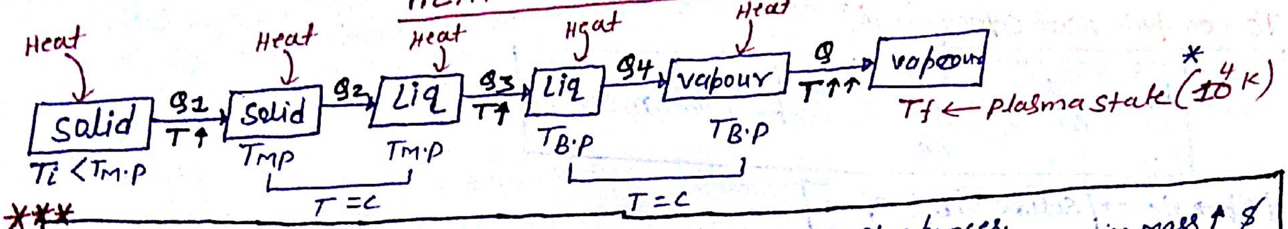
'HEATING CURVE'

(curve b/w temp. & heat in diff state of substance).



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NOTE→
- Mass converstion is applicable in phase conversion proces.
- A/c to Eienstein mass energy equivalent. If system absorb heat its mass ↑ & When Heat Release its mass ↓

AIIMS
EX→ If water freez or convert into ice A/c to Eienstein mass energy eqn mass of H2O → ↓

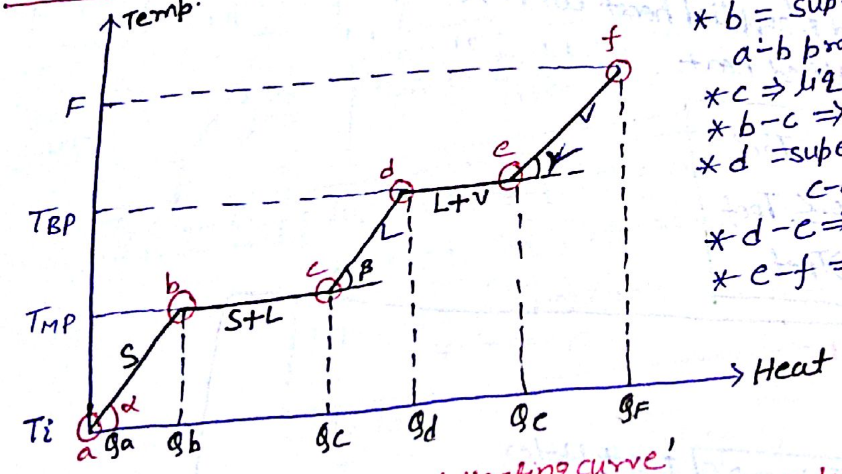
$$\boxed{E = mc^2}$$

$(1)(3\times10^8)^2 = 9\times10^{16} J$

$*m =$ part of mass wich is ~~convert~~ convert into energy.

NOTE→
- In a same state (solid, liq, gas) temp ↑ linearlly with supplied Heat.
- In phase converstion temp. remain same.

curve b/w temp. & Heat in diff state of substance called Heating curve.



- a = solid
- b = super heated solid
  a-b process ⇒ Heating of solid
- c ⇒ liq
- b-c ⇒ process → melting
- d = super heated liq.
  c-d ⇒ process → Heating of liq.
- d-e ⇒ process vaporisation
- e-f ⇒ process ⇒ Heating of vapour

'Application of Heating curve'

|1|→ To cal. or compair sp. heat of substance in diff state:

$$\boxed{c = \frac{\Delta Q}{M\Delta T} = \frac{1}{M\left(\frac{\Delta T}{\Delta Q}\right)}}$$

sp. heat $= \frac{1}{(\text{quantity})(\text{slope of Heating curve})}$

* $\boxed{\text{slope} = \tan\theta = dy/dx}$ ← angle tangent from ⊕ve X-axis.

