

The background of the slide is a light gray gradient, decorated with numerous realistic water droplets of various sizes. Some droplets are large and prominent, while others are small and subtle. They are scattered across the slide, with a higher concentration in the top-left and bottom-right corners, creating a clean, scientific, and aesthetically pleasing look.

Chapter 4

Macroscopic parameters and their measurement

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4.1 Work and internal energy

$$W = \int_{V_1}^{V_2} \bar{p}(V) dV$$

$$\Delta \bar{E} = -W$$
$$\bar{E}_b - \bar{E}_a = -W_{ab} = - \int_a^b dW$$

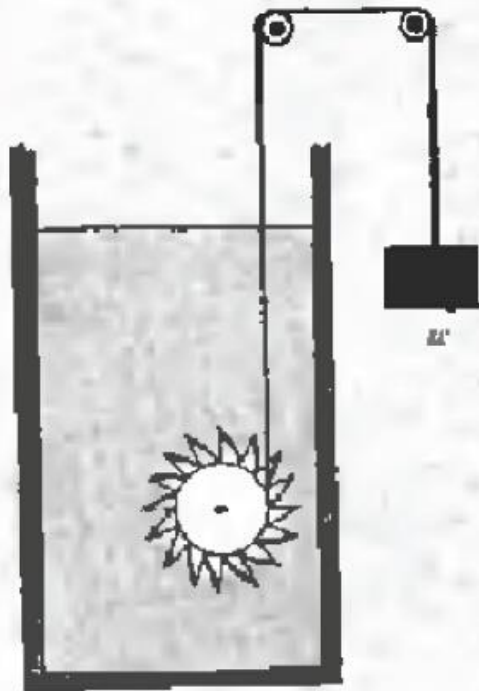


Fig. 2-7-5 A system consisting of a vessel containing a liquid and a paddle wheel. The falling weight can perform work on the system by rotating the paddle wheel.

4.1 Work and internal energy

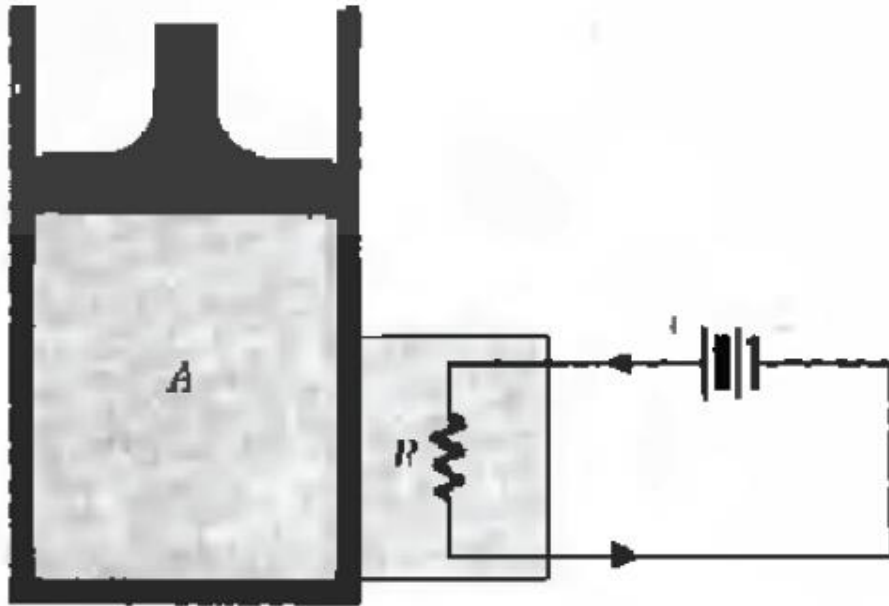


Fig. 4-1-2 A system consisting of a cylinder containing a gas. The volume V of the gas is determined by the position of the movable piston. The resistor R can be brought into thermal contact with this system.

