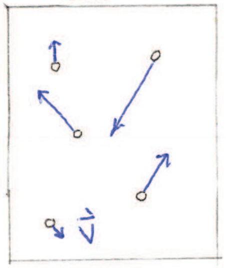
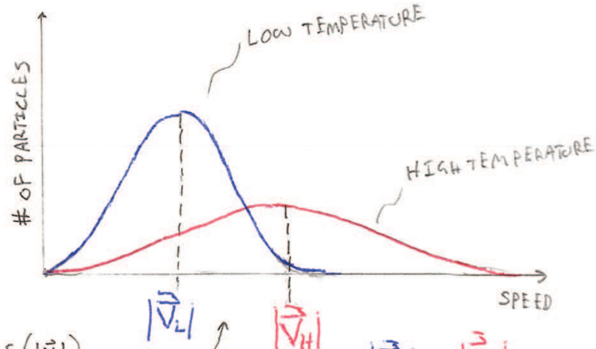
KINETIC THEORY OF GASES

GAS





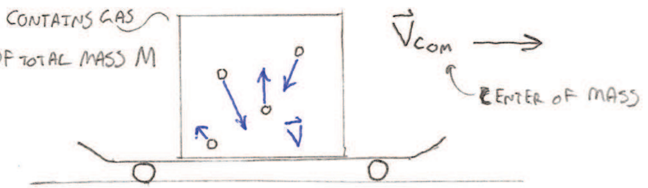
- RANDOM MOTION
- DISTRIBUTION OF SPEEDS $(|\vec{v}|)$

$|\vec{V}_L| < |\vec{V}_H|$

$T_L < T_H$

- THERMAL ENERGY (E_{TH}) — MEASURE OF MICROSCOPIC KE_{TR}

CONTAINS GAS OF TOTAL MASS M



- MACROSCOPIC TRANSLATIONAL KE OF GAS $= \frac{1}{2} M |\vec{V}_{com}|^2$
- AVERAGE MICROSCOPIC TRANSLATIONAL KE OF GAS $= \frac{1}{2}\bar{m}\, v_{RMS}^2$

$$\overline{KE}_{TR} = \frac{\sum_i \frac{1}{2} m_i v_i^2}{N} = \frac{1}{2}\bar{m}\, v_{RMS}^2$$

$N \equiv$ # OF PARTICLES

ROOT MEAN SQUARE $\}$ $v_{RMS} \approx \sqrt{v_{AVG}^2}$

- E^{TH} IS THE MEASURE OF MICROSCOPIC $\overline{KE}_{TR}$

$$E^{TH} = N\,\overline{KE}_{TR} = N \frac{1}{2}\bar{m}\, v_{RMS}^2$$

MONATOMIC GAS

BOLTZMANN POSTULATE

- EACH DEGREE OF FREEDOM PER PARTICLE CONTRIBUTES $\frac{1}{2}k_BT$ TO E^{TH}

TEMPERATURE $[K] \equiv T$ *SI UNIT → KELVIN

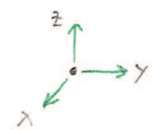
MACROSCOPIC MEASURE OF AVERAGE MICROSCOPIC KE_{TR}

BOLTZMANN'S CONSTANT $\frac{[M][L]^2}{[T]^2[K]} \equiv k_B$

$$k_B \approx 1.38 \times 10^{-23} \frac{kg\,m^2}{s^2\,K}$$

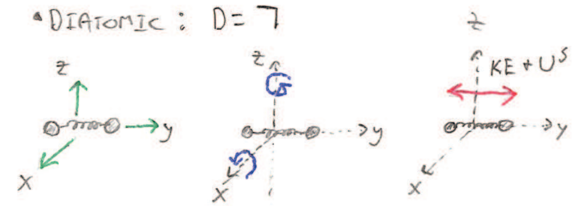
DEGREE OF FREEDOM [UNITLESS] $\equiv D$

- MONATOMIC : $D = 3$



3 TRANSLATIONAL

- DIATOMIC : $D = 7$



3 TRANSLATIONAL | 2 ROTATIONAL | 2 VIBRATIONAL

$$E^{TH} = N D \frac{1}{2} k_B T$$

COMBINE KINETIC THEORY OF GASES AND BOLTZMANN POSTULATE

- MICROSCOPIC (MONATOMIC GAS):

$$E^{TH} = N\,\overline{KE}_{TR} = N\frac{1}{2}\bar{m}\, v_{RMS}^2$$

- MACROSCOPIC (MONATOMIC GAS):

$$E^{TH} = \frac{3}{2} N k_B T$$

- MICRO = MACRO

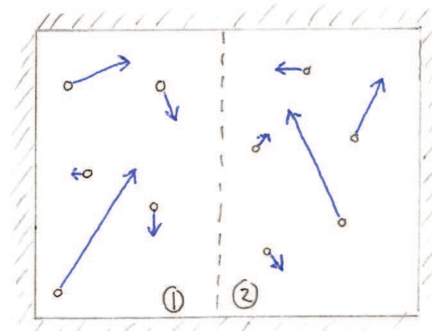
$$\cancel{N}\cancel{\tfrac{1}{2}}\bar{m}\, v_{RMS}^2 = \cancel{N}\tfrac{3}{\cancel{2}} k_B T$$

$$\bar{m}\, v_{RMS}^2 = 3 k_B T$$

THERMAL EQUILIBRIUM

- SAME $\overline{KE}_{TR}$ PER PARTICLE RESULTS IN SAME T

EXAMPLE: CLOSED SYSTEM WITH 2 REGIONS ISOLATED FROM SURROUNDINGS.



$$\underbrace{\overline{KE}_{1_{TR}} = \overline{KE}_{2_{TR}}}$$

$$T_1 = T_2$$