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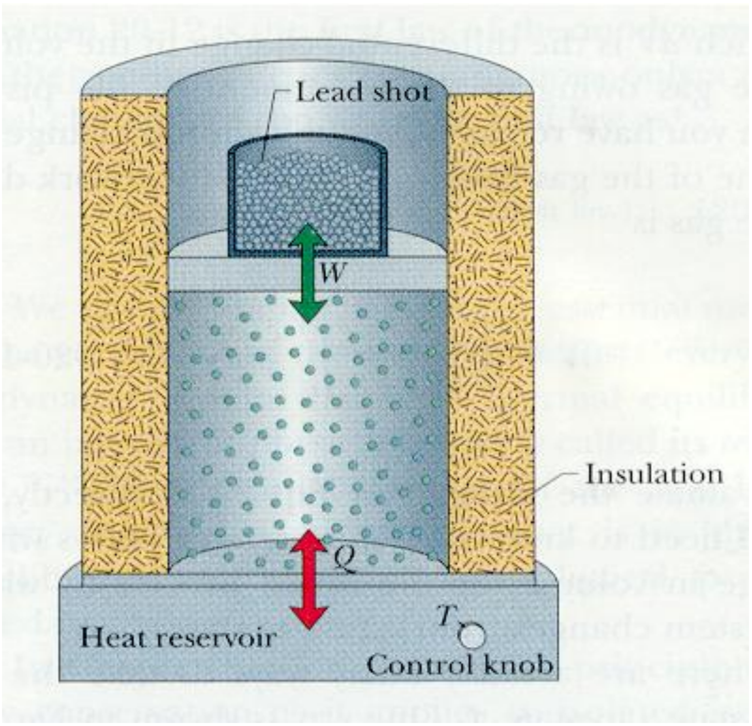
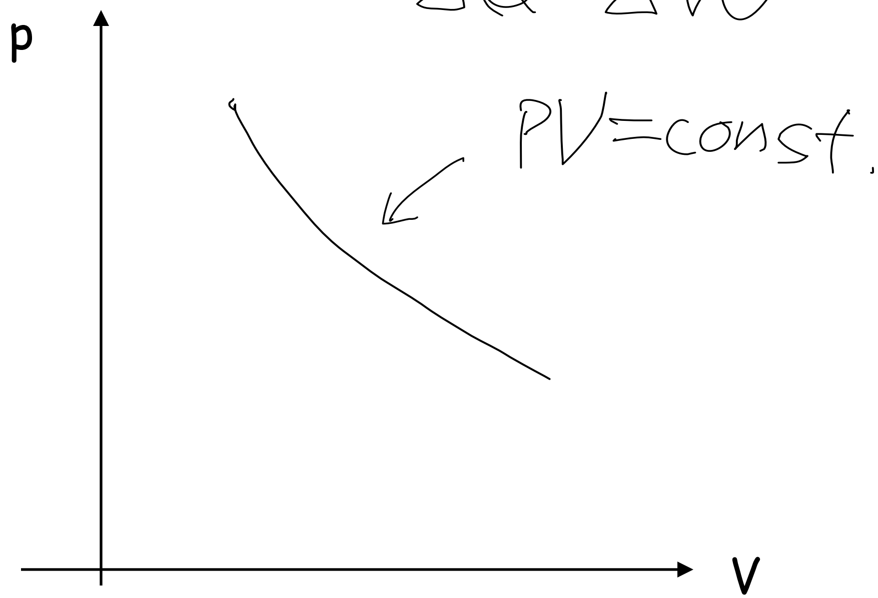
- The images and the pictures in this lecture are provided by the CDs accompanied by the books
  1. University Physics, Bauer and Westfall, McGraw-Hill, 2011.
  2. Principles of Physics, Halliday, Resnick, and Walker, Wiley, 8th and 9th Ed.
- The rest is made by me.

