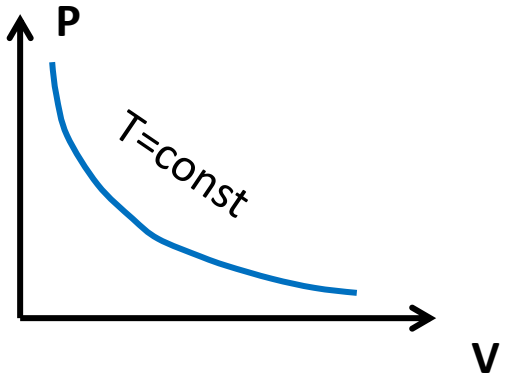
Experimental Gas Laws

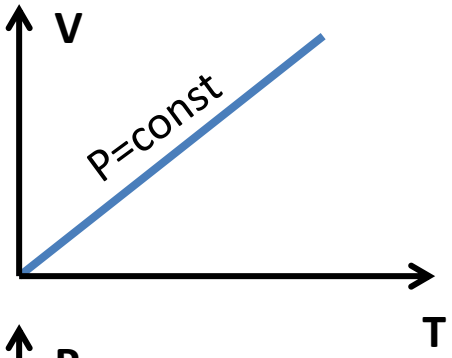
Boyle's Law :

$PV = const \quad (\text{when} \quad T = const)$



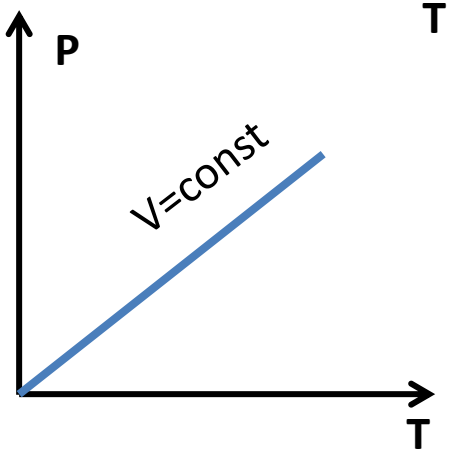
Charles's Law :

$\frac{V}{T} = const \quad (\text{when} \quad P = const)$



Gay - Lussac's Law :

$\frac{P}{T} = const \quad (\text{when} \quad V = const)$



$$T[K] \approx T^{0}C + 273.15$$

Combined Gas Law

$$PV = nRT$$

$n[mol] = \frac{m}{\mu}$ – quantity of substance (number of moles)

$m[g]$ – Mass of gas

$\mu\left[\frac{g}{mol}\right]$ – Molar Mass (molecular weight from periodic table)

$P[Pa]$ – Pressure ; $V[m^3]$ – Volume

The formula also works if we switch to more convenient units : $P[kPa]$ and $V[l]$

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

$$T[K] \approx T^0C + 273.15$$

- **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:

$$\mu_{H_20} = (2+16)\frac{g}{mol} = 18\frac{g}{mol}$$

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

$$\rho = \frac{M}{V}$$

$$n = \frac{M}{\mu}$$

$$\nu = \frac{N}{N_A}$$

Greek 'rho'

Greek 'mu'

Homework

Problem 1

Mole is a unit of so-called “quantity of substance”: it always contains the same number of molecules (known as Avogadro number). The number of moles is calculated as mass (in grams) divided by the molecular weight.

It is widely known that 1 mole of any gas occupies the same volume at normal conditions (atmospheric pressure, P=101kPa and room temperature T=20^{o}C). Starting with unified gas law, find this Volume (in liters).

Problem 2

Suppose you know density ρ (in g/ml) and molar mass ρ (in g/mol) for certain substance. Find how many molecules are contained in volume V of this substance. Express your result as a general formula $N=N(V, \rho, \mu, N_A)$.

Using this formula, determine how many molecules are there in V= 100 ml of each of the materials in the table (you will need to consult the Periodic table to find μ):

Substance	ρ (g/ml)	μ (g/mol)	# of molecules in V = 100 ml
liquid water, H_20	1		
liquid propane, C_3H_8	0.5		
Calcite (chalk)	2.7		
Aluminum*, Al	2.7		
Gold*, Au	19.3		

For metals (Al and Au) consider one atom to be a molecule.