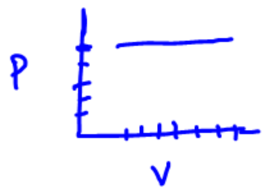
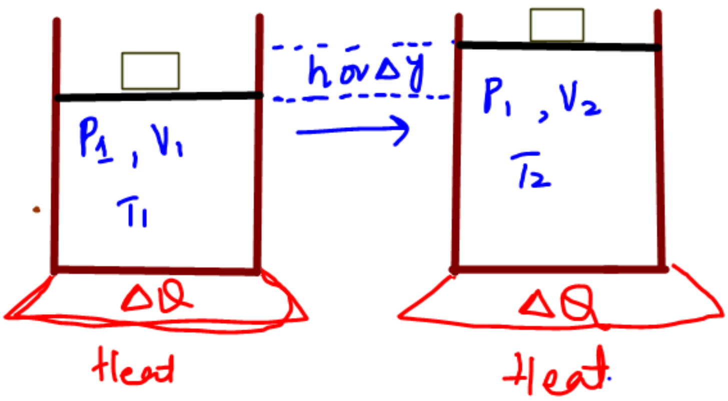
Lecture (4) Heat

Applications of 1st Law of Thermodynamics :-

1) Isobaric Process :-

"In which pressure of the system remains constant." Charles Law can be used.





U_1 to U_2 So, $\Delta U = U_2 - U_1$

V_1 to V_2 So, $\Delta V = V_2 - V_1$

ΔW = force × displacement

and $P = F/A \rightarrow F = PA$

So, $\Delta W = PA\Delta y$

$$\boxed{\Delta W = P\Delta V} \quad \text{—(1)}$$

$\left[\begin{array}{l} A = m^2 \\ L = m \\ V = m^3 \\ \quad L \times L \times L \end{array} \right]$

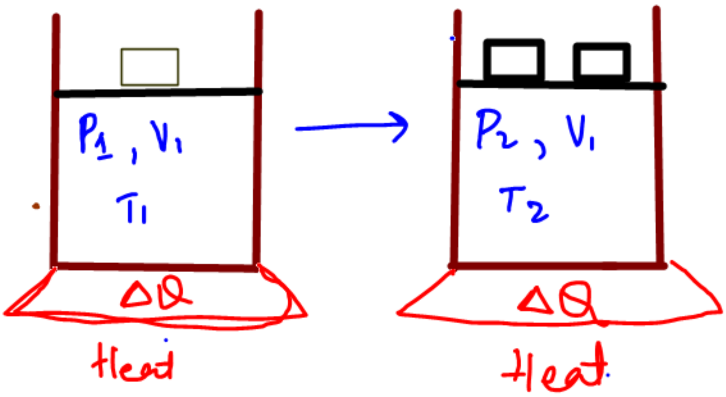
According to 1st Law of thermodynamics

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

eq (1) ⇒ $\boxed{\Delta Q = \Delta U + P\Delta V}$

2) Isochoric Process:-

"In which the volume of the system remains constant". We can use Pressure Law:



U_1 to $U_2 \longrightarrow \Delta U = U_2 - U_1$

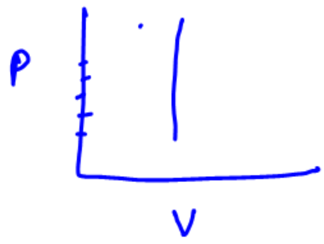
Since volume is constant $\longrightarrow \Delta V = 0$

So, $\Delta W = 0$

According to 1st Law of thermodynamics

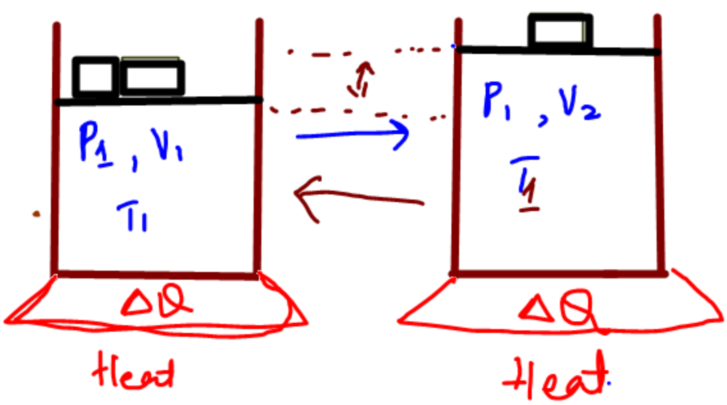
$$\Delta Q = \Delta U + \cancel{\Delta W}^{0}$$

$$\boxed{\Delta Q = \Delta U}$$



3) Isothermal Process:-

"In which the temperature remains constant". We can use Boyle's Law.



