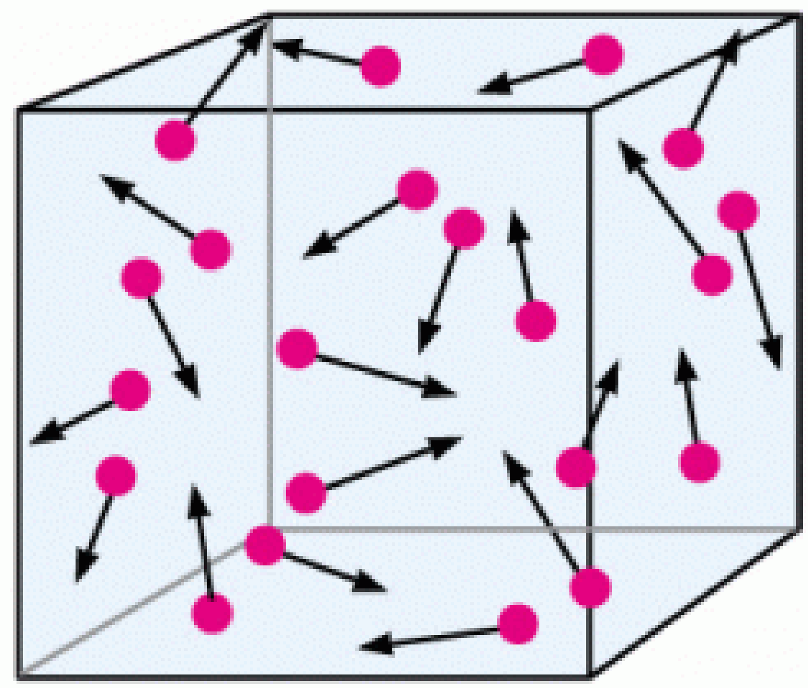
Kinetic Molecular Theory

IB PHYSICS | THERMAL PHYSICS

Kinetic Theory of Gases

Assumptions:

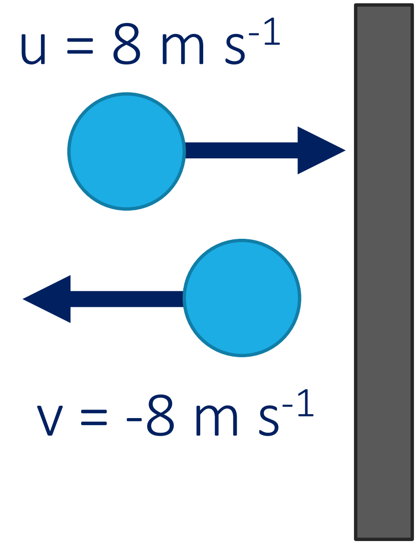
- Large # of identical molecules
- Volume of molecules is negligible
- Motion is random
- No forces between molecules
- All collisions are elastic



Review of Momentum / Collisions

What is the force of this ball on the wall?

