PHYSICS

(Heat)

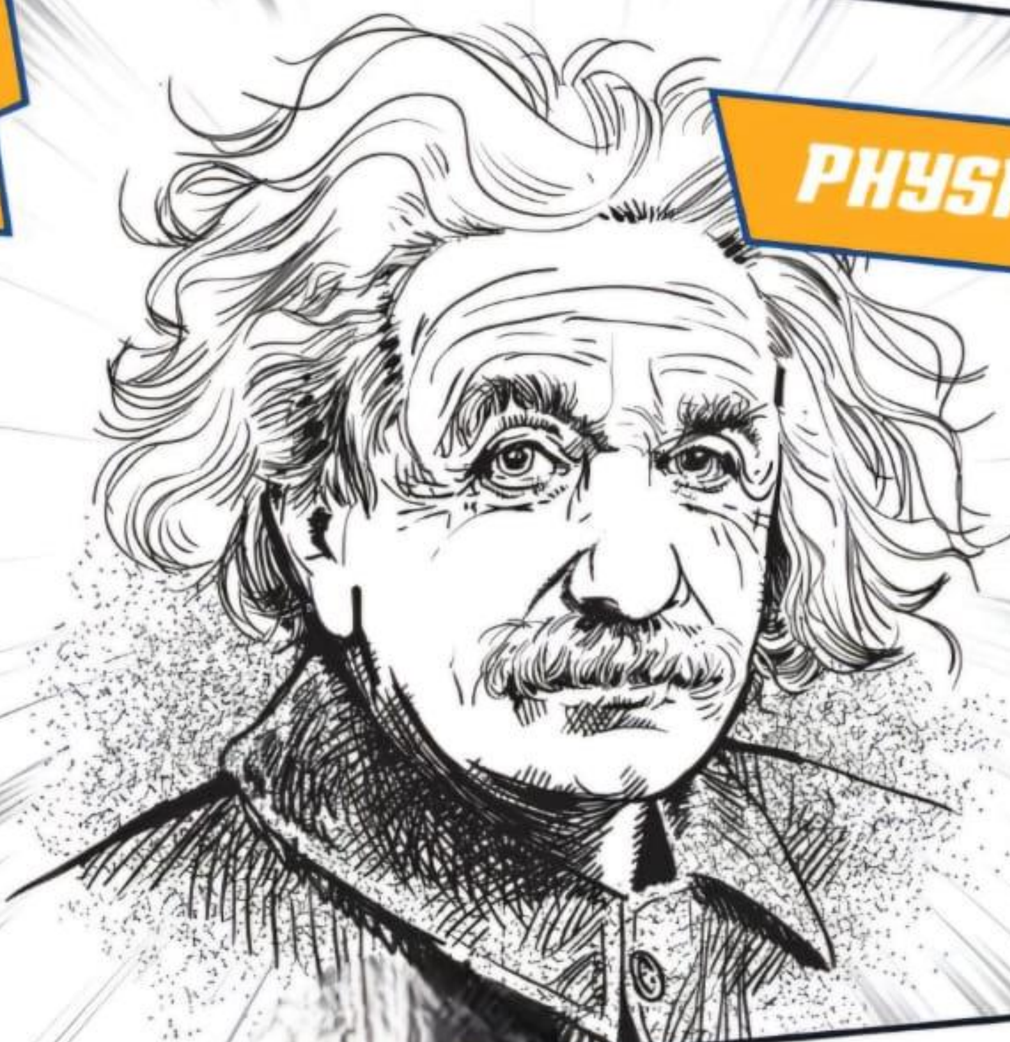
Thermodynamics

2024

NO. 6

1ST YEAR

PHYSICS DEP.