$$\bar{E}_v = \bar{E}_a - W_{ac} + (W - \Delta\bar{E})$$

$\Delta\bar{E}$: the change in mean energy of the resistor

4.2 Heat

$$Q_{ab} = (\bar{E}_b - \bar{E}_a) + W_{ab}$$

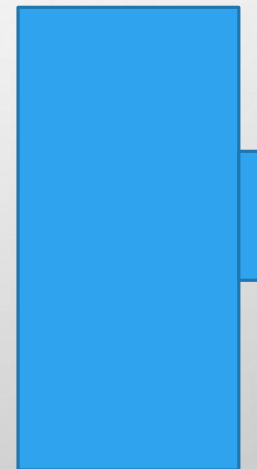
(1) Direct measurement in terms of work

$$W = \Delta \bar{E} + \Delta \bar{\epsilon}$$

$$Q_{ab} = \Delta \bar{E}$$

$$Q_{ab} = W - \Delta \bar{\epsilon}$$

A



Resistor

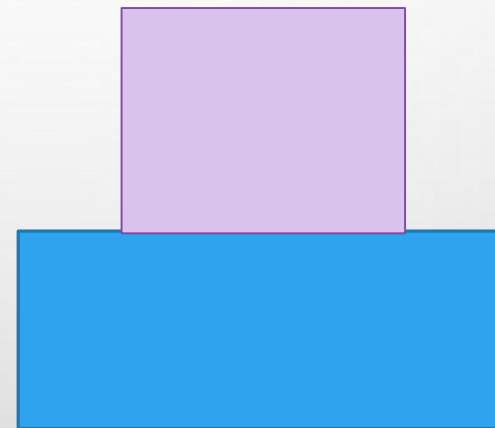
4.2 Heat

(2) Method of mixture

$$\Delta \bar{E}_A + \Delta \bar{E}_B = 0$$

$$Q_A + Q_B = 0$$

$$Q_A = -Q_B$$



System A

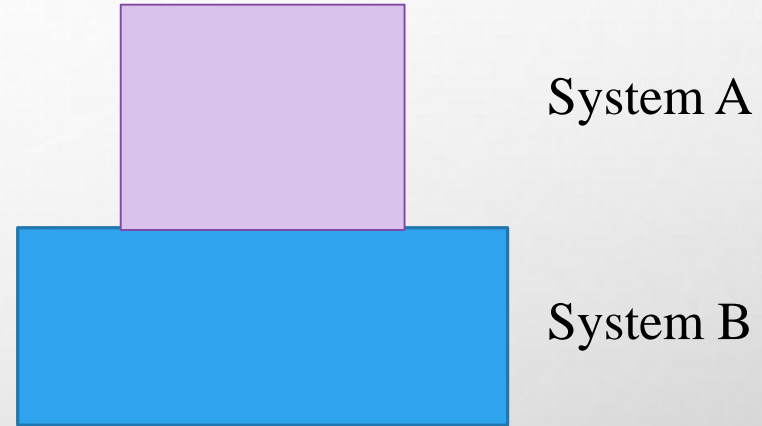
Reference System B

4.3 Heat capacity

$$C \equiv \frac{Q}{\Delta T}.$$

$$C_V = \left(\frac{\Delta U}{\Delta T} \right)_V = \left(\frac{\partial U}{\partial T} \right)_V.$$

$$C_P = \left(\frac{\Delta U - (-P\Delta V)}{\Delta T} \right)_P = \left(\frac{\partial U}{\partial T} \right)_P + P \left(\frac{\partial V}{\partial T} \right)_P.$$



