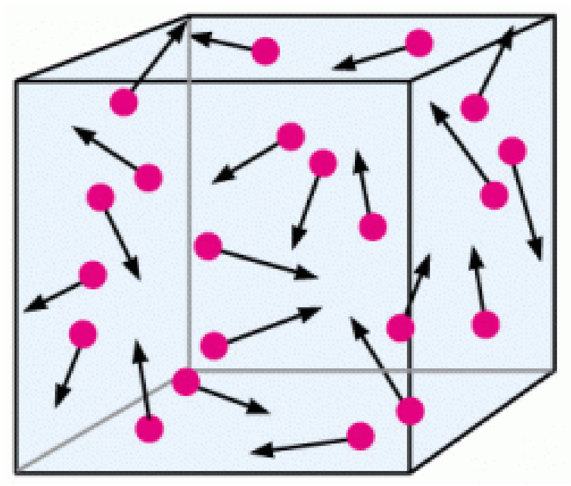
Gas Laws

IB PHYSICS | THERMAL PHYSICS

Ideal Gas

Assumptions:

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

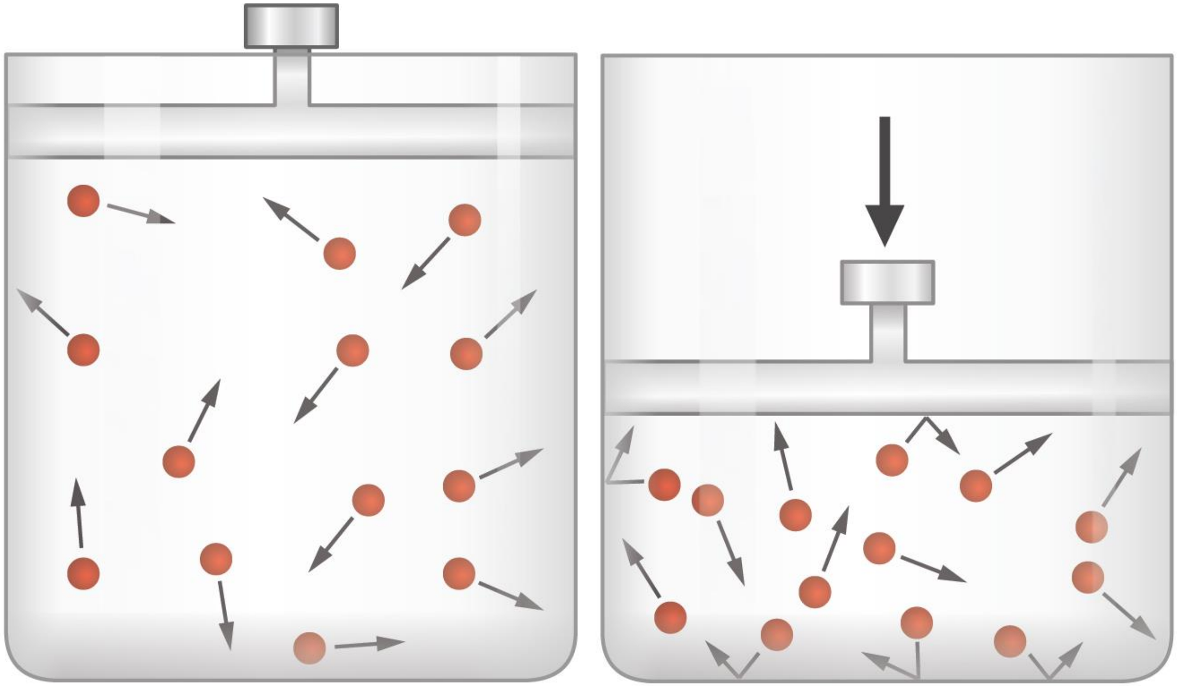


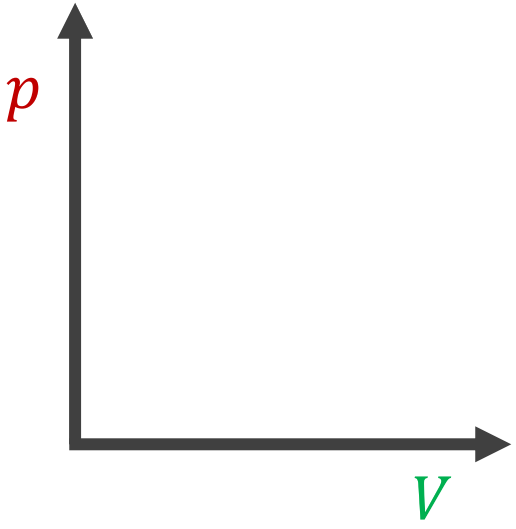
No longer ideal when…

Boyle's Law | Volume and Pressure

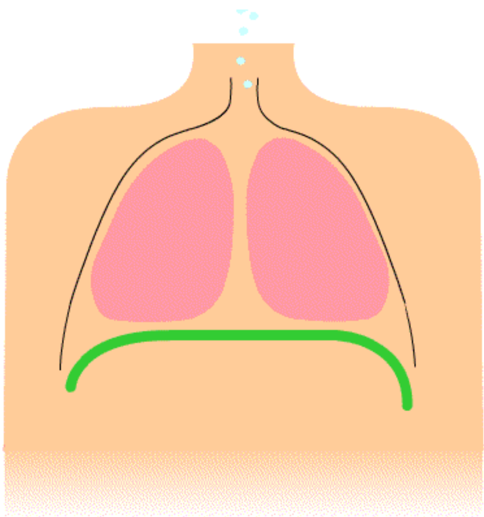
Volume

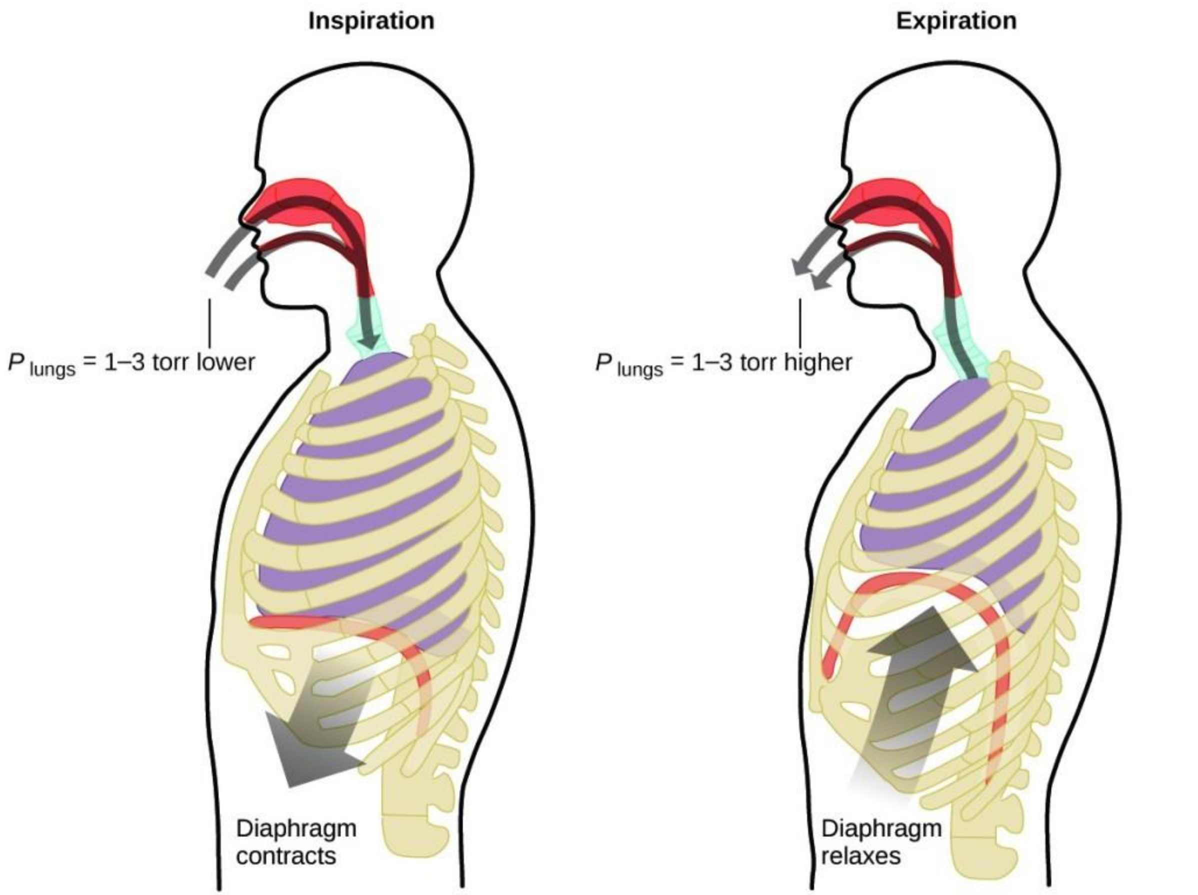
Pressure





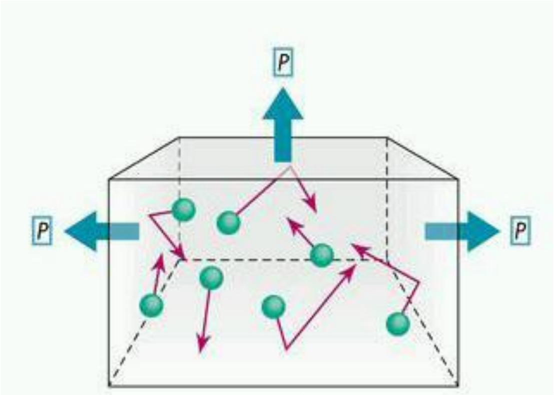
Boyle's Law | Volume and Pressure

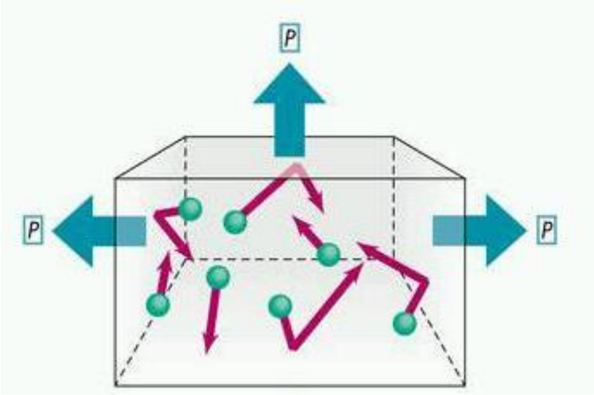


