SYNOPSIS:

- **Zeroth law of thermodynamics:** 'Two systems in thermal equilibrium with a third system are in thermal equilibrium with each other.'

- **Internal energy:** The **sum** of **kinetic** energies and **potential** energies of the molecular constituents of the system.

- **Two modes of energy transfer**:
  - **(a) Heat:** The energy transfer arising due to temperature difference between the system and the surroundings.
  - **(b) Work:** The energy transfer such as moving the piston of a cylinder containing the gas, by raising or lowering some weight connected to it.

- **First law of thermodynamics**: 'The general law of conservation of energy applied to any system in which energy transfer from or to the surroundings'.

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

  where **Δ Q** is the **heat** supplied to the system.

  Δ W is the **work** done by the system.

  Δ U is the **internal energy** of the system.

- **Specific heat capacity:**

  $$s = \frac{1}{m}\frac{\Delta Q}{\Delta T}$$

  where **m** is the mass of the substance and

  Δ Q is the heat required to change its temperature by

  Δ T the molar specific heat capacity of a substance.

- **Molar specific heat capacity**:

  $$C = \frac{1}{\mu}\frac{\Delta Q}{\Delta T}$$

  where μ is the number of moles of the substance.

- **Law of equipartition of energy**:

  $C = 3R$

  which generally agrees with experiment at ordinary temperatures.

- **Calorie:** The amount of heat required to raise the temperature of 1g of water from $14.5°C$ to $15.5°C$.

  1 cal = 4.186J.

- **Molar specific heat capacities at constant pressure and volume:**

  $C_p - C_v = R$

  where **R** is the universal gas constant.

- **Equilibrium states of a thermodynamic system**: The value of a state variable depends only on the particular state, not on the path used to arrive at that state.

- **Examples of state variables:**

  (a) Pressure (P),

  (b) Volume (V),

  (c) Temperature (T),

  (d) Mass (m).

- **Quasi–static process:** It is an infinitely slow process such that the system remains in thermal and mechanical equilibrium with the surroundings throughout.

- **Isothermal expansion:** An ideal gas from volume V_1 to V_2 at temperature T the heat absorbed (Q) equals the work done (W) by the gas:

$$Q = W = \mu RT \ln\left(\frac{V_2}{V_1}\right)$$

- **Adiabatic process of an ideal gas:**

$$PV^{\gamma} = \text{constant.}$$

Where $\gamma = \dfrac{C_p}{C_v}$

- **work done** by an ideal gas in an adiabatic change of state from (P_1,V_1,T_1) to (P_2,V_2,T_2) is

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

- **Heat engine:** A device in which a system undergoes a cyclic process resulting in conversion of heat into work. The **efficiency** η of the engine is:

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

Q_1 is the heat absorbed from the source,
Q_2 is the heat released to the sink, and the work output in one cycle is W.

- **Refrigerator or Heat pump:** The system extracts heat Q_2 from the cold reservoir and releases Q_1 amount of heat to the hot reservoir, with work W done on the system. The co-efficient of performance of a refrigerator is:

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

- **Cyclic Process:** A thermodynamic process in which system undergoes a series of processes, starting from some thermodynamic equilibrium state, and finally the system is brought back to its original state.

- **Thermal equilibrium:** When two systems are brought in thermal contact, heat flows from the system at higher temperature to that at lower temperature. When both the systems attain equal temperature, then there is no heat exchange.

- **Fahrenhit Scale:** The relation of this scale with Celsius scale is

$$t_f = 32 + \frac{9}{5} tc.$$

- **Kelvin – Planck statement:**
  'No process is possible whose sole result is the absorption of heat from a reservoir and complete conversion of the heat into work.'

- **Clausius statement**:
  'No process is possible whose sole result is the transfer of heat from a colder object to a hotter object.'

- The **second law** implies that no heat engine can have **efficiency** η equal to 1 or no refrigerator can have **co-efficient of performance** α equal to infinity.

- **Reversible Process:** Both the system and the surroundings return to their original states, with no other change anywhere else in the universe.

- **Spontaneous processes:** The idealized reversible process is a quasi–static process with no dissipative factors such as friction, viscosity etc.

- **Isolated system:** A system which does not interact with surrounding.

- **Statement of Max Planck:** 'It is impossible to construct a heat engine operating in a cycle that will extract heat from a reservoir and perform an equivalent amount of work'.

- **Linear expansion:** The increase in the length of a body with increase in temperature**.**

  The sum Kint + Uint is called **'internal energy'** of gas.

  The sum Kext + Uext is called **'external energy'** of gas.

- **Carnot engine:** A reversible engine, operating between temperatures T_1 (source) and T_2 (sink). The Carnot cycle consists of two isothermal processes connected by two adiabatic processes. The efficiency of a Carnot engine is :

  $$\eta = 1 - \frac{T_2}{T1} \text{(Carnot engine)}$$

- **No engine** operating between two temperatures can have efficiency greater than that of the **Carnot engine**.

  If **Q > 0**, heat is added to the system.

  If **Q < 0**, heat is removed to the system.

  If **W > 0**, work is done by the system.

  If **W <0**, work is done on the system.

- **Thermal expansion:** The substances increase with increase in temperature and decrease with decrease in temperature.

- **Isobaric Process:** The process during which pressure of the system remains constant.

- **Isochoric process:** Volume of a system remains constant during this process, no work is done during the process, from first law of thermodynamics:

  $Q = \Delta U$.

- **Isothermal Process:** A thermodynamic process during which temperature of a system remains constant.

- **Physical Quantities with its Symbols, Dimensions and Units**

Quantity	Symbol	Dimensions	Units	Remarks
Co-efficient of volume expansion	α_v	$[K^{-1}]$	K^{-1}	$\alpha_V = 3\,\alpha_1$
Heat supplied to a system	ΔQ	$[ML^2 T^{-2}]$	J	Q is not a state variable
Specific heat	s	$[L^2 T^{-2} K^{-1}]$	$J\ kg^{-1}\ K^{-1}$	
Thermal Conductivity	K	$[MLT^{-3} K^{-1}]$	$J\ S^{-1}\ K^{-1}$	$H = -KA\dfrac{dT}{dx}$