BRAIN MAP

CLASS XI

THERMODYNAMICS

THERMODYNAMICS

Laws of Thermodynamics

Thermal Equilibrium
The macroscopic variables such as pressure, temperature, volume, mass, composition, etc., which characterize a system, do not change with time.

Zeroth Law
Two systems in thermal equilibrium with a third system separately are in thermal equilibrium with each other.

First Law
Heat supplied to a gas may
(i) raise its internal energy
(ii) enable it to expand and thereby do external work. $dQ = dU + dW$

Second Law
There is no heat engine can have efficiency η equal to 1 or no refrigerator can have coefficient of performance is equal to infinity.

Carnot's Cycle
Isothermal expansion:

$$W_1 = \mu R T_1 \log_e \frac{V_2}{V_1}$$

Adiabatic expansion:

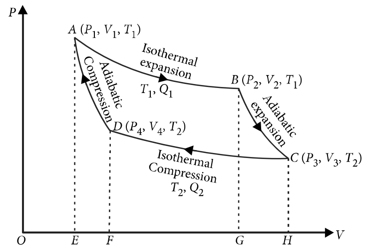
$$W_2 = \mu \frac{R(T_1 - T_2)}{\gamma - 1}$$

Isothermal compression:

$$W_3 = \mu R T_2 \log_e \frac{V_3}{V_4}$$

Adiabatic compression:

$$W_4 = \mu \frac{R(T_1 - T_2)}{\gamma - 1}$$



Net work done during the complete cycle,

$$W = W_1 + W_2 + (-W_3) + (-W_4)$$
$$= W_1 - W_3 = \text{Area ABCD}$$
$$(\text{As } W_2 = W_4)$$

Efficiency, $\eta = \dfrac{\text{Work done}}{\text{Heat input}} = \dfrac{W}{Q_1}$

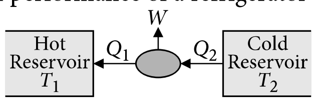
$$\eta = 1 - \frac{Q_2}{Q_1} = \frac{W}{Q_1}$$

Specific Heat Capacity
$\Delta Q = ms\Delta T = ms(T_f - T_i)$ or $s = \dfrac{\Delta Q}{m\Delta T}$

Molar specific heat capacity, $C = \dfrac{1}{\mu}\left(\dfrac{\Delta Q}{\Delta T}\right)$

Refrigerator
The coefficient of performance of a refrigerator is ;

$$\alpha = \frac{Q_2}{W} = \frac{Q_2}{Q_1 - Q_2}$$

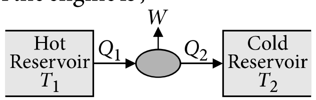


here, $(Q_1 < Q_2)$

State Variables and Equation of State
The relation between the state variables (P, V, T) of the system is called equation of state.
For μ moles of an ideal gas, equation of state is $PV = \mu RT$ and for 1 mole of an ideal gas it is $PV = RT$.

Heat Engine
The efficiency η of the engine is ;

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



here $(Q_1 > Q_2)$

Thermodynamic Processes

Relation between Coefficient of Performance and Efficiency of Refrigerator

$$\alpha = \frac{1 - \eta}{\eta}$$

Isothermal Process
Isothermal process : A thermodynamic process in which the temperature remains constant.

- Equation of isothermal process, PV = constant.
- Work done during isothermal process,

$$W = \mu RT \ln\left(\frac{V_f}{V_i}\right); \quad W = \mu RT \ln\left(\frac{P_i}{P_f}\right)$$

- The slope of isothermal curve on a P-V diagram at any point on the curve is given by

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

Adiabatic Process
Adiabatic Process : A thermodynamic process in which no heat flows between the system and the surroundings.

- Equation of adiabatic process,
  PV^γ = constant, where $\gamma = C_P/C_V$.
- Work done during adiabatic process,

$$W = \frac{(P_iV_i - P_fV_f)}{(\gamma - 1)}; \quad W = \frac{\mu R(T_i - T_f)}{\gamma - 1}$$

- The slope of adiabatic curve on a P-V diagram at any point on the curve is given by

$$\frac{dP}{dV} = -\gamma\left(\frac{P}{V}\right)$$

Isochoric Process
Isochoric (isometric) process : A thermodynamic process in which volume remains constant.

- Equation of isochoric process :
  $\dfrac{P}{T}$ = constant.
- No work is done by the gas in an isochoric process.
- The slope of the isochoric curve on a P-V diagram is infinite.

Isobaric Process
Isobaric process : A thermodynamic process in which pressure remains constant.

- Equation of isobaric process : $\dfrac{V}{T}$ = constant.
- Work done during isobaric process,
  $W = P(V_f - V_i) = \mu R(T_f - T_i)$.
- The slope of the isobaric curve on a P-V diagram is zero.