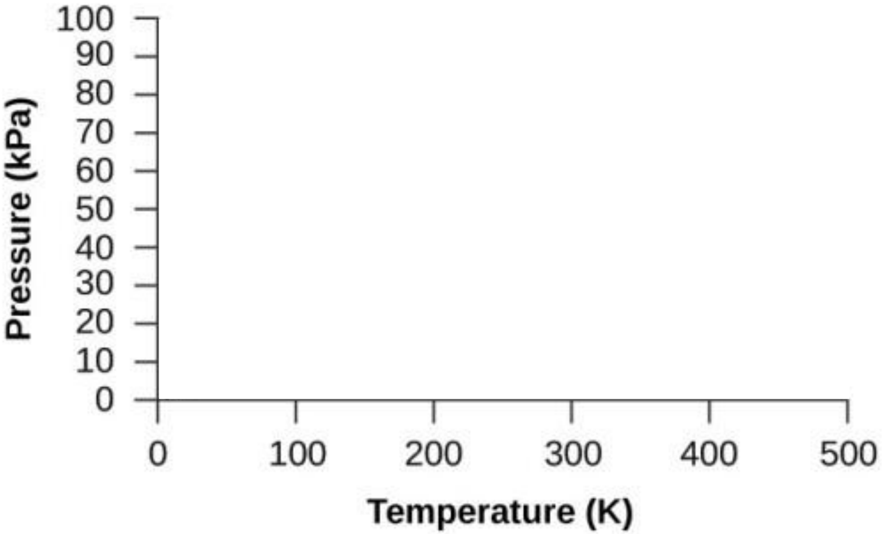


Pressure Law | Temp and Pressure

Temperature   Pressure



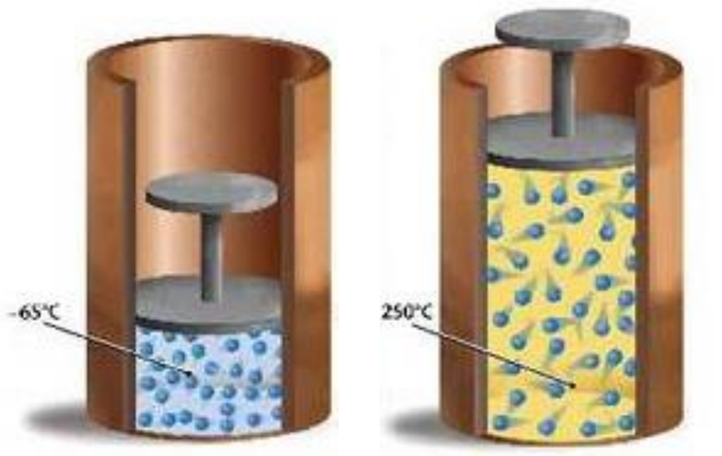


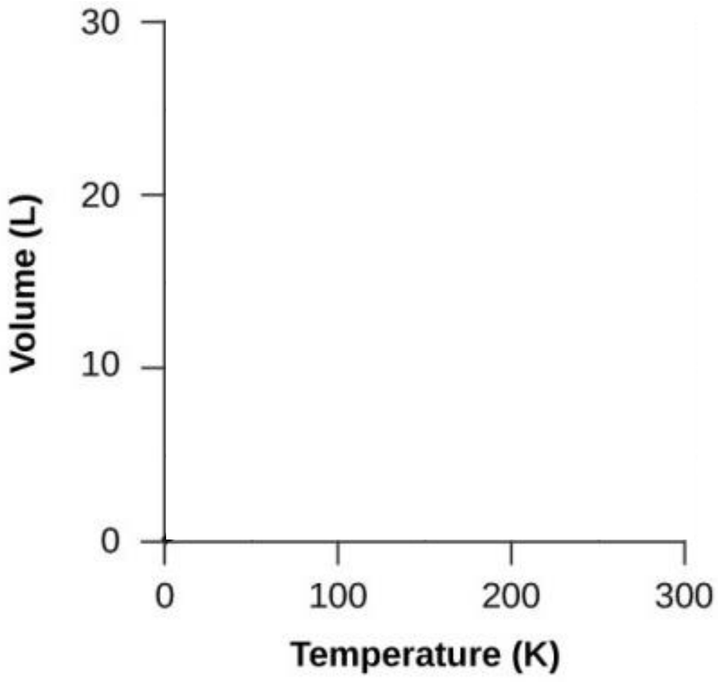


Pressure Law | Temp and Pressure

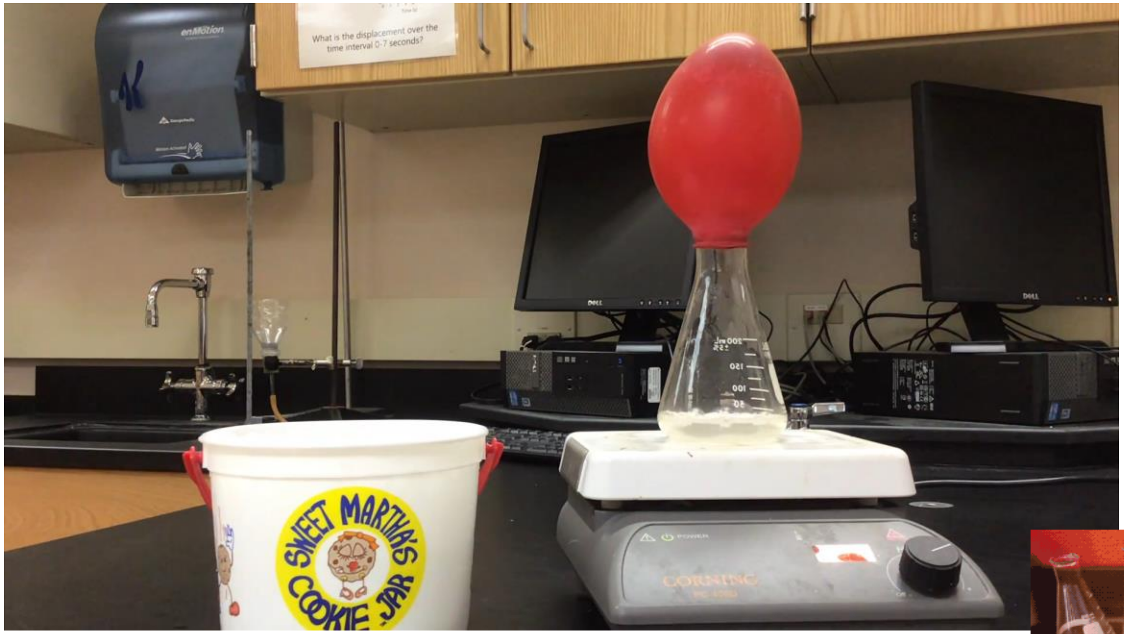
Charles's Law | Temp and Volume

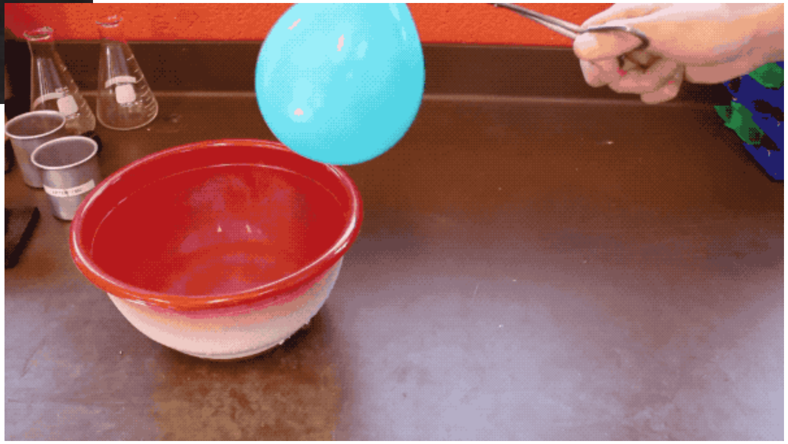
- ↑ Temperature
- Volume





Charles's Law | Temp and Volume





Ideal Gas Law

$$p \propto \frac{1}{V}$$

$$p \propto T$$

$$V \propto T$$

Ideal Gas Law