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Whatsapp & Group

HI MARVEL, WE HAVE SUPER HEROS TO

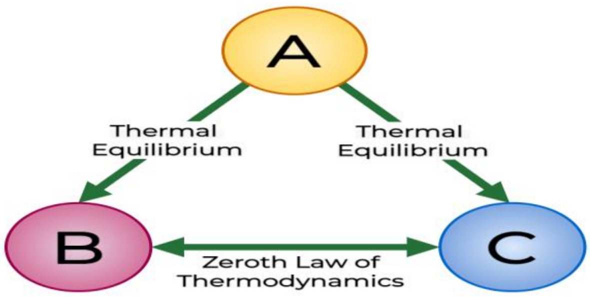
Thermodynamics

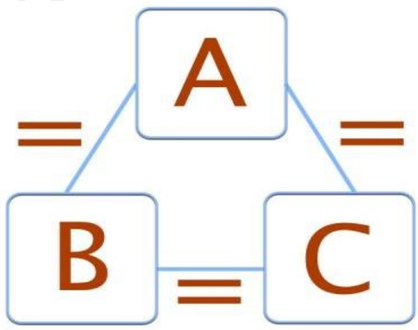
Zero law of Thermodynamics:

"If two systems are each in thermal equilibrium with a third system, then they are in thermal equilibrium with each other."

"إذا كان نظامان منفصلان في حالة توازن حراري مع نظام ثالث، فهذا يعني أن النظامين لهما نفس درجة الحرارة، وبالتالي يكونان أيضًا في حالة توازن حراري مع بعضهما البعض(النظام الثالث)

Thermal Equilibrium: Two systems are in thermal equilibrium if there is no net flow of heat between them when they are in contact.





First law of Thermodynamics:

- "Energy cannot be created or destroyed; it can only be transformed from one form to another or transferred between a system and its surroundings."

"الطاقة لا تُخلق ولا تُفنى، ولكن تتحول من شكل لآخر أو تنتقل بين النظام والمحيط."

$$\boxed{dH = dE + dW}$$

Change Thermal Energy (cal) | change in internal energy **dEαT** | Change in work

- $\because dH = m\,C_p dT$ $\Rightarrow$ Amount of heat Added At Const Pressure
- $\because dE = m\,C_V dT$ $\Rightarrow$ Change in in Ternal Energy
- $\because dW = P.dV$ $\Rightarrow$ Work done by using first law of Thermodynamics

Heat Capacity (C):

- Amount of heat needed to raise Temperature one degree.

1- Heat Capacity at Const volume (C_v)

✓ the amount of heat required to raise the temperature of a system by one degree, while keeping the volume constant.

2- Heat Capacity at Const Pressure (C_p)

✓ the amount of heat required to raise the temperature of a system by one degree while keeping the pressure constant.

Relation between Mechanical and Thermal Energy:

"Amount of Thermal energy (H) Proportional to The Work done"

$$\therefore W \alpha H$$

$$\boxed{\therefore W = JH}$$

J ⟶ Mechanical equivalent of heat (J/Calorie)

① Isochoric Change:

- dW is Positive This mean work done by gas and gas expand
- dW is Negative This mean work done on gas and Volume of gas decrease
- Isochore change occurs when $V = Const$ $dW = 0$

$$\boxed{\therefore\ dH = dE}$$

② Isothermal Change:

- If Temperature increase $\longrightarrow dE$ is Positive
- If Temperature decrease $\longrightarrow dE$ is Negative
- If Temperature remain Const $\longrightarrow dE = 0$ and change Called Isothermal

$$\boxed{\therefore\ dH = dW}$$

③ Adiabatic Change:

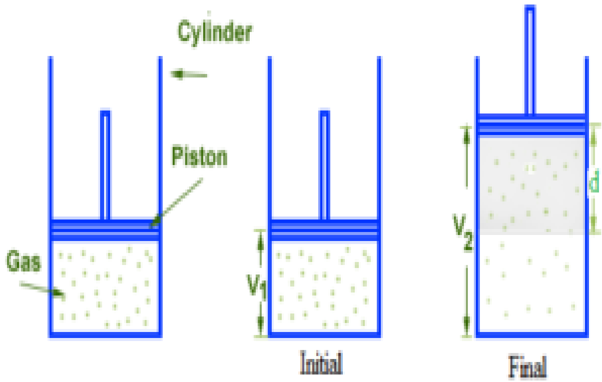
- If dH is Positive This means gas Endothermic
- If dH is Negative This mean That gas exothermic
- If dH is Zero. This mean The Heat energy is Const and This Change is adiabatic Change.

