Statistical Physics

PHYS:3730

https://uiowa.instructure.com/courses/213176

Thermodynamics

interactions of heat, work, energy

heat = fundamental form of energy

Statistical Mechanics:

thermodynamics from microscopic physics of many particles or degrees of freedom

heat = random motion of particles

Temperature: quantified by change in a measurable quantity, such as height of Hg, electrical resistance, etc.

Thermometer: object whose properties change with temperature

Thermal Equilibrium: When objects in contact reach the same temperature

Relaxation Time: the time it takes to reach thermal equilibrium

Heat: energy that flows spontaneously from hotter objects to colder objects for them to reach equilibrium

Temperature scales

Fahrenheit: freeze water at 32 °F   at 1 atm
boil water at 212 °F   pressure

Celsius: freeze water at 0 °C   at 1 atm
boil water at 100 °C   pressure

Kelvin: 0 K minimum ← limit low T
steps of 1 °C
freeze water at 273.15 K

ideal gas
purely from measurements
empirical

Pressure: force per area

$$R = 8.31 \frac{J}{mol \cdot K}$$

$$[PV] = \frac{F}{L^2} \cdot L^3 = F \cdot L$$

= energy

$$P\,V = n\,R\,T$$

Volume

Temperature in K

number of moles. Amount of stuff, now known to be

$$1 \text{ mol} = 6.022 \times 10^{23} \text{ molecules}$$

$$\text{Avogadro's number} = N_A = 6.022 \times 10^{23}$$

\# of molecules $N = n\,N_A$ n = # of moles

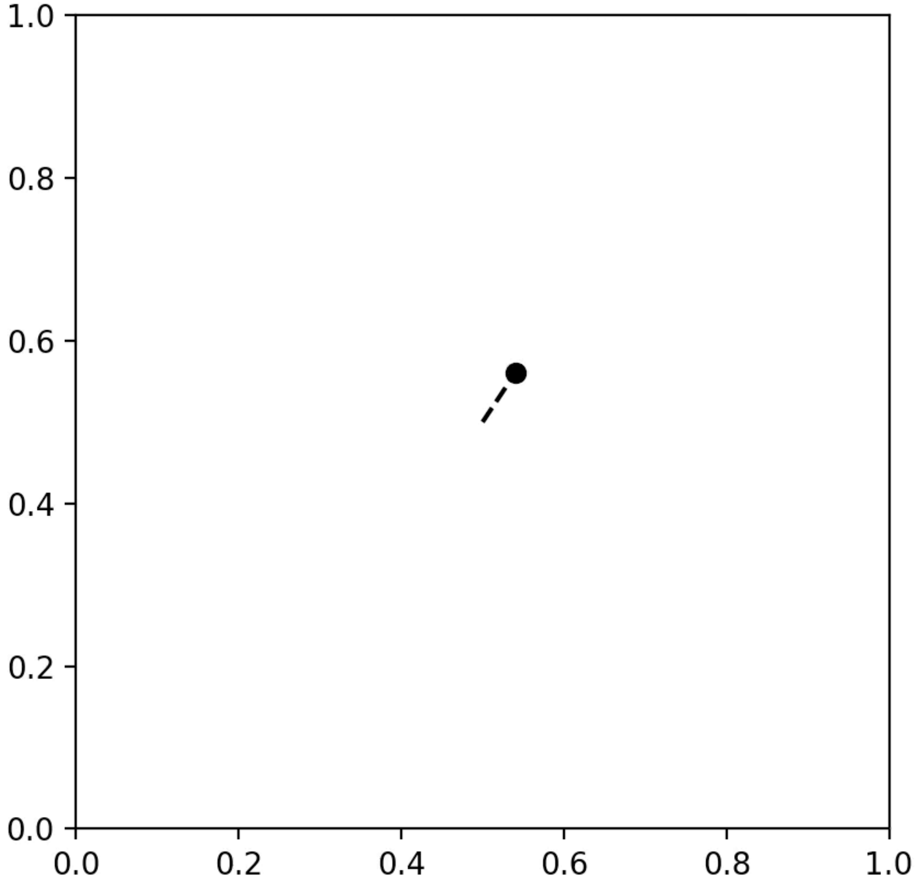
N_A = Avogadro's #

$$PV = N\left(\frac{R}{N_A}\right)T$$

$$PV = N(k)T$$

$$k = 1.381 \times 10^{-23}\ \mathrm{J/K}$$
$$= 8.617 \times 10^{-5}\ \mathrm{eV/K}$$