Quantity	Symbol	Unit
Pressure		
Volume		
Amount		
Temperature		

$$pV = nRT$$

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

What is the pressure of 23 mol of a gas behaving ideally in a 0.25 m^3 container at 310 K?

Change in Volume

A fixed mass of an ideal gas has a volume of 0.14 m^3 at 301 K. If its temperature is increased to 365 K at the same pressure, what is its new volume, V_2?

$$pV = nRT$$

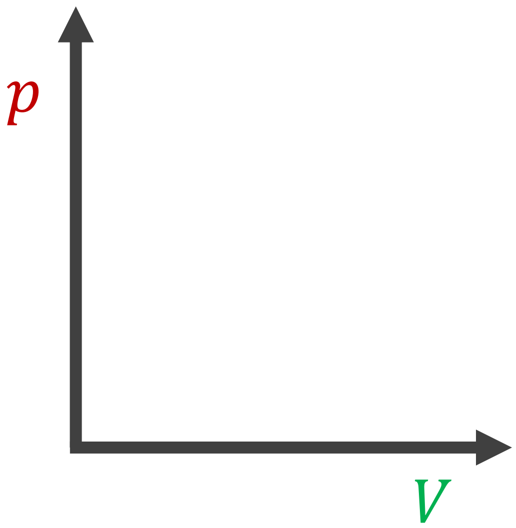
Try This

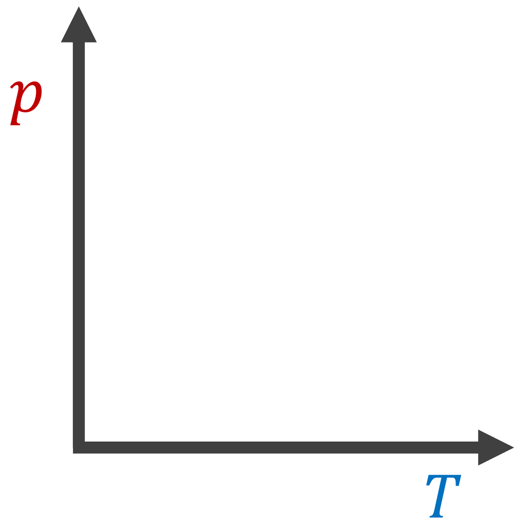
