

1 VSAQ + 1LAQ = 2M + 8 M= 10 MARKS

12. THERMODYNAMICS

• Laws of Thermodynamics • Specific Heat • Isothermal & Adiabatic Process
• Latent Heat • Reversible & Irreversible Process • Heat Engines

SMART SYNOPSIS

- Thermal Equilibrium** is a state of a system in which temperature remains the same and no heat flows between systems. [VSAQ]
- Zeroth law of thermodynamics:** If two systems A and B are separately in thermal equilibrium with a third system C, then A & B are also in thermal equilibrium with each other.
(If $A = C$ & $B = C$ then $A = B$) [VSAQ]
- Heat** is a form of Energy that flows from a point of higher temperature to a point of lower temperature. **CGS unit :** Calorie **SI unit :** Joule
One Calorie is the amount of heat required to raise the temperature of one gram of water through 1°C at a pressure of 1 atm. [VSAQ]
- Internal energy(U) :** The internal energy of gases at room temperature is due to potential energy and kinetic energy of the molecules and atoms of the gases.
- 5.1 First law of Thermodynamics :** The heat supplied to a system is equal to the algebraic sum of increase in its internal energy and external work done.
Note : Using this law we can find the change in internal energy (dU) of the system.
- 5.2 Mathematical form :** $dQ = dU + dW$
Sign convention : If work is done **by** the system, dW is taken as **positive**. [VSAQ]
If work is done **on** the system, dW is taken as **negative**.
When heat is **supplied** to the system, dQ is taken as **positive**.
When heat is **taken out** from the system, dQ is taken as **negative**.
- Heat Capacity** is the amount of heat required to raise the temperature of a substance through 1°C .
$$\text{Heat capacity} = \frac{dQ}{dT} \quad \text{S.I unit : JK}^{-1}.$$
- Specific heat capacity** is the amount of heat required to raise to the temperature of unit mass of a substance through 1°C or 1K. [VSAQ]
$$\text{Specific heat capacity } S = \frac{1}{m} \frac{dQ}{dT}$$
- Molar specific heat capacity** is the amount of heat required to raise the temperature of 1gm mole of a gas through 1°C or 1K. [VSAQ]
$$\text{Molar specific heat capacity } C = \frac{1}{n} \frac{dQ}{dT}. \text{ Here } n \text{ is the number of moles of the gas}$$

9. Specific heats of a Gas :

9.1 Specific heat at constant pressure (C_p) : At constant pressure, the quantity of heat required to increase the temperature of one mole of a gas through one degree, is called specific heat of the gas at constant pressure.

9.2 Specific heat at constant volume (C_v) : At constant volume, the quantity of heat necessary to increase the temperature of one mole of a gas through one degree, is called specific heat of gas at constant volume.

9.3 Relation between C_p and C_v : $C_p - C_v = R$, R is the universal gas constant. [LAQ]

10. Thermodynamic process:

10.1. Quasi - Static process: A Quasi-Static process is defined as 'an infinitesimally slow process' in which the system remains in thermal and mechanical equilibrium with the surroundings at each and every intermediate state.

10.2 Isothermal Process is a process in which change in pressure and volume takes place at constant temperature.

10.3 Adiabatic Process is a process in which changes in pressure and volume of a gas takes place at constant heat energy .

10.4. Isochoric process is a process that takes place at constant volume of the system. [VSAQ]

10.5. Isobaric process is a process that takes place at constant pressure of the system. [VSAQ]

10.6. Cyclic Process is a process in which the system after passing through various stages (of pressure, volume and temperature changes) returns to its initial state
In a cyclic process, the total heat absorbed by the system equals the work done by the system'.