isothermal process

T= constant ($\Delta E = 0$) ; $\Delta Q = \Delta E + \Delta W$

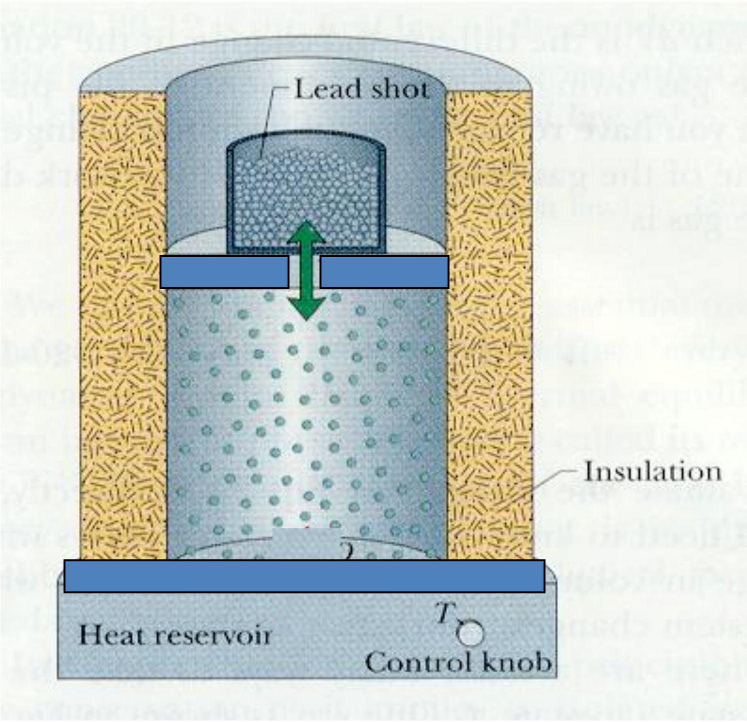
$\Delta Q = \Delta W$

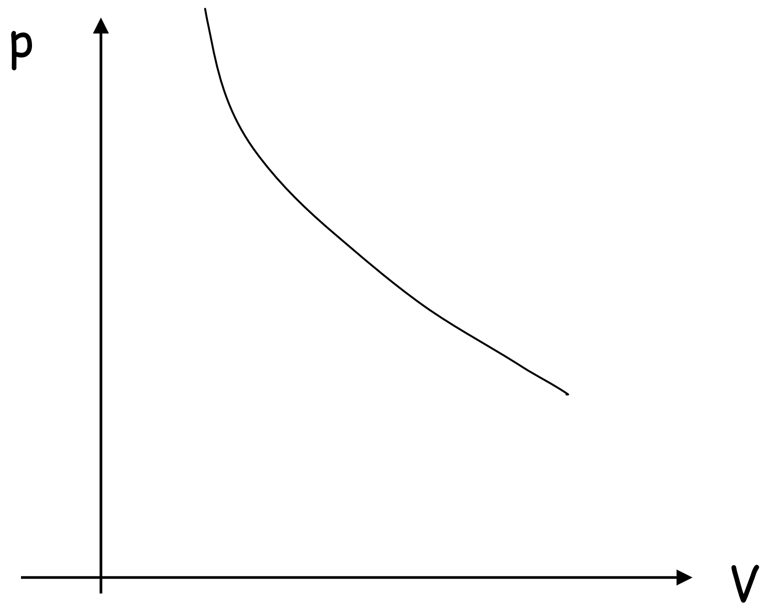




adiabatic process

$\Delta Q = 0$; $\Delta Q = \Delta E + \Delta W$



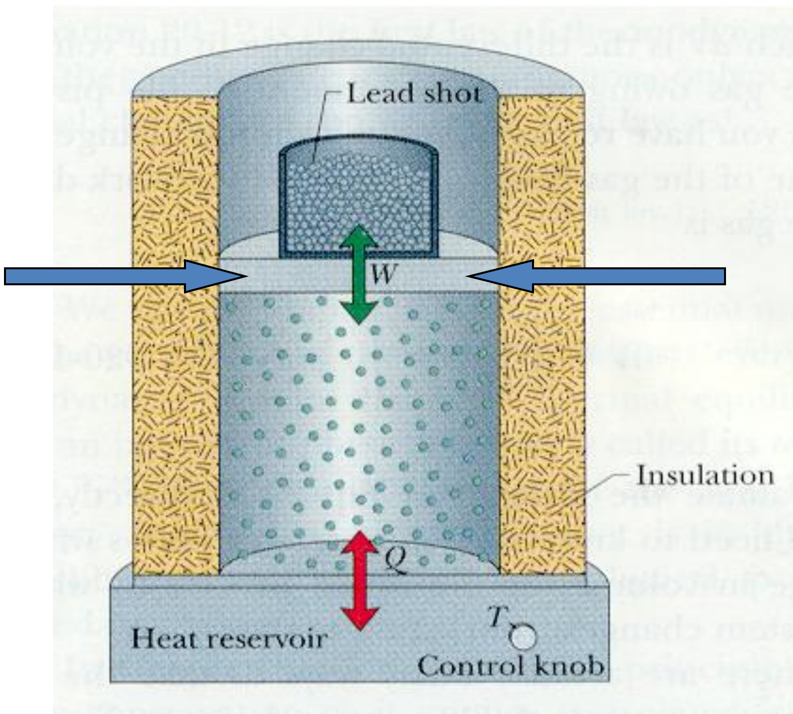


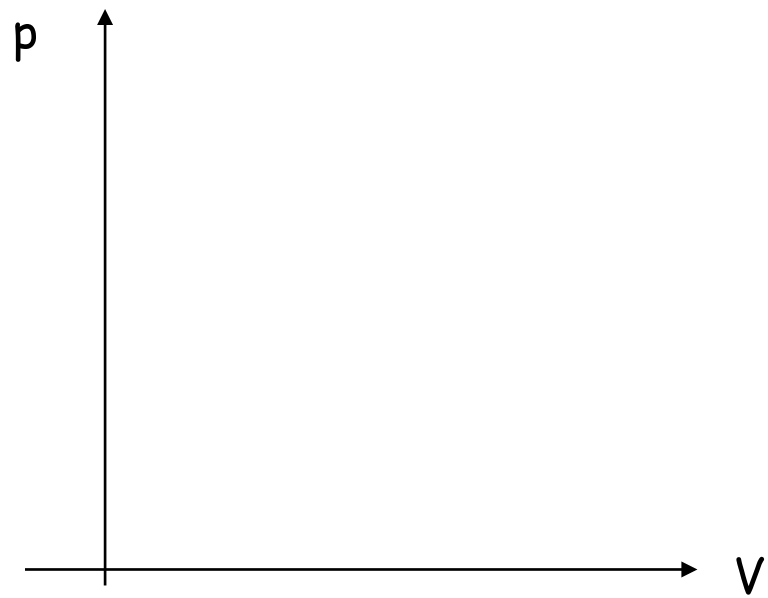
$\Delta E + \Delta W = 0$

$\Delta W = -\Delta E$