A sample of ammonia is found to occupy 0.250 L under laboratory conditions of 27 °C and 0.850 atm. Find the volume of this sample at 0 °C and 1.00 atm.

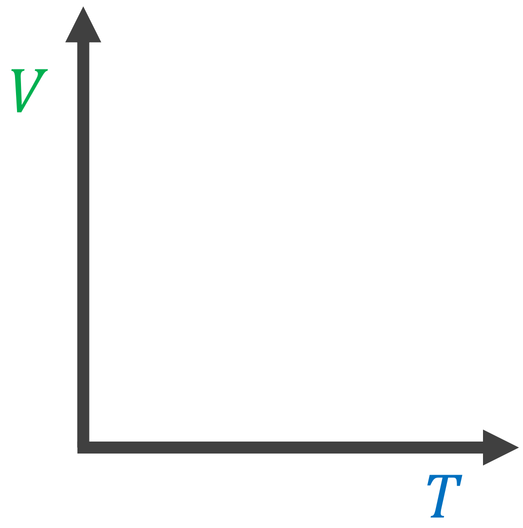
$$pV = nRT$$

Draw these graphs

$$pV = nRT$$







Related Constants

Gas Constant

$R = 8.31\ J\ K^{-1}\ mol^{-1}$

Boltzmann's constant

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

Average Kinetic Energy

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

Boltzmann's constant

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

Gas Constant

$R = 8.31\ J\ K^{-1}\ mol^{-1}$

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Lesson Takeaways

- ❑ I can identify conditions when a substance is no longer considered an ideal gas
- ❑ I can describe the relationships between volume, temperature, and pressure in an ideal gas
- ❑ I can use the Ideal Gas Law to solve for pressure, volume, amount, or temperature
- ❑ I can use the Ideal Gas Law to describe how changing one or more variable(s) would affect another