For a given amount of heat absorbed, $c_p > c_v$

4.4 Enthalpy

$$H \equiv U + PV.$$

$$C_P = \left(\frac{\partial H}{\partial T} \right)_P.$$

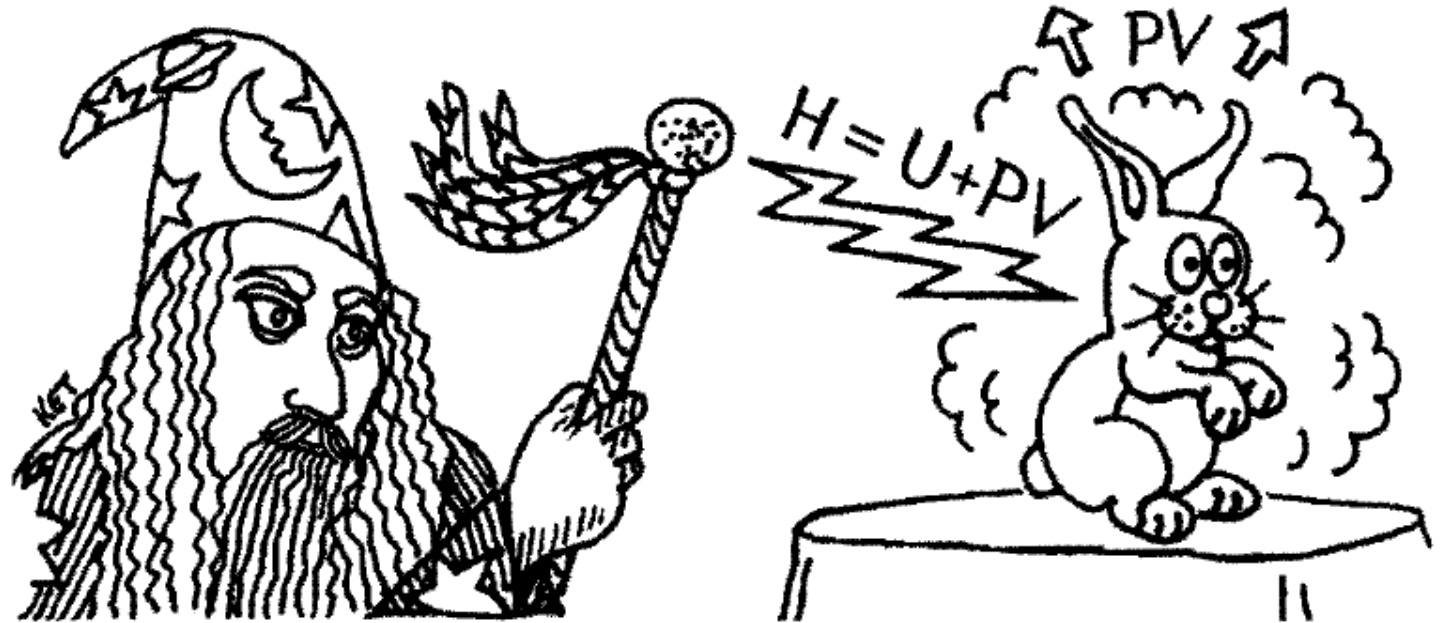


Figure 1.15. To create a rabbit out of nothing and place it on the table, the magician must summon up not only the energy U of the rabbit, but also some additional energy, equal to PV , to push the atmosphere out of the way to make room. The *total* energy required is the **enthalpy**, $H = U + PV$.

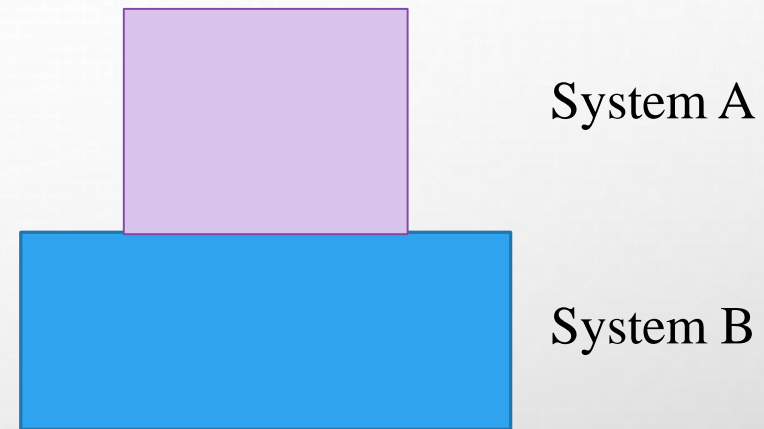
4.5 Entropy

$$dS = \frac{dQ}{T} \quad (\text{reversible process})$$

$$S_b - S_a = \int_{a(\text{eq})}^b \frac{dQ}{T}$$

$$S(T_b) - S(T_a) = \int_a^b \frac{dQ}{T} = \int_{T_a}^{T_b} \frac{C_v(T') dT'}{T'}$$