constant-volume process

$\Delta W = 0$; $\Delta Q = \Delta E + \Delta W$

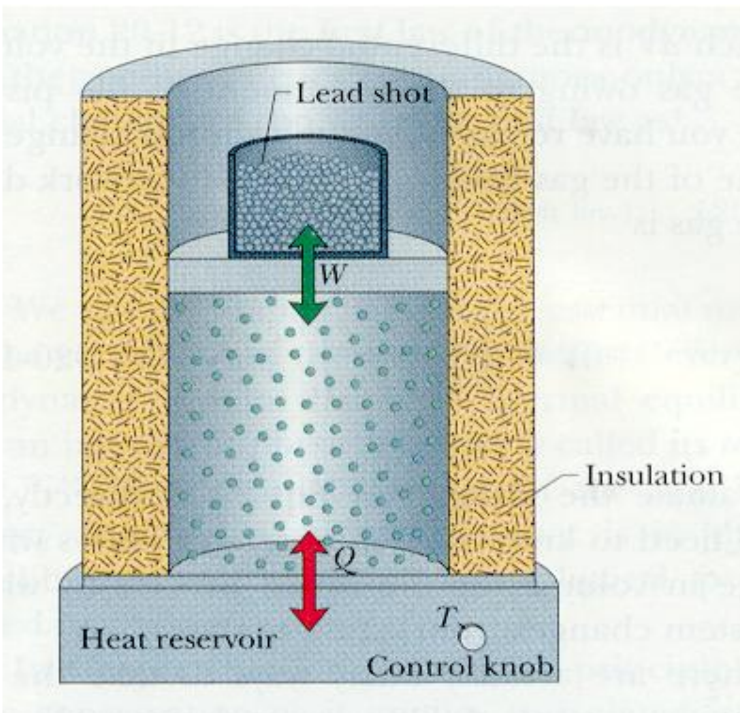


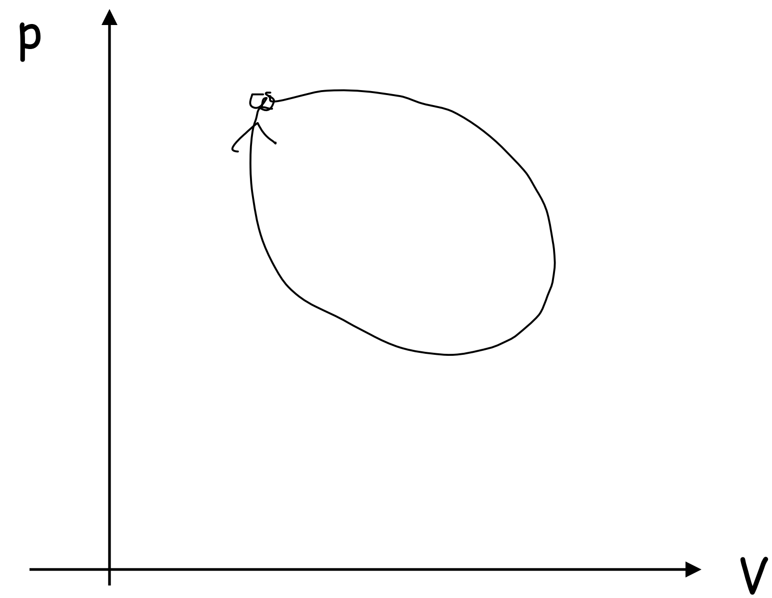


$\Delta Q = \Delta E$

cyclic process

$\Delta E = 0$; $\Delta Q = \Delta E + \Delta W$



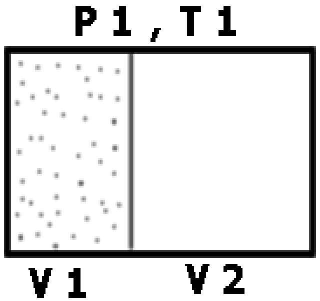


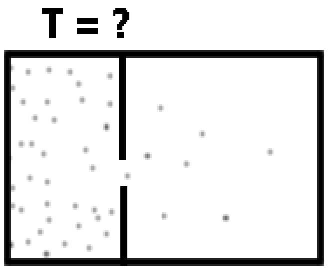
$\Delta E = 0$

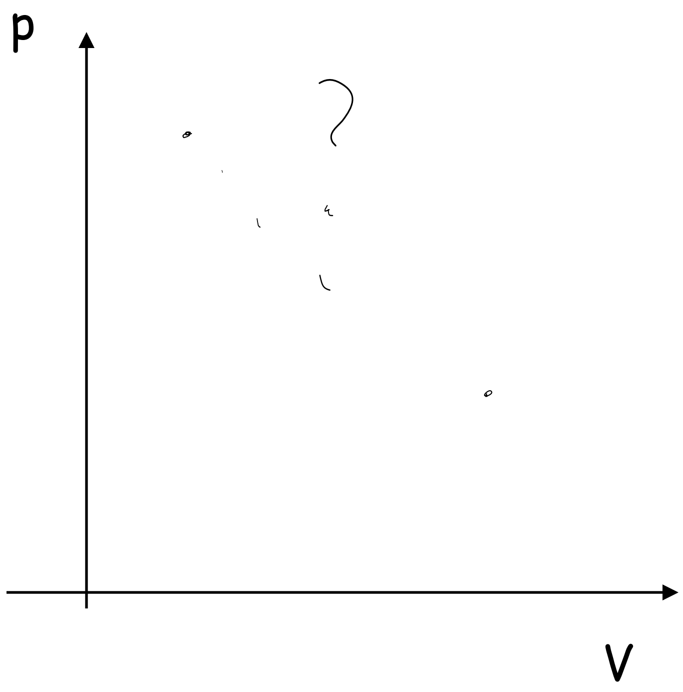
$\Delta Q = \Delta W$

