CHAPTER-11: THERMODYNAMICS

Part–1 : Basic Concepts • Internal Energy • First Law of Thermodynamics

1. Thermodynamic System

A specified quantity of matter or a region under study is called a **Thermodynamic System**.

Types

- Open System
- Closed System
- Isolated System

---

2. Surroundings

Everything outside the thermodynamic system is called the **Surroundings**.

---

3. Thermodynamic Equilibrium

A system is said to be in equilibrium when

- Thermal Equilibrium
- Mechanical Equilibrium
- Chemical Equilibrium

exist simultaneously.

---

4. State Variables

The variables which define the state of a system are:

- Pressure (P)
- Volume (V)
- Temperature (T)

---

5. Equation of State (Ideal Gas)

$$\boxed{PV = nRT}$$

Where

- P = Pressure
- V = Volume
- n = Number of moles
- R = Universal Gas Constant
- T = Absolute Temperature

---

6. Universal Gas Constant

$$\boxed{R = 8.314 J\ mol^{-1}K^{-1}}$$

---

7. Internal Energy

Internal Energy is the total kinetic and potential energy of all molecules of a system.

Symbol:U

8. Change in Internal Energy

$$\boxed{\Delta U = U_2 - U_1}$$

9. Heat (Q)

Heat is the energy transferred due to temperature difference.
SI Unit:Joule

10. Work Done

For constant pressure,

$$\boxed{W = P\Delta V}$$

Where

$$\boxed{\Delta V = V_2 - V_1}$$

11. Sign Convention

Heat

- Heat Supplied to System → **Positive (+Q)**
- Heat Given by System → **Negative (−Q)**

Work

- Work Done by System → **Positive (+W)**
- Work Done on System → **Negative (−W)**

12. First Law of Thermodynamics

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

Equivalent form

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

This law is based on the **Law of Conservation of Energy**.

13. Cyclic Process

For a complete cycle,

$$\boxed{\Delta U = 0}$$

Therefore,

$$\boxed{Q = W}$$

Exam Tips

- **Temperature in Kelvin**
- Fix Sign Convention in First Law related questions
- Cyclic Process→ Internal Energy Change: **Zero**

Part–2 : Thermodynamic Processes • Heat Capacities • Adiabatic Equation

14. Isothermal Process

Temperature remains constant.

$$\boxed{\Delta T = 0}$$

Hence,

$$\boxed{\Delta U = 0}$$

Work Done

$$\boxed{W = nRT \ln\left(\frac{V_2}{V_1}\right)}$$

Also,

$$\boxed{Q = W}$$

15. Isochoric (Constant Volume) Process

$$\boxed{\Delta V = 0}$$

Therefore,

$$\boxed{W = 0}$$

From First Law,

$$\boxed{W = 0}$$

16. Isobaric (Constant Pressure) Process

$$\boxed{P = \text{Constant}}$$

Work Done

$$\boxed{W = P(V_2 - V_1)}$$

17. Adiabatic Process

No heat exchange takes place.

$$\boxed{Q = 0}$$

From First Law,

$$\boxed{\Delta U = -W}$$

18. Adiabatic Equation

$$PV^{\gamma} = \text{Constant}$$

Also,

$$TV^{\gamma-1} = \text{Constant}$$

and

$$T^{\gamma}P^{1-\gamma} = \text{Constant}$$

---

19. Heat Capacity

At Constant Volume

$$Q = nC_v\Delta T$$

At Constant Pressure

$$Q = nC_p\Delta T$$

---

20. Mayer's Relation

$$C_p - C_v = R$$

---

21. Ratio of Heat Capacities

$$\gamma = \frac{C_p}{C_v}$$

For Monoatomic Gas

$$\gamma = \frac{5}{3}$$

For Diatomic Gas

$$\gamma = \frac{7}{5}$$

---

22. Internal Energy of Ideal Gas

$$U = \frac{f}{2}nRT$$

where f = Degrees of Freedom.

---

23. Work Done in Adiabatic Process

$$W = \frac{P_1V_1 - P_2V_2}{\gamma - 1}$$

Thermodynamic Processes Summary

Process	Constant	Heat	Work	Internal Energy
Isothermal	Temperature	Q =W	✔	ΔU=0
Isochoric	Volume	Q = ΔU	0	✔
Isobaric	Pressure	✔	PΔV	✔
Adiabatic	No Heat	0	✔	ΔU = −W

Exam Tips

- Isothermal Process→Internal Energy does not change
- Adiabatic Process→Heat Transfer: Zero
- Remember

$$\boxed{C_p > C_v}$$