Boltzmann's constant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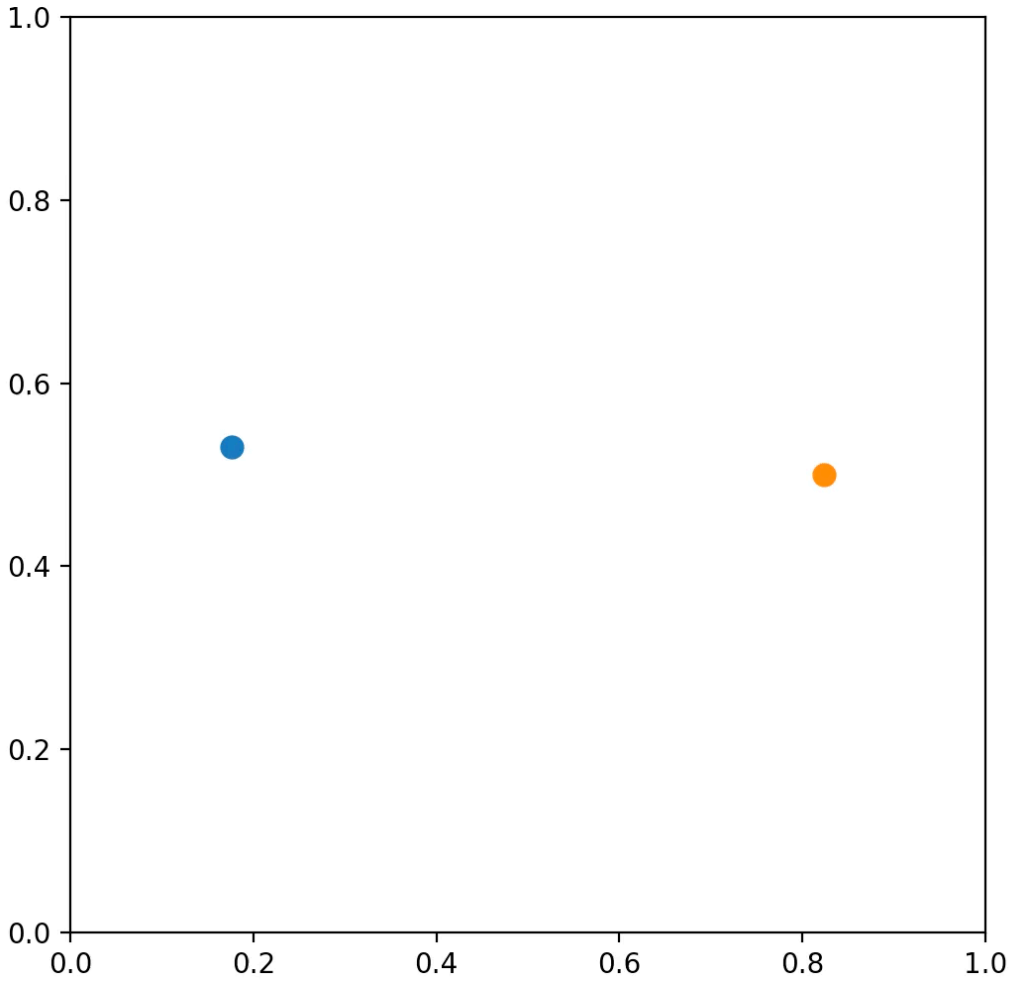
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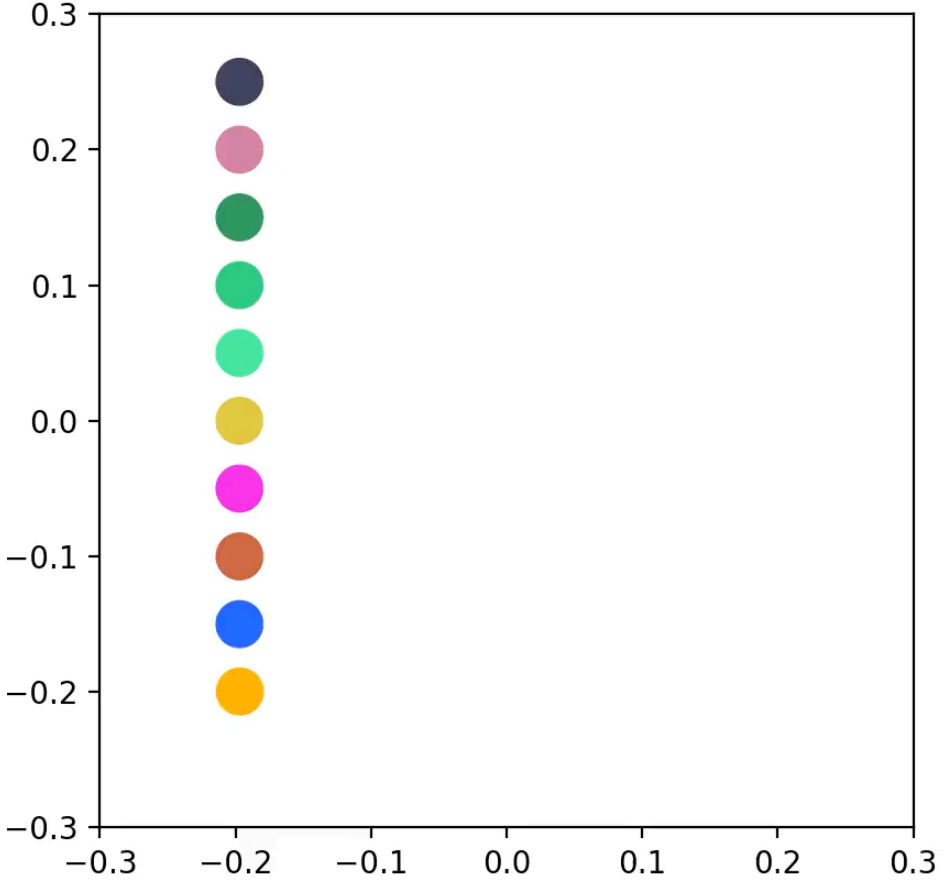
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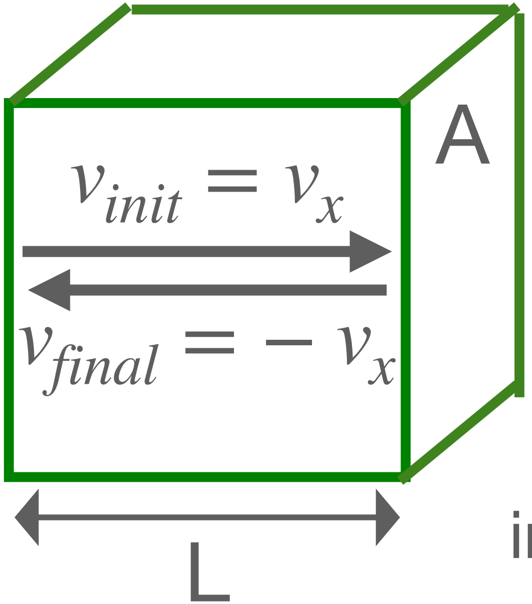

Assume a molecule makes many round trips before colliding with another molecule

time between collisions with one wall

$$\Delta t = \frac{2L}{v_x}$$

impulse per collision: $\Delta p = m(v_x - (-v_x)) = 2v_x$

$$P = \frac{F_x}{A} = \frac{\Delta p / \Delta t}{A} = \frac{m v_x^2}{AL}$$

$$PV = Nm\overline{v_x^2} = NkT$$

$$KE = N\frac{1}{2}m\bar{v}_x^2 = N\frac{1}{2}kT$$

$$KE = N\left(\frac{1}{2}m\bar{v}_x^2 + \frac{1}{2}m\bar{v}_y^2 + \frac{1}{2}m\bar{v}_z^2\right) = N\frac{3}{2}kT$$