Exercise - 6

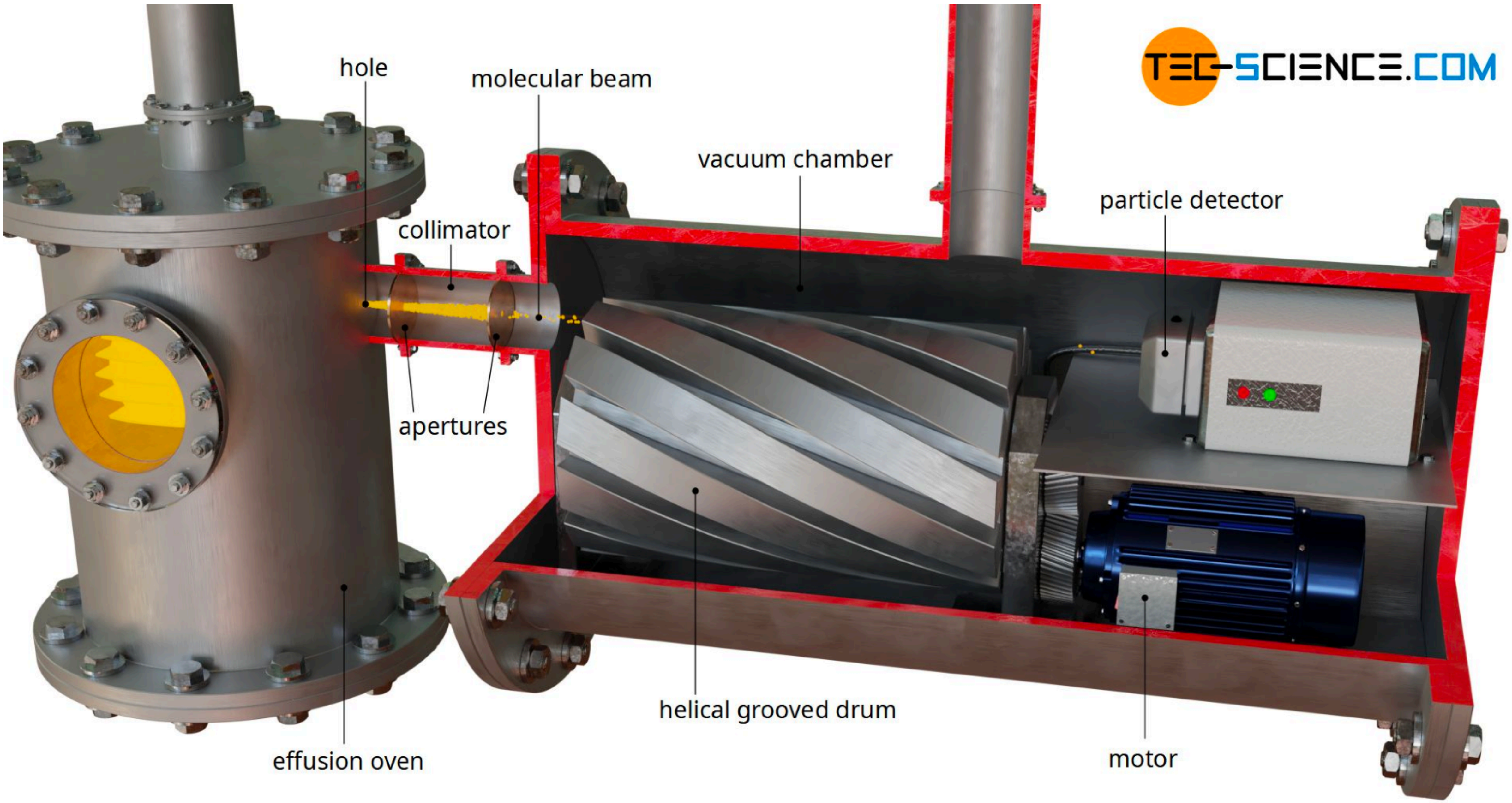
A certain ideal gas has a molar specific heat of $C_v = 7R/2$. A 2.00-mol sample of the gas always starts at pressure 1.00×10^5 Pa and temperature 300 K. For each of the following processes, determine (a) the final pressure, (b) the final volume, (c) the final temperature, (d) the change in internal energy of the gas, (e) the energy added to the gas by heat, and (f) the work done on the gas. of

(i) the gas is heated at constant pressure to 400 K,
(ii) the gas is heated at constant volume to 400 K,
(iii) the gas is compressed at constant temperature to 1.20×10^5 Pa,
(iv) the gas is compressed adiabatically to 1.20×10^5 Pa.