free expansion

$\Delta Q = 0, \Delta W = 0$; $\Delta Q = \Delta E + \Delta W$







$\Delta E = 0$

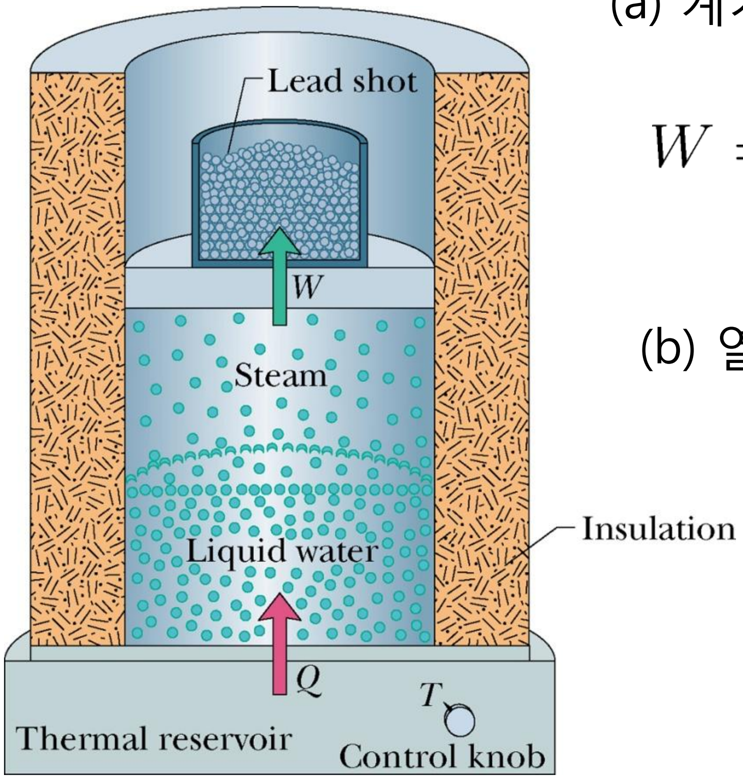
TABLE 18-5

The First Law of Thermodynamics: Four Special Cases

The Law: $\Delta E_{\text{int}} = Q - W$ (

Process	Restriction	Consequence
Adiabatic	$Q = 0$	$\Delta E_{\text{int}} = -W$
Constant volume	$W = 0$	$\Delta E_{\text{int}} = Q$