$$Impulse = F\Delta t = \Delta p$$



m = 5 kg

Δt = 0.2 s

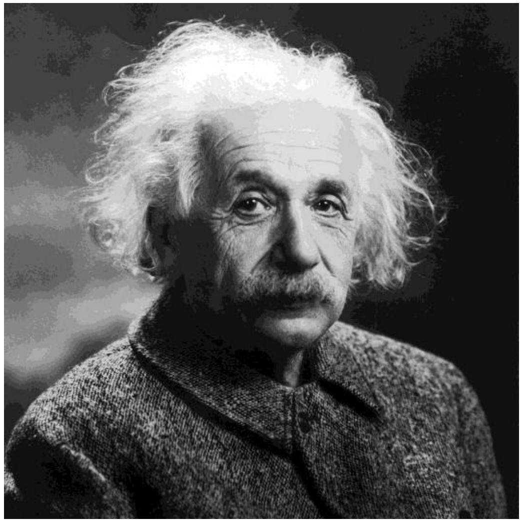
Pressure

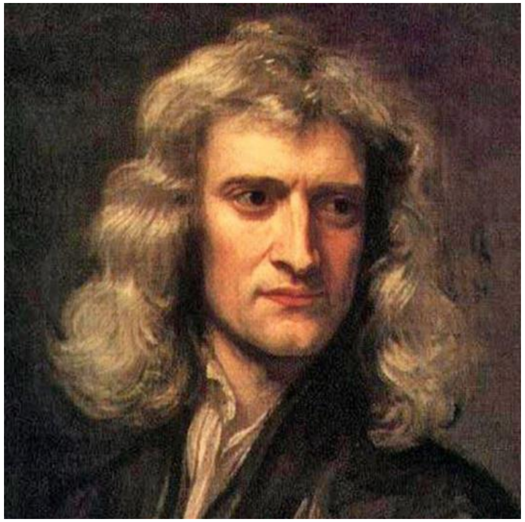
When many molecules collide with the sides of a container it is measured as **pressure**

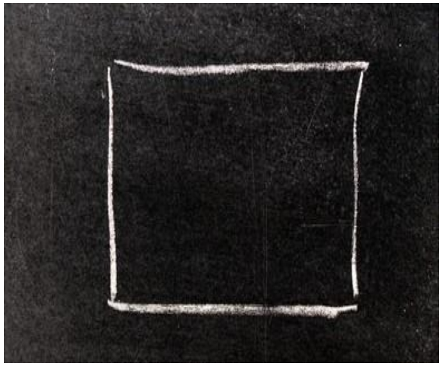
Quantity	Symbol	Unit	
Force			
Area			
Pressure			

$$p = \frac{F}{A}$$

A brief interlude...