$$S(T_b) - S(T_a) = C_v \ln \frac{T_b}{T_a}$$



4.5 Entropy

$$\Delta S_A = S_A(T_f) - S_A(T_A) = \int_{T_A}^{T_f} \frac{m_A c_A' dT}{T} = m_A c_A' \ln \frac{T_f}{T_A}$$

$$\Delta S_A + \Delta S_B = m_A c_A' \ln \frac{T_f}{T_A} + m_B c_B' \ln \frac{T_f}{T_B}$$

$$\begin{aligned} \ln x &\leq x - 1 & (= \text{sign for } x = 1) \\ -\ln x &\geq -x + 1 \end{aligned}$$

$$\ln y \geq 1 - \frac{1}{y} \quad (= \text{sign for } y = 1)$$

$$\begin{aligned} \Delta S_A + \Delta S_B &\geq m_A c_A' \left(1 - \frac{T_A}{T_f}\right) + m_B c_B' \left(1 - \frac{T_B}{T_f}\right) \\ &= T_f^{-1} [m_A c_A' (T_f - T_A) + m_B c_B' (T_f - T_B)] \\ &= 0 \quad \text{by (4.4.13)} \end{aligned}$$

Thus $\Delta S_A + \Delta S_B \geq 0$

4.6 Extensive and intensive parameters

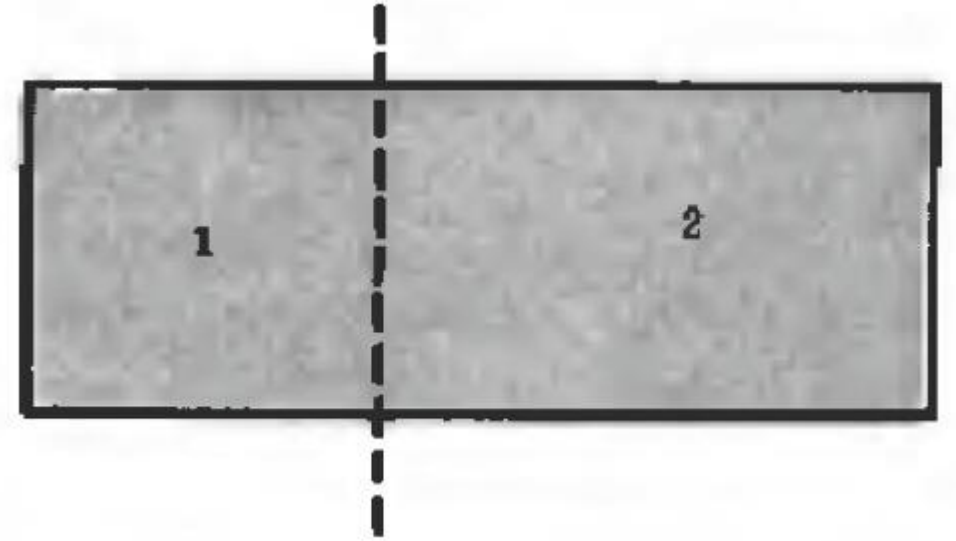
1. $y_1 + y_2 = y$: extensive

2. $y_1 = y_2 = y$: intensive

Extensive parameters: V, M, E, C, S, etc

Intensive parameters: ρ , P, T, etc

$$\frac{\text{Extensive parameter 1}}{\text{Extensive parameter 2}} = \text{Intensive parameter}$$



The image features a light gray background with a subtle radial gradient. In the top-left and bottom-right corners, there are clusters of realistic water droplets of various sizes, some overlapping. A faint, circular watermark is visible in the upper center of the page.

Thank you!!