Closed cycle	$\Delta E_{\text{int}} = 0$	$Q = W$
Free expansion	$Q = W = 0$	$\Delta E_{\text{int}} = 0$

Sample prob.



(a) 계가 한 일

$$W = \int_{V_i}^{V_f} p dV = p \int_{V_i}^{V_f} dV = p(V_f - V_i)$$

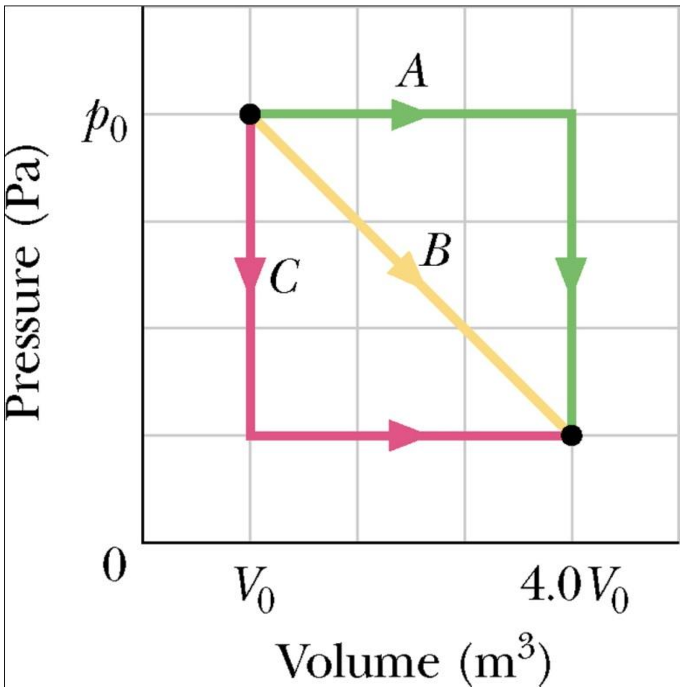
(b) 열로 전달된 에너지 $Q = L_V m$

(c) 내부에너지 변화량

$$\Delta E_{\text{int}} = Q - W$$

$$\text{water } 1 \text{ kg}, p = 1.01 \times 10^5 \text{ Pa} \rightarrow \text{water vapor}$$