Exercise - 6

Distribution of molecular speeds

Thus far, we have considered only average values of the energies of all the molecules in a gas and have not addressed the distribution of energies among individual molecules.

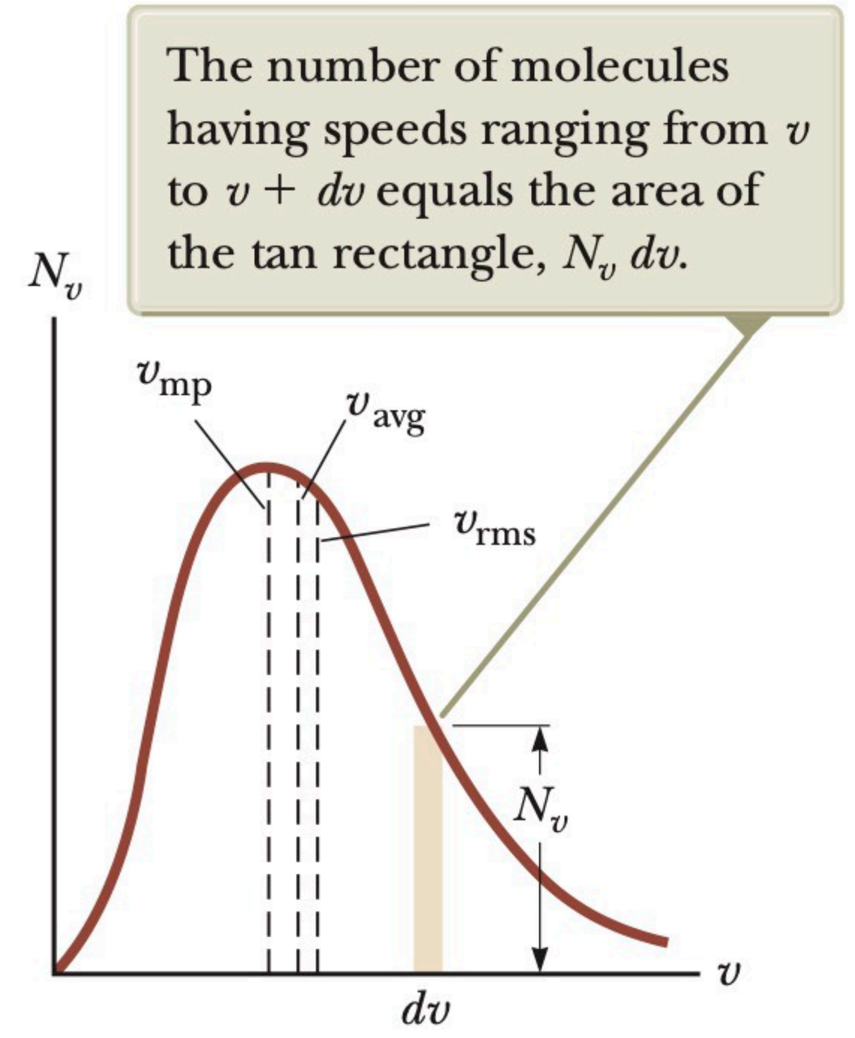


Distribution of molecular speeds

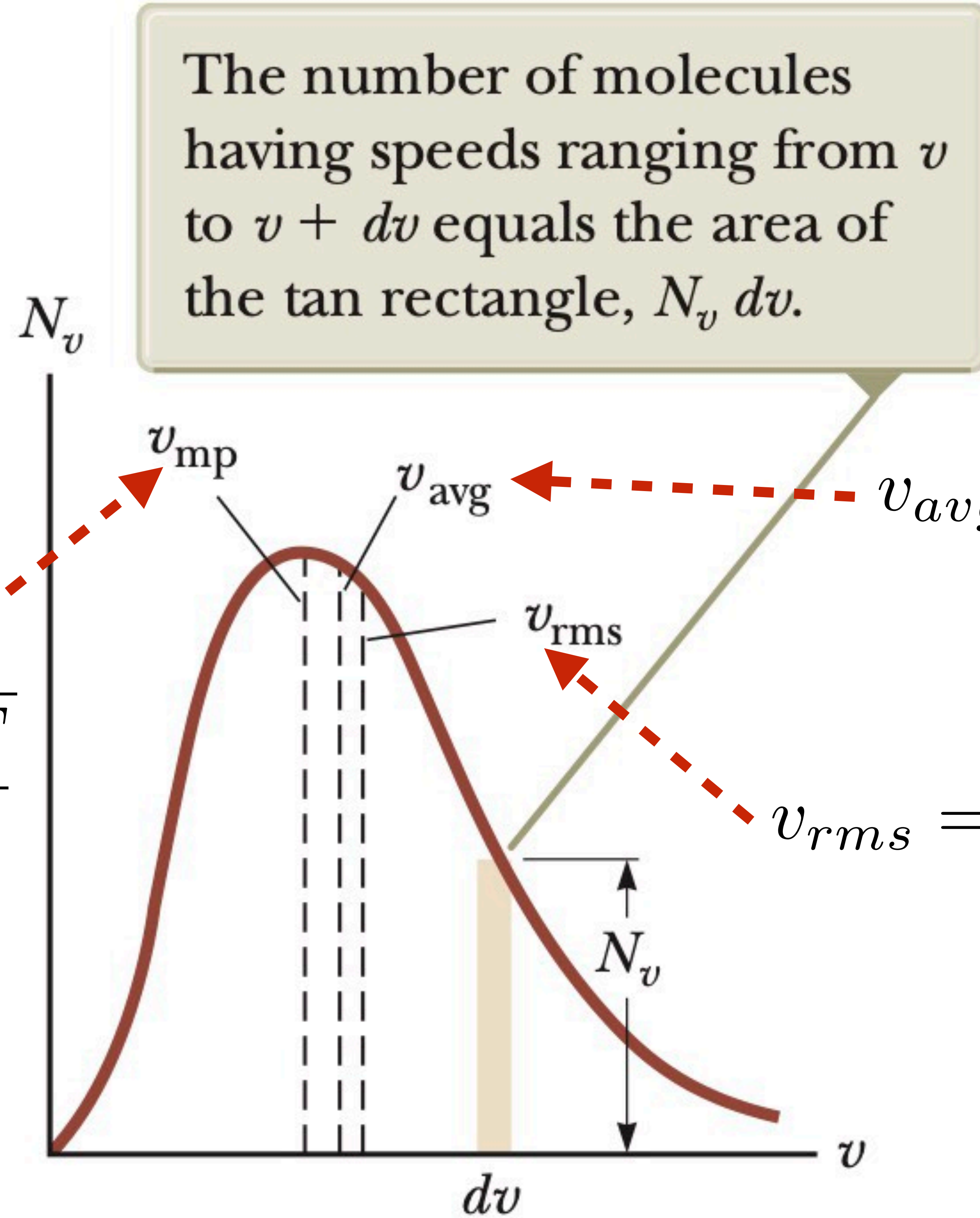
The fundamental expression that describes the distribution of speeds of N gas molecules is

$$N_v = 4\pi N \left(\frac{m_0}{2\pi k_B T}\right)^{3/2} v^2 e^{-m_0 v^2/2k_B T}$$

Maxwell–Boltzmann speed distribution function. If N is the total number of molecules, the number of molecules with speeds between v and $v + dv$ is $dN = N_v dv$.