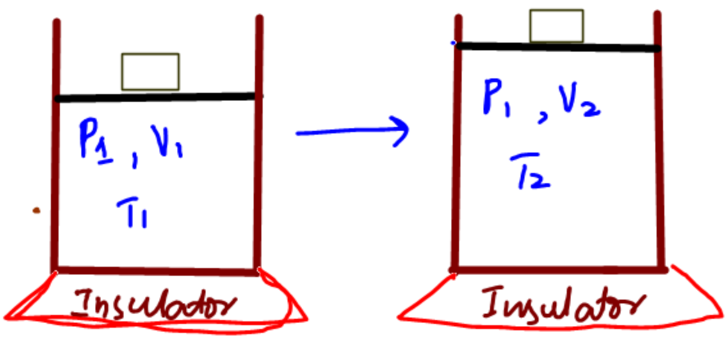
$u_2 = u_1 \longrightarrow \Delta u = 0$

According to 1st Law of Thermodynamics

$$\Delta Q = \Delta U + \Delta W$$
$$= 0 + \Delta W$$
$$\boxed{\Delta Q = \Delta W}$$

4) Adiabatic Process :-

"In which system has no surroundings that is no heat can flow in or out of the system."



Since, $\Delta Q = 0$ but work is done due to change in temperature because of the insulator

According to First Law of Thermodynamics

$$\Delta Q = \Delta U + \Delta W$$
$$0 = \Delta U + \Delta W$$
$$\boxed{-\Delta U = \Delta W}$$

2nd Law of Thermodynamics

1) Kelvin's Statement

"It is impossible to drive a continuous supply of work by cooling a body temperature lower than the coldest of its surroundings".

2) Clausius Statement :-

"It is impossible to cause heat to flow from cold body to hot body without doing any work".

Equivalence of Kelvin & Clausius

Suppose kelvin statement is false, that it is possible to construct an engine which takes heat from the source and converts it completely into work and rejects no heat to the sink: It means the source is capable to do work by itself. Thus it will extract heat from the cold body, which provides basis of such a refrigerator which transfers heat from cold body to hot body without the expenditure of energy which is contrary to the clausius statement.

Carnot Engine ~

Efficiency = $\frac{\text{Work done}}{\text{Heat absorbed}}$

1) $E = \left(1 - \frac{Q_2}{Q_1}\right) \times 100$

2) $E = \left(1 - \frac{T_2}{T_1}\right) \times 100$

Entropy ~

$$\Delta S = \frac{\Delta Q}{T} \quad \text{unit } J/K$$

Numericals (Chap 11)

Prob 11.1 |-

The normal human body Temp is 98.4°F. What is the temp on Celsius Scale?

Sol

$$T°C = \frac{5}{9}(T°F - 32)$$

$$= \frac{5}{9}(98.4 - 32)$$

$$= \frac{5}{9}(66.4)$$

$$\boxed{T°C = 36.88°C}$$

(wed)

11.2 – A steel rod of length exactly 0.2 cm at −2.5°C. What will be the change in length at 25°C.
(β for steel = 3.3×10^{-8} K)

Sol

$L_1 = 0.2$ cm $\quad \Delta L = ?$

$T_1 = -2.5$ °C $\quad \alpha = ?$

$T_2 = 25$ °C

$\Delta T = T_2 - T_1 = 25 - (-2.5)$

$\boxed{\Delta T = 27.5}$ °C

$\beta = 3\alpha$

$\beta = 3(3.3 \times 10^{-8})$

$\boxed{\beta = 9.9 \times 10^{-8}\ K^{-1}}$

For Linear Expansion

$L_2 = L_1(1 + \alpha\Delta T)$

$L_2 = L_1 + L_1\alpha\Delta T$

$L_2 - L_1 = L_1\alpha\Delta T$

$\Delta L = L_1\alpha\Delta T$

$= (0.2)(9.9 \times 10^{-8})(27.5)$

$\boxed{\Delta L = 54.45 \times 10^{-8}\ \text{cm}}$