

Physics 122 — Thermal Physics

Lecture Notes: Week 3, Day 3

1 Adiabatic Processes

Definition

An **adiabatic process** is a thermodynamic process in which **no heat is exchanged** with the surroundings:

$$Q = 0$$

1.1 First Law of Thermodynamics (Course Convention)

Sign convention: Work done *by the environment on the system* is positive.

$$\Delta E = Q + W$$

For an adiabatic process:

$$\Delta E = W$$

1.2 Physical Examples

- Opening a soda bottle (rapid gas expansion)
- Spraying deodorant
- Diesel engine compression (no spark plug)

Rapid expansion or compression occurs too quickly for heat transfer.

1.3 Temperature Change

- Expansion $\rightarrow W < 0 \rightarrow$ internal energy decreases \rightarrow gas cools
- Compression $\rightarrow W > 0 \rightarrow$ internal energy increases \rightarrow gas heats

2 Adiabatic vs Isothermal Processes

2.1 Ideal Gas Law

$$PV = nRT$$

2.2 Isothermal Process

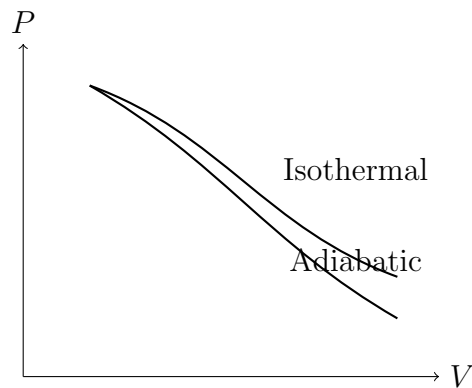
$$T = \text{constant}, \quad P = \frac{nRT}{V}$$

2.3 Adiabatic Process

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

where

$$\gamma = \frac{C_P}{C_V}$$



Adiabatic curves are steeper than isothermal curves.

3 Thermal Expansion

3.1 Linear Expansion

Linear Expansion

$$\Delta L = \alpha L_0 \Delta T$$

- α has units of K^{-1}
- Depends on material

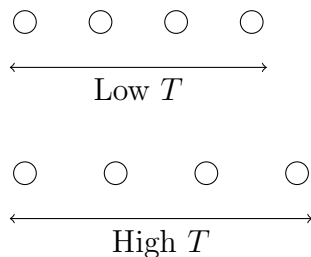
3.2 Volume Expansion

$$\Delta V = \beta V_0 \Delta T$$

For isotropic solids:

$$\beta \approx 3\alpha$$

3.3 Microscopic Picture



Higher temperature increases atomic vibration amplitude, increasing average spacing.

4 Example: Warming a Frozen Popsicle

Problem: A 50 g popsicle is removed from a freezer at -10°C and warmed to 20°C .

Given:

$$c_{\text{ice}} = 2100 \text{ J}/(\text{kg} \cdot \text{K})$$

$$c_{\text{water}} = 4200 \text{ J}/(\text{kg} \cdot \text{K})$$

$$L_f = 3 \times 10^5 \text{ J/kg}$$

Steps

$$Q_1 = mc_{\text{ice}}(0 - (-10))$$

$$Q_2 = mL_f$$

$$Q_3 = mc_{\text{water}}(20 - 0)$$

Total Heat

$$Q = Q_1 + Q_2 + Q_3 \approx 1.93 \times 10^4 \text{ J}$$