Problem



$$p_0 = 40\text{Pa},\ V_0 = 1.0\text{m}^3$$

각 과정에서 기체가 한 일은?

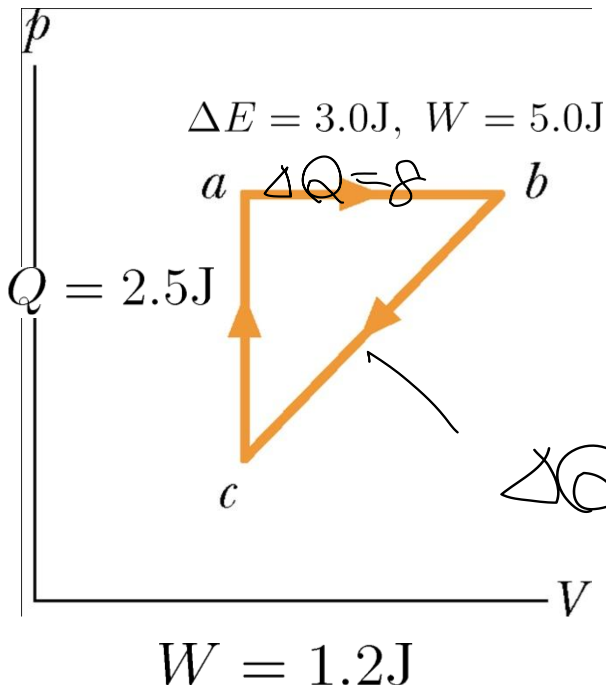
$W_A = 3p_0V_0$

$W_B = \frac{15}{8}p_0V_0$

$W_C = \frac{3}{4}p_0V_0$

Problem

$\Delta Q = \Delta W$
$= 1.2J$



ab, bc를 따라갈 때 전달된 열에너지는?

$\Delta Q = \Delta E_{int} + \Delta W$

$= 3.0 + 5.0 = 8.0J$

$\Delta Q = \cancel{-6.8J}$

$10.5 + \Delta Q = 1.2$

$\Delta Q = 1.2 - 10.5 = -9.3J$

Ch. 19 Ideal gases

thermodynamics

Kinetic theory

statistical
physics

Avogadro's number

- 1 N_A = 1 mole을 이루는 원자 또는 분자의 개수

  = 6.02×10^{23}

  = C^{12} 12 gram 안에 들어 있는 탄소원자의 수
- 원자 수준의 미시적 세계와 거시적 세계 간의 환산인자
- It is a very very large number.

→ 大數의 법칙

몰 수 n

$$n = \frac{N}{N_A} = \frac{M_{\mathrm{sam}}}{M} = \frac{M_{\mathrm{sam}}}{mN_A}$$

ideal gas

- 질점 (내부구조나 부피 없이 질량만 있는 입자)으로 구성되어 있다.
- 분자-분자간의 상호작용은 탄성충돌 뿐이다.

  (서로 잡아 당기거나, 밀치지 않는다.)