* $\boxed{\tan\alpha > \tan\beta > \tan\gamma}$

* $\left[\left(\frac{\Delta T}{\Delta Q}\right)_{solid} > \left(\frac{\Delta T}{\Delta Q}\right)_{liq.} > \left(\frac{\Delta T}{\Delta Q}\right)_{vapour}\right]$

* $\boxed{C_{solid} < C_{liq} < C_{gas}}$

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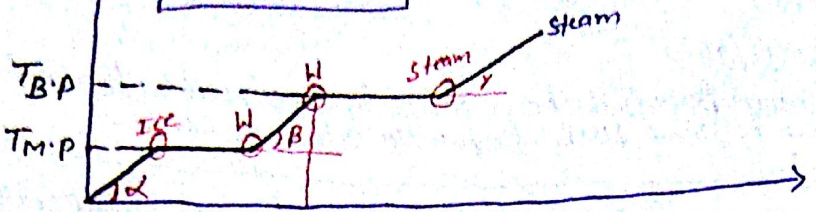
Exception

$C_{steam} < C_{Ice} < C_{Water}$

$\boxed{\gamma \text{ or } \gamma > \alpha > \beta}$



To compair Heat capacity in diff. state

$$\boxed{H_C = \frac{\Delta Q}{\Delta T} = \frac{1}{\frac{\Delta T}{\Delta Q}} = \frac{1}{\text{Slope of Heating curve}}}$$

|a| → H_C → $\boxed{\text{Solid} < \text{Liq.} < \text{vapour}}$

|b| → $\left(\frac{dT}{dQ}\right)_{melting} = 0 = \left(\frac{dT}{dQ}\right)_{vaporisation}$.

*** [Sp. heat & ~~Heat~~ Heat capacity
Melting point = vaporisation = ∞ ← Not define → Latent Heat]

When Diff phase substance Mix in a calorimetry

[Ice + Water, Ice + Steam, Water + Steam] in a given phase.

Step-I → Draw heating curve b/w minm & maxm temp.

Step-II → Assume Reference point.

Ice + Water ⇒ Ref = 0°C Water.

Tref → Ice + steam / Water + steam ⇒ Tref = 100°C H_2O.

same

Step III → calculate Required & supplied heat w.r.to reference point.

Step IV → cal. Required & supplied heat ,, ,, ,, ,,

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$$\boxed{\begin{aligned} Q_R &= Q_S \Rightarrow T_f = T_{Ref} \\ Q_R &> Q_S \Rightarrow T_f \le T_{Ref} \\ Q_R &< Q_S \Rightarrow T_f \geq T_{Ref} \end{aligned}}$$

**** Trick

Mix. in a same amount :

Case-I → Ice + Water
0°C TW

|a| → $0 < T_W < 80°C \Rightarrow \boxed{T_{mix} = 0°C}$ Ice + Water

|b| → $T_W = 80°C \Rightarrow \boxed{T_{mix} = 0°C}$ → only for H_2O.

|c| → $80°C < T_W \le 100°C \Rightarrow \boxed{T_{mix} > 0°C} \Rightarrow \boxed{T_{mix} = \frac{Q_{Remain}}{M_{mix}}}$

Case-II → Ice + Steam / Water + Steam

$\boxed{T_S = 100} \Rightarrow \boxed{T_{mix} = 100°C}$

***

For different amount

* $T_{Mix} = \frac{M_W C_W T_W - M_{ice} L_f}{M_W C_W + M_{Ice} C_W}$

* $T_{Mix} < 0°C \Rightarrow T_{Mix} = 0°C$

* $M_{ice} = M_W$

For same Amount.

$$\boxed{T_{Mix} = \frac{T_W - 80}{2}}$$

[POC]

'PRINCIPLE OF CALORIMETRY'

When two body comes in contact heat tranfer takes place from High temp. body to Low body temp. till the temp. are equalised. In this process high temp. body losses its heat & low temp. body gain. Magnitude of Heat loss is equal to magnitude of Heat gain is called principle of calorimetry.

$$\boxed{|\text{Heat loss}| = |\text{Heat gain}|}$$

Assumption of POC

When two body comes in contact there is no heat transfer take place from conduction, convection & radiation & any other method. (chemical RKN)

*→ NOTE → Energy conservation is Applicable of P.O.C.

Application of POC *

[1] → To calculate final temp. of Mix →

in calorimetry.

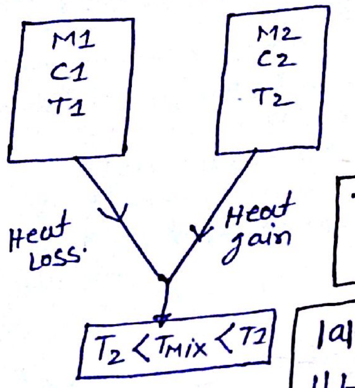
CaseI → same phase substance Mix.