▶ $dH = 0$ $0 = dE + dW$

$$\boxed{\therefore\ -dE = dW}$$

Work done during gas Expansion:

suppose That Amount of gas Placed inside Cylinder Fitted with frictionless Piston of Area (A) if gas expand it will do Work done on Piston and move it by distance dx



$\because dw = F.dx$

$\because F = P.A$

$\therefore dw = PAdx$

$\because dV = P.dx$

$$\therefore dw = P.dV \quad \Rightarrow \quad W = \int_{V_1}^{V_2} P.dv = P.(V_2 - V_1)$$

① Isochoric Change:

- dW is Positive This mean work done by gas and gas expand
- dW is Negative This mean work done on gas and Volume of gas decrease
- Isochore change occurs when $V = Const$ $\quad dW = 0$

$$\therefore dH = dE$$

Eternal energy of ideal gas:

$$\because dH = dE + dW$$

- At Const volume $dH = mC_V dT$, $dw = 0$

$\therefore mC_V dT = dE + 0$

$\therefore dE = mC_V dT$

$\therefore E = \int mC_V dT$

$E = mC_V T + Const$

$if \Rightarrow T = 0$

$\therefore E = 0$

$$\boxed{\therefore E = mC_V T}$$

② Isothermal Change:

- If Temperature increase $\longrightarrow dE$ is Positive (Heating)
- If Temperature decrease $\longrightarrow dE$ is Negative (Cooling)
- If Temperature remain Const $\longrightarrow dE = 0$ and change Called Isothermal

$$\boxed{\therefore dH = dW}$$

Relation between C_v & C_p

- $\because dH = mC_p dT$ $\Rightarrow$ Amount of heat Added At Const Pressure
- $\because dE = mC_V dT$ $\Rightarrow$ Change in in Ternal Energy
- $\because dW = P.dV$ $\Rightarrow$ Work done by using first law of Thermodynamics

$$dH = dE + dw$$

$$\therefore mC_p dT = mC_v dT + \frac{P.dv}{J}$$

$\because$ *From ideal gas Law* $\quad PV = mRT \quad\quad \therefore PdV = mRdT$

$$\therefore mC_p dT = mC_v dT + \frac{mRdT}{J}$$

$$\boxed{\therefore \boldsymbol{C_p = C_v + \frac{R}{J}} \quad \Rightarrow \quad \boldsymbol{C_p - C_v = \frac{R}{J}}}$$

- All of Them by $\frac{Cal}{g.cm}$

Ratio between C_v & C_p

$$\because C_p - C_v = \frac{R}{J} \qquad \div \boldsymbol{C_v}$$

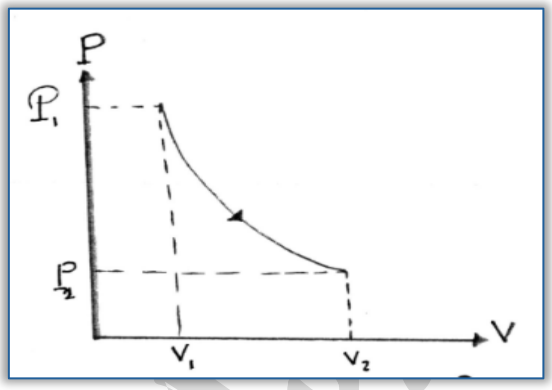
$$\therefore \frac{C_p}{C_v} - 1 = \frac{R}{JC_v}$$

$$\because \gamma = \frac{C_p}{C_v} \gg 1 \ \ beCause\ C_p > C_v$$

$$\boxed{\therefore \gamma - 1 = \frac{R}{JC_v} \quad \Rightarrow \quad \gamma = 1 + \frac{R}{JC_v}}$$

dynamics of ideal gas at Const "T"