11.1 Heat Engine is a device used to convert heat energy into mechanical energy.

11.2 Carnot engine is a reversible heat engine operating between two temperatures. [LAQ]

$$\text{Carnot engine's efficiency, } \eta = 1 - \frac{T_2}{T_1}$$

11.3 Refrigerators is just the reverse of a heat engine.

12. Second law of Thermo dynamics : [VSAQ][LAQ]

(a) Kelvin - Plank Statement: It is impossible to construct an ideal heat engine with 100% thermal efficiency. (or) It is impossible to construct a heat engine that absorbs heat from a hot reservoir which converts completely that heat into work . [VSAQ]

(b) Clausius Statement: It is impossible to construct an ideal refrigerator.
(or) It is impossible to transfer heat from a colder object to a hotter object

13. Reversible and Irreversible Processes :

13.1 Reversible process is a process that can be retraced back in the opposite direction.

Examples of reversible processes : (i) Fusion of ice (ii) Vaporisation of water

13.2 Irreversible Process is a process that cannot be retraced back in the opposite direction.

Examples of irreversible processes :

(i) Work done against friction (ii) Diffusion of gases (iii) Magnetization of a material.

1. THERMAL EQUILIBRIUM

- State of a system in which only temperature remains the same and no heat flows between systems.

4. INTERNAL ENERGY (U)

- The internal energy of a system (especially gases) is due to the potential energy and kinetic energy of the molecules and atoms.

6. HEAT CAPACITY & SPECIFIC HEAT

Heat Capacity

- Amount of heat required to raise the temperature of a substance through 1°C.

$$C = \frac{dQ}{dT}$$

Unit : J K⁻¹

Specific Heat Capacity

- Amount of heat required to raise the temperature of unit mass of a substance through 1°C (or 1 K).

$$S = \frac{1}{m} \frac{dQ}{dT}$$

Unit : J kg⁻¹ K⁻¹

9. HEAT ENGINES

- Device that converts heat energy into mechanical energy. Carnot Engine
- A reversible heat engine operating between two temperatures :
 - T₁ = Hot reservoir
 - T₂ = Cold reservoir
- Efficiency of Carnot Engine

$$\eta = 1 - \frac{T_2}{T_1}$$

2. ZEROth LAW OF THERMODYNAMICS

- If two systems A and B are separately in thermal equilibrium with a third system C, then A and B are also in thermal equilibrium with each other.

Mathematical Form

$$\text{If } A = C \text{ and } B = C \\ \text{then } A = B$$

3. HEAT

- Heat is a form of energy that flows from a point of higher temperature to a point of lower temperature.

Units

- SI unit : joule (J)
- CGS unit : calorie (cal)

5. FIRST LAW OF THERMODYNAMICS

- Heat supplied to a system is equal to the algebraic sum of increase in its internal energy and external work done.

$$\text{Equation } dQ = dU + dW$$

Sign Convention

- Work done by the system → dW is positive (+)
- Work done on the system → dW is negative (-)
- Heat supplied to the system → dQ is positive (+)
- Heat taken out of the system → dQ is negative (-)

7. SPECIFIC HEATS OF A GAS

- C_p : Specific heat at constant pressure
- C_v : Specific heat at constant volume

$$\text{Relation } C_p - C_v = R$$

where R = Universal gas constant

11. SECOND LAW OF THERMODYNAMICS

(a) Kelvin-Planck Statement

- It is impossible to construct an ideal heat engine with 100% thermal efficiency.

(b) Clausius Statement

- It is impossible to construct an ideal refrigerator.

10. REFRIGERATOR

- Reverse of a heat engine.
- Transfers heat from a colder body to a hotter body by doing external work.

8. THERMODYNAMIC PROCESSES

- Quasi-static Process : in thermal and mechanical equilibrium.
- Isothermal Process : Temperature remains constant. $dQ = 0$
- Adiabatic Process : No heat exchange.
- Isochoric Process : Volume remains constant.
- Isobaric Process : Pressure remains constant.
- Cyclic Process : Total heat absorbed = Total work done by the system.

12. THERMODYNAMICS

Concepts & Formulas