* 밀도가 낮은 단원자 분자로 구성된 기체가 가장 근사한 예

- 이상기체 상태방정식 :

$$\boxed{pV = nRT}$$

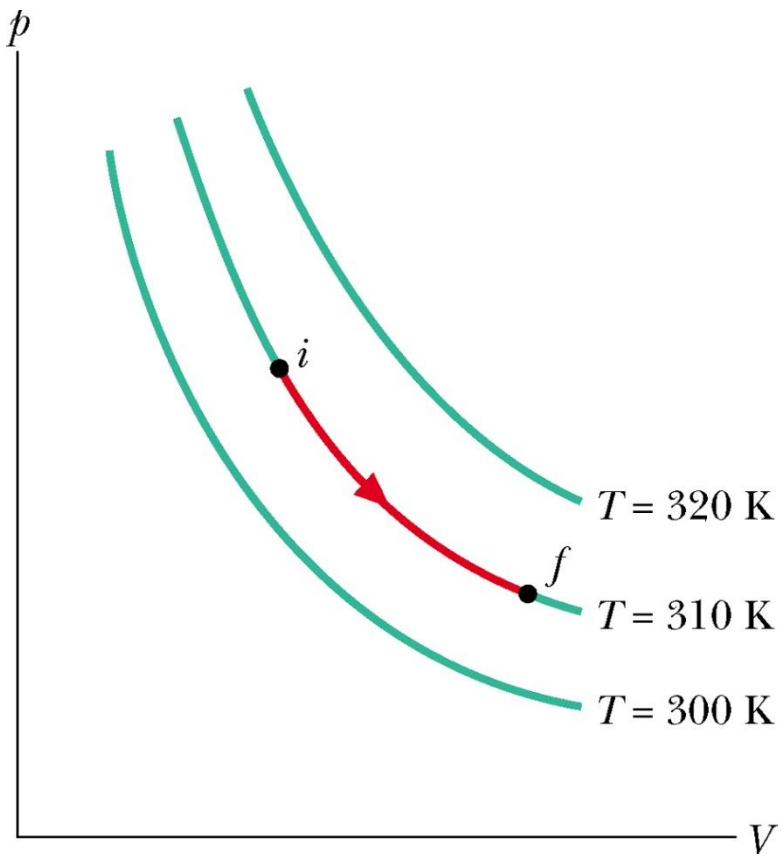
$$\boxed{pV = Nk\,T}$$

$$R = 8.31\ \mathrm{J/mole\cdot K}$$

$$k = \frac{R}{N_A} = 1.38\times10^{-23}\ \mathrm{J/mole\cdot K}$$

Boltzmann 상수

이상기체의 등온팽창



$$p = nRT\frac{1}{V}$$

$$\begin{aligned} W &= \int_{V_i}^{V_f} p dV = \int_{V_i}^{V_f} \frac{nRT}{V} dV \\ &= nRT \int_{V_i}^{V_f} \frac{dV}{V} = nRT \ln\frac{V_f}{V_i} \end{aligned}$$

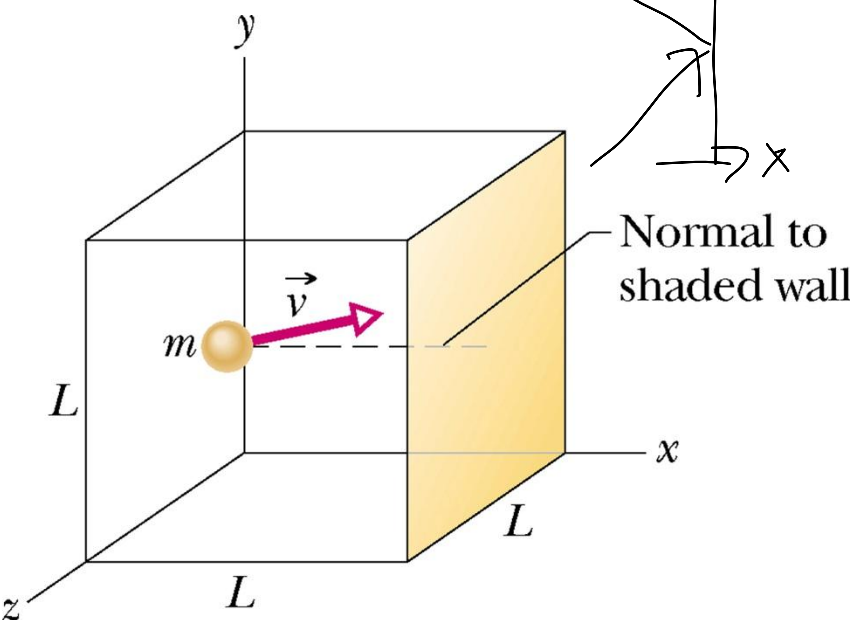
참고:

등적과정 $W = 0$

등압과정 $W = p(V_f - V_i) = p\Delta V$

$\langle v^2\rangle = \langle v_x^2\rangle + \langle v_y^2\rangle + \langle v_z^2\rangle = 3\langle v_x^2\rangle$ $\quad v_{rms} = \sqrt{\langle v^2\rangle}$

압력, 온도 및 rms 속력



입자 한 개가 충돌할 때 운동량 변화

$$\Delta p_x = -mv_x - mv_x = -2mv_x$$

입자의 왕복시간 $\quad \Delta t = 2L/v_x$

평균 단위시간당 전달된 선운동량

$$\frac{\Delta p_x}{\Delta t} = \frac{2mv_x}{2L/v_x} = \frac{mv_x^2}{L}$$

$$p = \frac{F_x}{L^2} = \frac{m}{L^3}(v_{x1}^2 + v_{x2}^2 + \cdots + v_{xN}^2) \qquad nN_A \text{ 개}$$

$$= \frac{nmN_A}{L^3}(v_x^2)_{\text{avg}} = \frac{nM(v_x^2)_{\text{avg}}}{V} = \frac{nM(v^2)_{\text{avg}}}{3V}$$

$$v^2 = v_x^2 + v_y^2 + v_z^2$$

$$\frac{nRT}{V} = \boxed{p = \frac{nMv_{\text{rms}}^2}{3V}, \quad v_{\text{rms}} = \sqrt{\frac{3RT}{M}}}$$

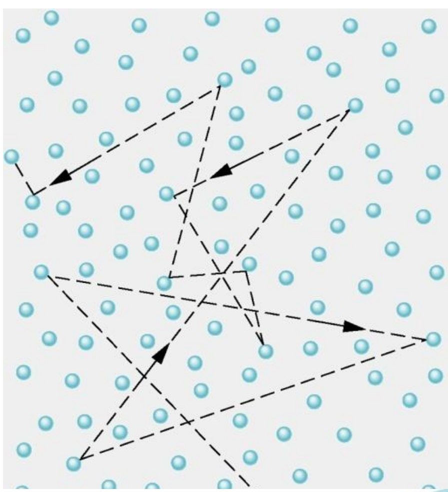
$E_{int} = \frac{3}{2}NkT$

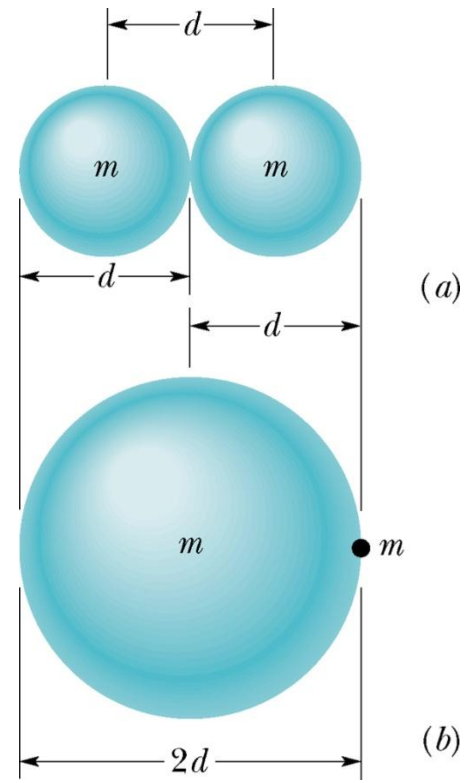
Translational kinetic energy

$E_{int} =$ $$\boxed{K_{avg} = \frac{1}{2}m(v^2)_{avg} = \frac{1}{2}mv_{rms}^2 = \left(\frac{1}{2}m\right)\frac{3RT}{M} = \frac{3}{2}kT}$$

Mean free path

$$\lambda = \frac{1}{\sqrt{2}\pi d^2 N/V}$$





$$\lambda = \frac{v\Delta t}{\pi d^2 v \Delta t N/V} = \frac{1}{\pi d^2 N/V}$$

$$v_{rel} = \sqrt{2}v_{avg}$$