THERMODYNAMICS

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Thermodynamics is concerned with the work done by a system and the heat it exchanges with its surroundings.

When the system is taken quasistatically from the equilibrium state *i* to another equilibrium state *f*, the total work done by the system is

$$W = \int_{V_i}^{V_f} P \; dV$$

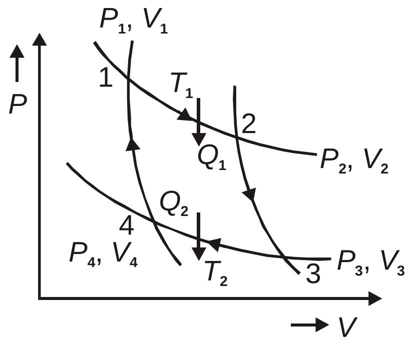
The work is represented by the *area under the curve*. If $V_f > V_i$, the work done by the gas is ***positive***. If the volume *decreases*, the work done by the gas is ***negative***.

FIRST LAW OF THERMODYNAMICS

We know that both the total work done W and the total heat transfer Q *to* or *from* the system depend on the thermodynamic *path*. However, the difference $Q - W$, is the same for *all* paths between the given *initial* and *final* equilibrium states, and it is equal to the change in internal energy ΔU of the system.

$$\Delta U = Q - W$$

APPLICATIONS OF THE FIRST LAW OF THERMODYNAMICS



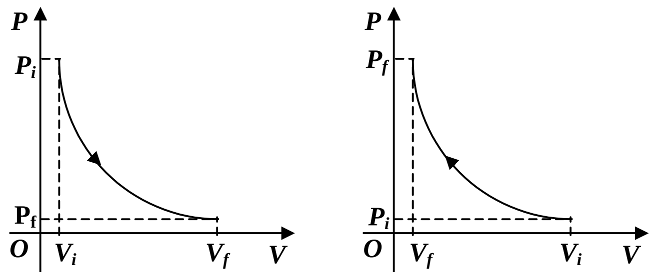
$1 \to 2$	Isothermal Expansion	$\Delta U = 0$ $W_1 = Q_1 = nRT \ln \frac{V_2}{V_1}$ (positive)
$2 \to 3$	Adiabatic Expansion	$Q = 0$ $W_2 = -\Delta U = \frac{nR\Delta T}{1-r}$
$3 \to 4$	Isothermal Compression	$\Delta U = 0$ $W_3 = Q_2 = nRT \ln \left(\frac{V_4}{V_3}\right)$ (negative)
$4 \to 1$	Adiabatic Compression	$Q = 0$ $W_4 = -\Delta U = \frac{nR\Delta T}{1-r}$

Important

1. $C_p - C_v = R$

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

(d) Isothermal Process



(a) (b)

PV diagram of isothermal process
(a) Isothermal expansion
(b) Isothermal compression

In an isothermal process, temperature of the system remains constant. For an ideal gas the equation of the process is given by

$PV = nRT$

= constant

Work done in an isothermal process is given by

$$W = \int_{V_i}^{V_f} PdV = nRT\int_{V_i}^{V_f} \frac{dV}{V}$$

or $$W = nRT\ln\left|\frac{V_f}{V_i}\right|$$

Since temperature of the system remains constant, therefore, there is no change in internal energy.

$$\Delta U = nC_v \Delta T = 0$$

(e) Adiabatic Process

In an adiabatic process, the system does not exchange heat with the surroundings,
i.e. $Q = 0$.

For an ideal gas the equation of the adiabatic process is

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

Where, γ is the adiabatic exponent.

Work done: $W = \int_{V_i}^{V_f} PdV$