IF ideal gas expands at Const Temperature ($dE = 0$) The Volume increase From V_1 to V_2 and Pressure decrease From P_1 to P_2



$$\because T = Const \qquad \therefore PV = const \qquad \therefore P = \frac{const}{V}$$

$$\because W = \int_{V_1}^{V_2} P.dv = \int_{V_1}^{V_2} \frac{C}{V} dV = C \int_{V_1}^{V_2} \frac{dV}{V} = C \ ln \frac{V_2}{V_1} = C \ Ln \frac{P_1}{P_2}$$

$$\because C = P_1 V_1 = P_2 V_2 = mRT$$

$$\boxed{\therefore w = P_1 V_1 \ln \frac{\boldsymbol{V_2}}{\boldsymbol{V_1}} = P_2 V_2 \ln \frac{\boldsymbol{V_2}}{\boldsymbol{V_1}} = mRT \ln \frac{\boldsymbol{V_2}}{\boldsymbol{V_1}}}$$

▶ **Change in internal Energy** $\Rightarrow$ $T = const$ $\qquad \therefore dE = 0$

$$\boxed{\therefore dH = dw \rightarrow H = \frac{W}{J}}$$

Any heat added equal Work done.

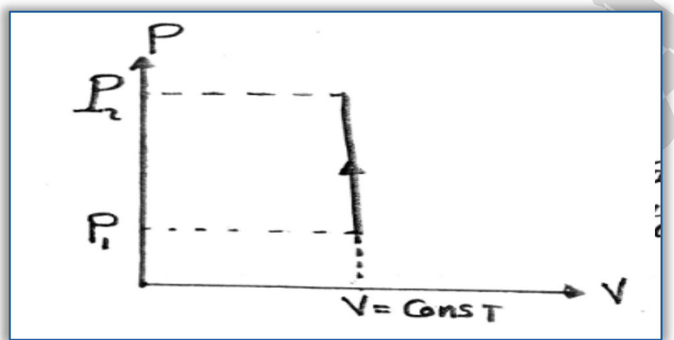
Dynamics of ideal gas at Const Volume ($V = const$)

$\because V = Const \quad \therefore dW = 0 \quad \Rightarrow$ From I^{st} law $\Rightarrow dH = dE + 0$

As Temperature Change from T_1 to T_2

- **Change in internal Energy:** $dE = mC_v(T_2 - T_1)$

$\because dH = dE + dw \qquad \because dw = 0 \qquad \therefore dH = dE = mC_v(T_2 - T_1)$



Example

Amount of air Volume 0.4 m^3 and Pressure $5kg/cm^2$ allowed Them to expand At Const Temp. droped Compressed until it becomes $1kg/cm^2$ Calculate The work done.

Solution

$V_1 = 0.4m^3$, $P_1 = 5\ kg/cm^2 = 5 * 10^4\ kg/m^2$, $P_2 = 1kg / cm^2 = 10^4\ kg/m^2$

$$\because w = C\ ln\frac{V_2}{V_1} = P_1V_1 \ln\frac{P_1}{P_2}$$

$$\therefore W = 5 * 10^4 * 0.4\ \ln 5 = 3.21 * 10^4\ kg.m$$

Example

Amount of air mass $1kg$ and Temperature $40°c$ Put under Pressure so Tremains const rising Pressure of $1.5\ kg/cm^2$ to $6kg/cm^2$ Calculate the Amount of heat lost

$C_V = 0.17\ Cal/g.c$, $C_P = 0.24Cal/g.c$, $J = 428.6$

Solution

$$C_p - C_v = \frac{R}{J} \qquad \therefore R = J(C_P - C_V)$$

$$= 428.6(0.24 - 0.17) = 30kg.m/k$$

$$\therefore W = mRT\ Ln\frac{P_1}{P_2} = 1 * 30 * 313\ ln\ \frac{1.5}{6} = -1.3\ X\ 10^4\ Kg.cm^2$$

$$\therefore \text{The Amount of heat equi volent} \Rightarrow \quad H = \frac{W}{J} = \frac{-1.3 \times 10^4}{428.6}$$

$$= -40.3\ \text{Kcal}$$