Eg → S+S, L+L, G+G

$|\text{Heat gain}| = M_2 C_2 (T_{Mix} - T_2)$

$|\text{Heat loss}| = M_1 C_1 (T_1 - T_{Mix})$

$$\boxed{|\text{Heat gain}| = |\text{Heat Loss}|}$$



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$$\boxed{T_{Mix} = \frac{M_1 C_1 T_1 + M_2 C_2 T_2}{M_1 C_1 + M_2 C_2} \text{ or, } \frac{\mu_1 C_1 T_1 + \mu_2 C_2 T_2}{\mu_1 C_1 + \mu_2 C_2}}$$

***

[a] → $C_1 \neq C_2$, $M_1 = M_2 \Rightarrow T_{Mix} = \frac{C_1 T_1 + C_2 T_2}{C_1 + C_2}$

[b] → $C_1 = C_2$, $M_1 \neq M_2 \Rightarrow T_{Mix} = \frac{M_1 T_1 + M_2 T_2}{M_1 + M_2}$

[c] → $C_1 = C_2$, $M_1 = M_2 \Rightarrow T_{Mix} = \frac{T_1 + T_2}{2} \Leftarrow T_{avg}$.

HC = same

only for Gas

$$T_{Mix} = \frac{\mu_1 C_{V1} T_1 + \mu_2 C_{V2} T_2}{\mu_1 C_{V1} + \mu_2 C_{V2}}$$

$$T_{mix} = \frac{\mu_1 f_1 T_1 + \mu_1 f_2 T_2}{\mu_1 f_1 + \mu_2 f_2}$$

$C_V = \frac{f}{2} R$

$C_{V1} = \frac{f_1}{2} R$

$C_{V2} = \frac{f_2}{2} R$

**

same phase *

$$T_{min} < T_{Mix} < T_{max}$$

$$T_{mix} \neq T_{max}$$

$$T_{mix} \neq T_{min}$$

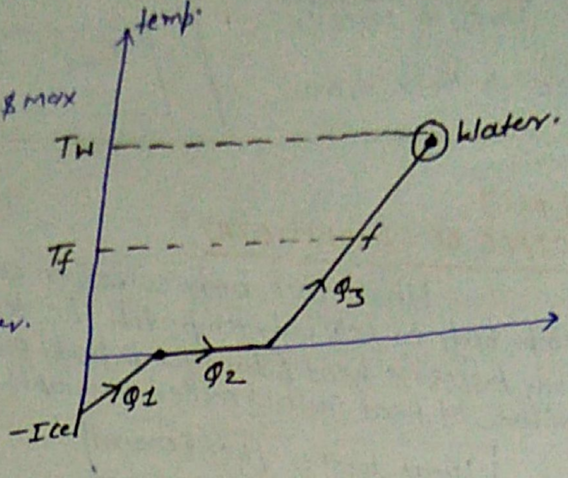
****** NOTE → * When same substance mix in a calorimetry final temp. of mix is always b/w minm & max temp.

* It is not equal to minm & maxm temp.

caseII → Diff. phase substance Mix in a calorimetry

Ice + Water, Water + steam, Ice + steam.

Ex → Ice + Water.



StepI → Draw heating curve b/w min & max temp in a given phase.

StepII → Assume Reference point temp.

Treference → | Ice + Water ⇒ 0°C Water
Ice + Steam ⇒] ⇒ 100°C Water.
Water + Steam ⇒]

StepIII → calculate amount of supplied LatentHeat & Require Latent Heat to reference point temp.

StepIV → (a) → $q_R = q_S = \boxed{T_f = T_{reference}}$
(b) → $q_R > q_S \Rightarrow \boxed{T_f \leq T_{ref}}$
(c) → $q_R < q_S \Rightarrow \boxed{T_f \geq T_{ref}}$

$$\text{Heat gain} = q_1 + q_2 + q_3$$
$$= M_{ice} C_{ice}[0-(-T_{ice})] + M_{ice} L_f + M_{ice} C_w (T_f = 0)$$

$$|\text{Heat Loss}| = M_w c_w (T_w - T_f)$$

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$$\boxed{T_f = \frac{M_w C_w T_w + M_{ice} C_{ice}(-T_{ice}) - M_{ice} L_f}{M_w C_w + M_{ice} C_w}}$$

(i) → $T_f < 0°C$ (⊖ve) ⇒ (Ice + Water) ($T_f = 0°C$)
(ii) → $T_f = 0°C$ ⇒ only Water
(iii) → $T_f > 0°C$ (only Water)