Distribution of molecular speeds

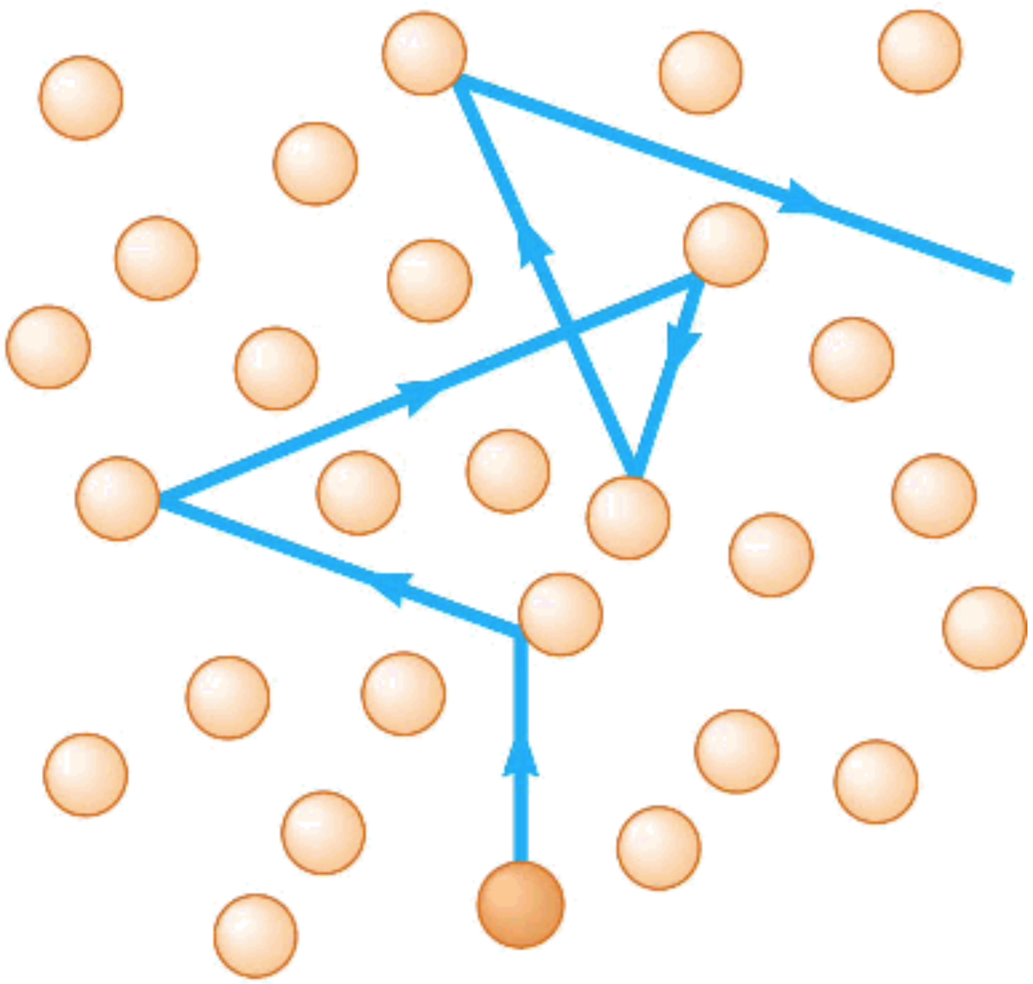


$$v_{mp} = \sqrt{\frac{2k_BT}{m_0}}$$

$$v_{avg} = \sqrt{\frac{8k_BT}{\pi m_0}}$$

$$v_{rms} = \sqrt{\frac{3k_BT}{m_0}}$$

Mean free path



The mean free path, of a molecule is the average distance that a molecule travels before colliding with another molecule. It is given by

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

where d is the diameter of the molecule and N/V is the number of molecules per unit volume. The number of collisions that a molecule makes with other molecules per unit time, or collision frequency f, is given by $f = v_{avg}/\lambda$

Exercise - 7

Twenty particles, each of mass m_0 and confined to a volume V, have various speeds: two have speed v, three have speed $2v$, five have speed $3v$, four have speed $4v$, three have speed $5v$, two have speed $6v$, and one has speed $7v$. Find (a) the average speed, (b) the rms speed, (c) the most probable speed, (d) the average pressure the particles exert on the walls of the vessel, and (e) the average kinetic energy per particle.

Exercise - 7

Exercise - 8

If the diameter of an oxygen molecule is 2.00×10^{-10} m,
(a) find the mean free path of the molecules in a scuba tank that has a volume of 12.0 L and is filled with oxygen at a gauge pressure of 100 atm at a temperature of 25.0°C,
(b) what is the average time interval between molecular collisions for a molecule of this gas?

Exercise - 8