- **1 Mole [mol]** of any substance contains the same number of molecules , called **Avogadro Number:**

$$N_A \approx 6.02 \cdot 10^{23} \frac{1}{mol}$$

- Molar Mass, **μ [g/mol]** is the mass of 1 mole of a given substance. To find it, you need to add up **atomic weights** of all the atoms in a single molecule. Those can be found in Periodic Table.

Example:

$$\mu_{H_2 0} = (2+16)\frac{g}{mol} = 18\frac{g}{mol}$$

	Volume	Mass	Amount of Substance	Number of Molecules
Symbol	**V**	**M**	**n**	**N**
Units	[m^3] or [cm^3]	[kg] or [g]	[mol]	**1**

$$\rho = \frac{M}{V} \qquad n = \frac{M}{\mu} \qquad \nu = \frac{N}{N_A}$$

Greek ‘rho’

Greek ‘mu’

Ideal Gas Law (revisited)

Classical version (with moles)

$$PV = nRT$$

Here $n = \frac{m}{\mu}$ is amount of substance (in moles),

$R \approx 8.3 \frac{J}{mol \cdot K}$ is called Universal Gas Constant.

"Molecular" version

$$PV = Nk_bT$$

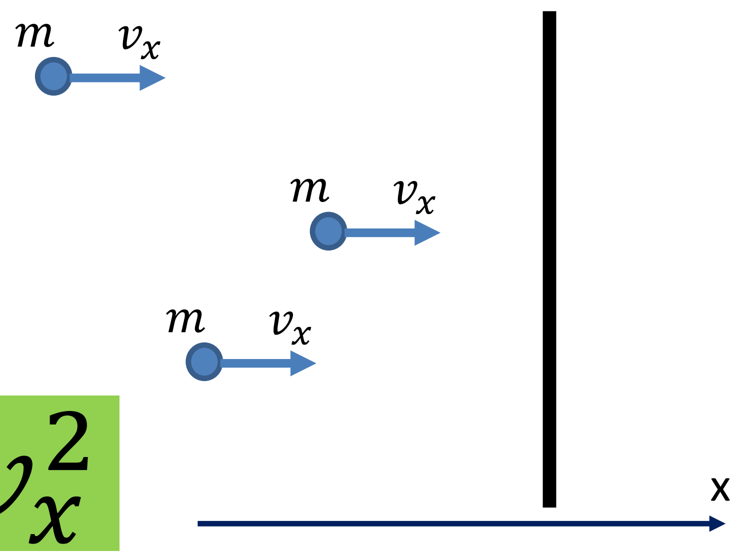
Here $N = n \cdot N_A$ is number of molecules,

$k_B = \frac{R}{N_A} \approx 1.36 \cdot 10^{-23} \frac{J}{K}$

is called Boltzmann Constant

Kinetic energy per degree of freedom is

$$\frac{mv_x^2}{2} = \frac{k_bT}{2}$$



$$PV = Nmv_x^2$$

Results of Boltzmann's kinetic theory: pressure of molecules bombarding the wall.

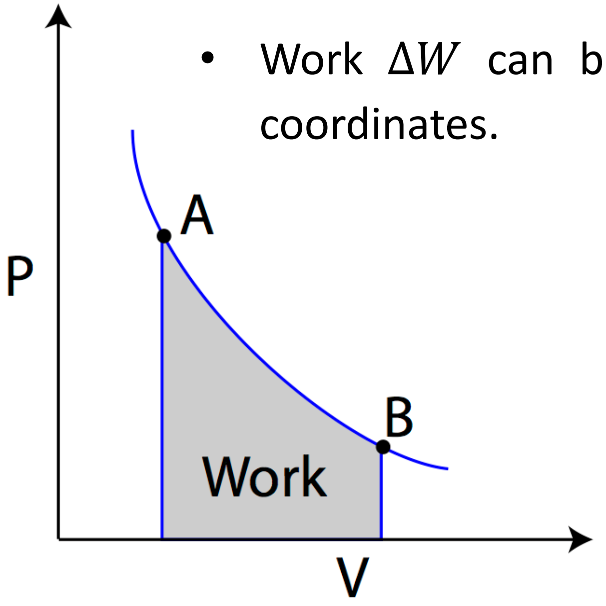
Applying the 1st Law of Thermodynamics to ideal gas

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

- ΔQ - total heat adsorbed by gas

- ΔE – change in internal energy, $\Delta E = \mathrm{n}C_V\Delta T$. Here C_V is specific heat per mole at constant volume, can be found as $C_V = \mathrm{dR}/2$ (d-number of degrees of freedom per molecule, R is universal gas constant)

- Work ΔW can be found as an integral $\int PdV$, or area under P(V) plot coordinates.



Problem 1

What is the number of molecules in a room of size 4x5x2.5 meters, at normal conditions (*T=300K, P= 100kPa*)? Find the total kinetic energy of these molecules, associated with translational motion and rotation (most of those molecules are nitrogen and oxigen).

Problem 2

Below is PV diagram for 1 mole of gas. Find the change in internal energy , work done by the gas, and the total heat adsorbed by it during this process. Initial and final states are: (0.02 m^3, 100 kPa) and (0.03 m^3, 150 kPa). Specific heat of gas at constant volume is C_V =20 J/K/mol. Note that PV=RT for for n=1 mole.