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(a) → $T_f = \dfrac{M_w T_w - 0.5\, ice\, T_{ice} - 80\, M_{ice}}{M_w + M_{ice}}$

(b) → $M_w = M_{ice}$

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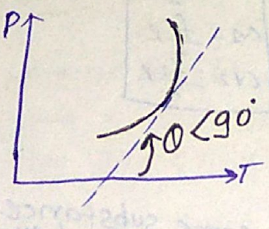
$T_f = \dfrac{M_w T_w - 80\, M_{ice}}{M_w + M_w}$

(c) → $T_{ice} = 0°C$ $\boxed{T_f = \left(T_w - \frac{80}{2}\right)}$
$M_w = M_{ice}$

(i) → $< T_w < 80° \Rightarrow \boxed{T_f = 0°}$ (Ice + Water)
(ii) → $T_w = 80°C \Rightarrow \boxed{T_f = 0°C}$ (only water)
(iii) → $80° \leq T_w < 100°C \Rightarrow \boxed{T_f = 0°C}$ (only Water)

Phase Indicating curve or, P-T curve

*→



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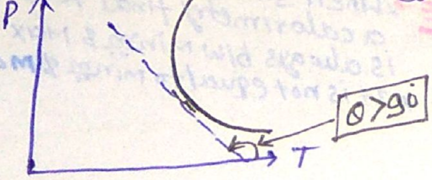
$\dfrac{dp}{dt}$ = slope = m = tan θ = ⊕ve.

* dp = ⊕ve ⇒ dT = ⊕ve ⇒ P↑ ⇒ T↑ (M.P/B.P↑)
* dp = ⊖ve ⇒ dT = ⊖ve ⇒ P↓ ⇒ T↓ (MP/B.P↓)

*→



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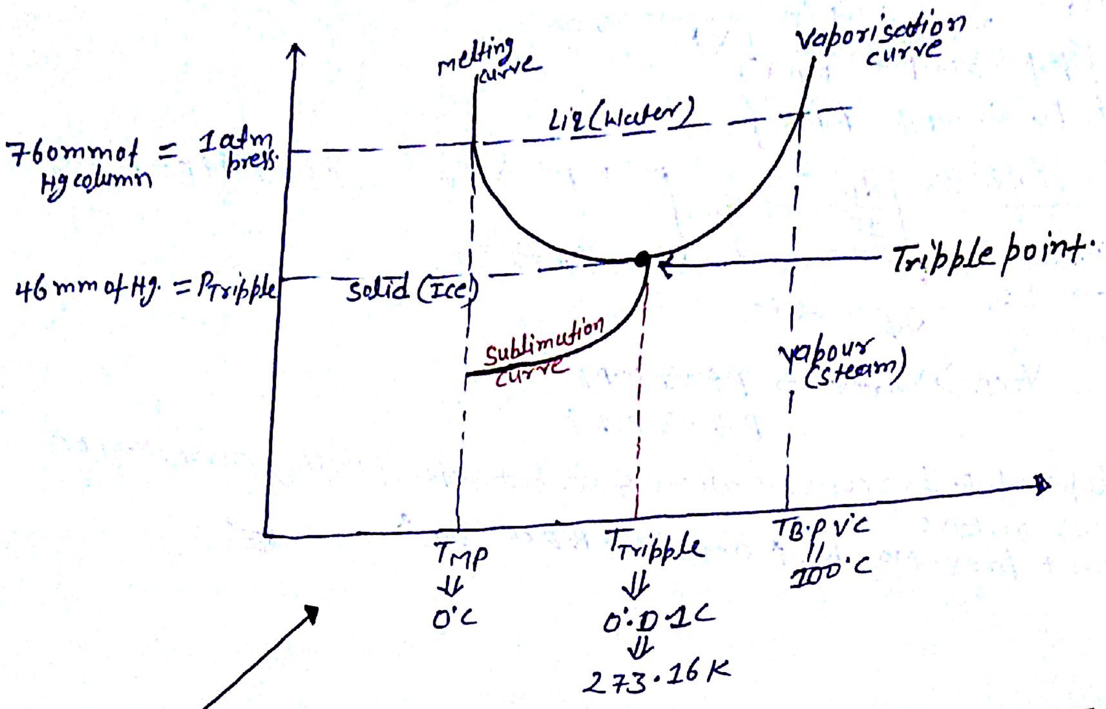
slope = $\dfrac{dp}{dt}$ = tan θ = ⊖ve ← θ>90°

