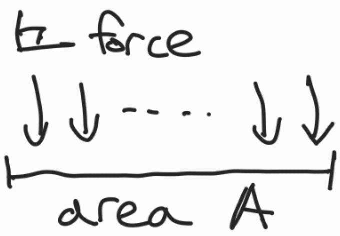
LESSON 1-4 : Gas Laws and Kinetic Theory

Gas Pressure

pressure = $\dfrac{\text{force perpendicular to the area}}{\text{contact area}}$ $\Rightarrow$ $\overset{(Pa)}{P} = \dfrac{F\ (N)}{A\ (m^2)}$

unit of pressure : Pascal (Pa) $\quad 1\ Pa = 1\ N/m^2$

unit of force : Newton (N)



Ex : If 500 N force is exerted on $0.2\,m^2$ what is the pressure?

Ans : $500\,N / 0.2\,m^2 = \underline{\underline{2500\ Pa}}$

Gas pressure is due to molecular collisions on the container's wall

balloon
氣球

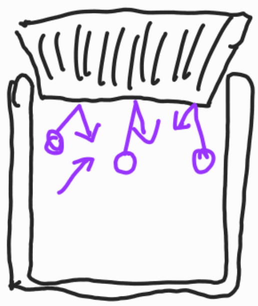
Total force exerted : molecules collisions (F)

Total Area : area of ballon (A)

$P = F/A$

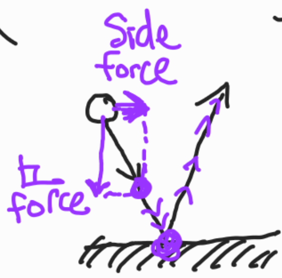
lid

cup



$\dfrac{\text{Total molecules collisions on the lid}}{\text{Area of the lid}} = \underline{P_{lid}}$

Note : Perpendicular Force Component Only



Gas Laws

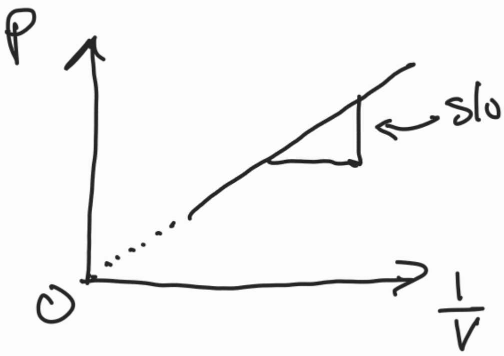
Boyle's Law

(for a given amount of gas)

$$\boxed{p_1 V_1 = p_2 V_2} = \text{constant}$$

(before) (after) (fixed T)

p : pressure (Pa) V: volume (m^3) Temperature : (K)



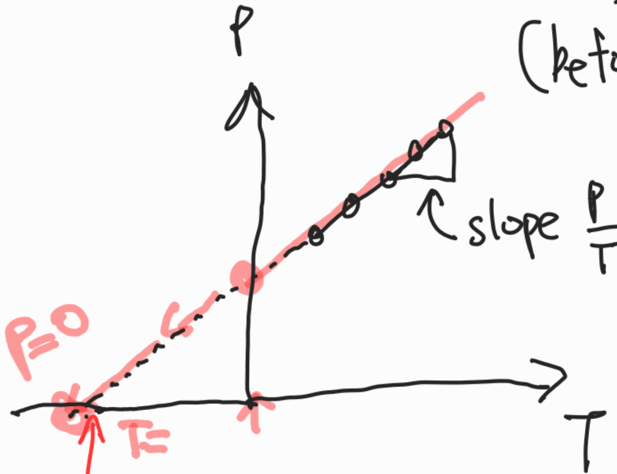
slope $= \frac{P}{1/V} = PV =$ constant

Example : A hydrogen balloon gets bigger when it goes higher in the air (lower pressure)

Pressure Law

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} = \text{constant}$$

(before) (after) (fixed V)



slope $\frac{P}{T}$

zero pressure

bsolute zero temp $\underline{-273°C}$

$-273°C = 0\,K$

Therefore $\underbrace{K + 273 = °C}$

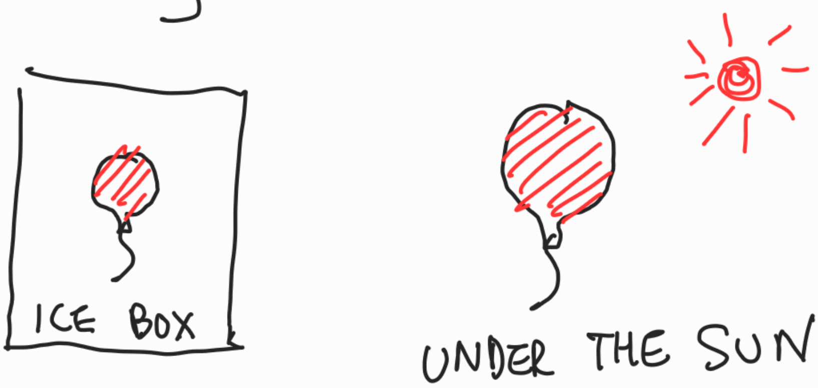
kelvin scale

Example : Spray Paint Can gets cold after continuous spraying

Charles' Law

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} = \text{constant} \quad (\text{for fixed } p)$$

Example: Balloon gets small in a freezer, gets big in hot weather



Gas Law

$$\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2} \quad (T_1, T_2 \text{ are in } K)$$

Combine the 3 laws together, we get the Gas Law

Ideal Gas Law

for all kinds of gases

$$\frac{pV}{T} = \text{constant} = nR$$

n: number of moles — see ideal gas model

R: $8.31\ J K^{-1} mol^{-1}$ universal gas constant

Kinetic Theory (K.T.) equation (under ideal gas model)

$$pV = \frac{1}{3} N m \langle v^2 \rangle_{rms}$$

p: pressure

V: volume

N: no of molecules

v: speed of molecules

Ideal Gas Model

Assumptions made. Quite different from reality

1. Number of molecules very large
   They are all in random motion
2. Molecules size (negligible)
3. Molecules far apart (no attraction)
4. Total elastic wall
5 Collision time negligible
6. gravity negligible

One mole of gas $= 6.02 \times 10^{23}$ molecules
$= N_A$

Kinetic Theory Equation

$$\boxed{pV = nRT = \frac{1}{3} M V_{rms}^2}$$

Average Translation KE per mole

$$N_A \times \boxed{\frac{1}{2} m \langle v^2 \rangle_{rms}} = \frac{3}{2} RT$$

temp in K

rms = root mean square $\rightarrow$ $v_{rms} = \sqrt{v^2}$

~END~