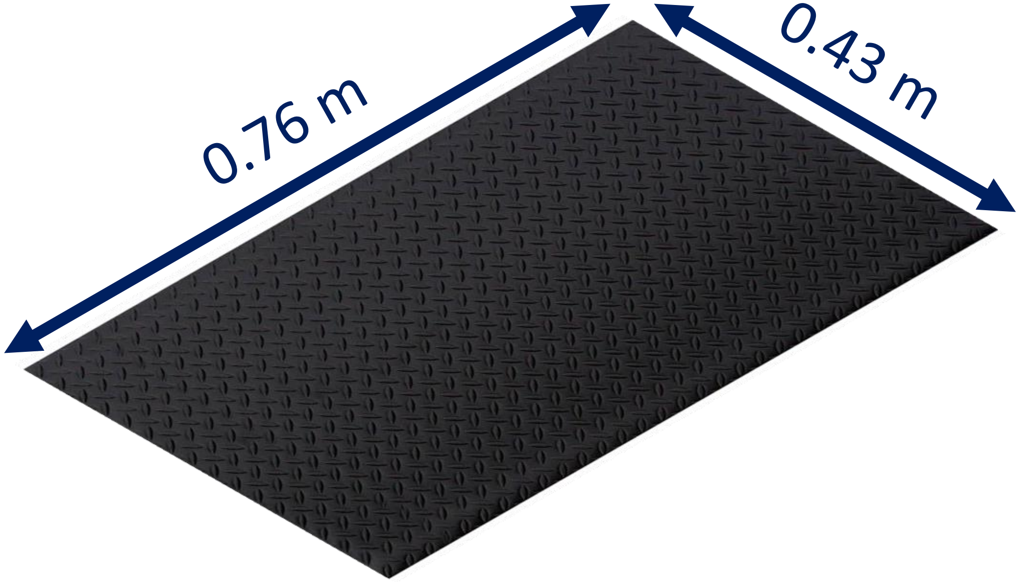
Units of Pressure

There are several different units used to measure pressure of a gas

1 atm = 101,325 Pa = 760 Torr = 760 mm Hg

Atmospheric Pressure

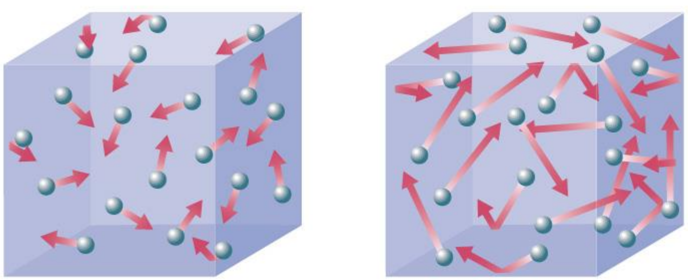
What is the force from atmospheric pressure on this doormat?



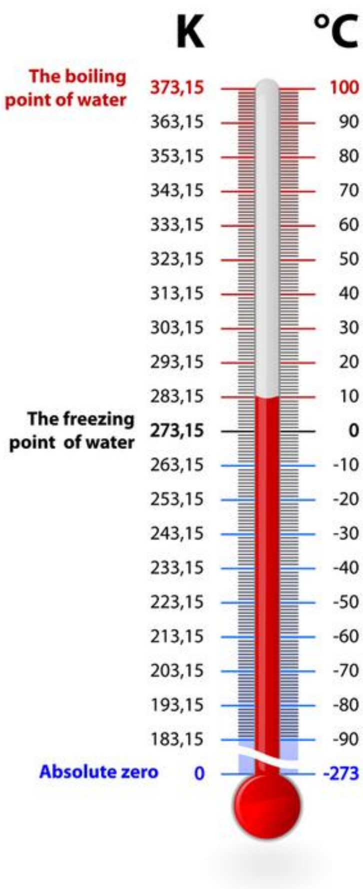
Temperature Review

Measure of how **hot** or **cold** something feels

Temperature is the average **kinetic energy** of the molecules of a substance



Kelvin Scale (K)



Average Kinetic Energy

$$\bar{E}_K = \frac{3}{2}k_B T$$

$k_B \rightarrow Boltzmann's\ constant$

$k_B = 1.38 \times 10^{-23}\ J\ K^{-1}$

Quantity	Symbol	Unit
Average Kinetic Energy		
Absolute Temperature		

IB Physics Data Booklet

Sub-topic 3.1 – Thermal concepts	Sub-topic 3.2 – Modelling a gas
$Q = mc\Delta T$ $Q = mL$	$p = \frac{F}{A}$ $n = \frac{N}{N_A}$ $pV = nRT$ $\bar{E}_K = \frac{3}{2}k_B T = \frac{3}{2}\frac{R}{N_A}T$

Quantity	Symbol	Approximate value
Acceleration of free fall (Earth's surface)	g	$9.81\ \text{m s}^{-2}$
Gravitational constant	G	$6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$
Avogadro's constant	N_A	$6.02 \times 10^{23}\ \text{mol}^{-1}$
Gas constant	R	$8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$
Boltzmann's constant	k_B	$1.38 \times 10^{-23}\ \text{J K}^{-1}$

Try This | 1

Calculate the average translational kinetic energy of molecules in the air at 27°C

What is Kinetic Energy?

$$\bar{E}_K = \frac{3}{2} k_B T$$

$k_B \rightarrow Boltzmann's\ constant$

$k_B = 1.38 \times 10^{-23}\ J\ K^{-1}$

Try This | 2

Calculate the average speed for oxygen molecules at 0°C. (the mass of an oxygen molecule is 5.32×10^{-26} kg)

Which molecules move faster?

H_2 gas at 23°C

1
H
1.01

O_2 gas at 23°C

8
O
16.00

Lesson Takeaways

- ❑ I can describe the conditions necessary for a substance to be considered an ideal gas
- ❑ I can define pressure with appropriate fundamental and derived units
- ❑ I can relate average molecular kinetic energy with absolute temperature
- ❑ I can calculate the average molecule speed for a molecule at a certain temperature
- ❑ I can discuss how the mass of a molecule changes its overall speed at a given temperature