* dp = ⊕ve ⇒ dT ⇒ ⊖ve ⇒ P↑ ⇒ T↓ (MP/BP↓)
* dp = ⊖ve ⇒ dT ⇒ ⊕ve ⇒ P↓ ⇒ T↑ (MP/BP↑)

→ P-T curve of Ice - Water - Steam



P-T curve of H2O

***** AIIMS A/R

$\#\left(\frac{dp}{dt}\right)_{melting} = \ominus ve$ — P↑ ⇒ M.P↓ ; P↓ ⇒ M.P↑

- $P > 1\,atm \Rightarrow T_{M.P} < 0°C$
- $P < 1\,atm \Rightarrow T_{M.P} > 0°C$

$\#\left(\frac{dp}{dt}\right)_{vaporisation} = \oplus ve$ — P↑ ⇒ B.P↑ ; P↓ ⇒ B.P↓

- $P > 1\,atm \Rightarrow T_{B.P} > 100°C$
- $P < 1\,atm \Rightarrow T_{B.P} < 100°C$

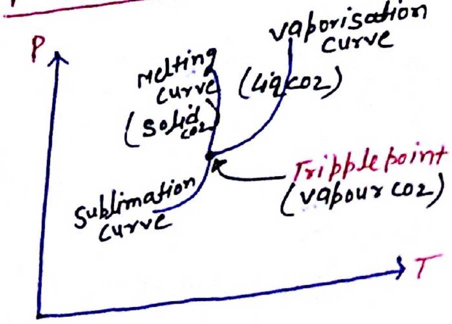
*** A/R

EX → * At surface of moon due to low press. 0°C Ice direct sublimate in vapour & Water at 30°C vaporised bcoz due to low press.

* AT Mountain due to low press. M.P of Ice ↑ & B.P of Water ↓se.

* In a press. cooker due to high press B.P of Water become 3 times (300°C to 400°C) becomes more than B.P of H2O.

P-T curve of CO2



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$*\left(\frac{dp}{dt}\right)_{melting} = \oplus ve$ — P↑ ⇒ M.P↑ ; P↓ ⇒ MP↓

$*\left(\frac{dp}{dt}\right)_{vaporisation} = \oplus ve$ — P↑ ⇒ B.P↑ ; P↓ ⇒ B.P↓

* V↑ ⇒ P↓ ⇒ T↑
* V↓ ⇒ P↑ ⇒ T↓

CLASSIOUS FORMULA

$$\boxed{\frac{dp}{dT} = \frac{L}{T(V_f - V_i)}}$$

$$\boxed{\left(\frac{dp}{dT}\right)_{vaporisation} = \frac{L_V}{T_{B.P}(V_f - V_i)}}$$

$$\boxed{\left(\frac{dp}{dT}\right)_{melting} = \frac{L_f}{T_{MP}(V_f - V_i)}}$$

|a|→ $\underline{V_f > V_i} \Rightarrow \boxed{\frac{dp}{dT} = \oplus ve}$ $\begin{bmatrix} P\uparrow \Rightarrow T\uparrow \\ P\downarrow \Rightarrow T\downarrow \end{bmatrix}$

Ex→ solid $\xrightarrow[V\uparrow]{}$ Liquid $\xrightarrow[V\uparrow]{}$ vapour

$\begin{bmatrix} P\uparrow \Rightarrow M.P\uparrow,\ B.P\uparrow \\ P\downarrow \Rightarrow M.P\downarrow,\ B.P\downarrow \end{bmatrix}$

|b|→ $\underline{V_f < V_i\ (V\downarrow)} \Rightarrow \boxed{\frac{dp}{dT} = \ominus ve}$ → $P\uparrow \Rightarrow T\downarrow$; → $P\downarrow \Rightarrow T\uparrow$

Eg → Rubber, plastic.

Ex→ Ice $\xrightarrow[V\downarrow]{}$ Water

$V_{Ice} > V_{Water} \Rightarrow P\uparrow \Rightarrow M.P\downarrow$
$P\downarrow \Rightarrow M.P\uparrow$

NOTE→ * slope of Boiling curve is always ⊕ve but slope of melting curve may be ⊕ve or, ⊖ve.

* on ↑ press. may be ↑ or ↓ but B.p always ↑.