AP Physics - Temp - Heat - Kinetic Theory - Ideal Gases

Note Title 12/3/2007

A gas may be treated as an Ideal Gas when it is far away from vaporization (liquid → gas) or from sublimation (solid → gas). Specifically, this means at: low density
low pressure
high temperature

Ideal Gas Law

$$PV = \eta RT$$

P = absolute pressure (not gage)
V = volume
T = absolute temperature (Kelvin)
η = # moles

$$\eta = \frac{\text{\# molecules}}{\text{Avogadro's \#}} = \frac{N}{N_A} = \frac{N}{6.02 \cdot 10^{23}}$$

$$\eta = \frac{\text{mass of substance}}{\text{molar mass}}$$

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

or

$$R = 0.0821 \frac{L \cdot atm}{mol \cdot K}$$

Alternative Form: $PV = Nk_BT$

$$PV = \eta RT$$
$$PV = \frac{N}{N_A} RT$$
$$PV = N\left(\frac{R}{N_A}\right)T \rightarrow PV = N k_B t$$

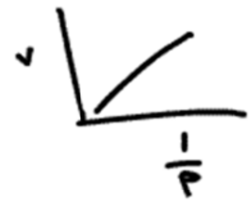
where $k_B = \frac{R}{N_A} = 1.38 \cdot 10^{-23}$ J/K

k_B = Boltzmann's Constant

How we came up with ideal gas law...

Boyle's Law: $V \propto \frac{1}{P}$ at a constant temp

or

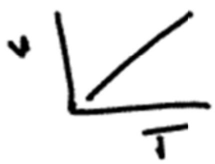


$V \propto \frac{1}{P}$

$V = (\text{constant}) \cdot \frac{1}{P}$

$\longrightarrow P \cdot V = \text{constant}$

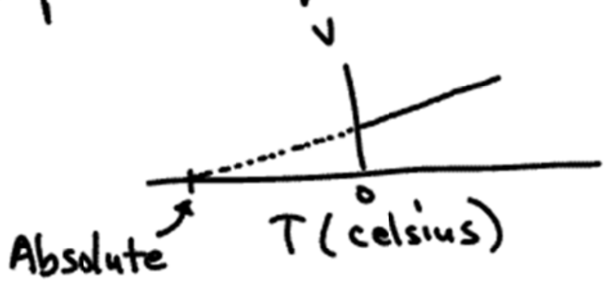
Charles's Law: $V \propto T$ at constant pressure



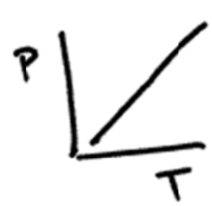
$V \propto T$

$V = (\text{constant})\,T$

* Note that with Charles's Law we can trace the straight line down to a temperature where volume = 0. Since volume can't possibly be negative, this temperature must be the minimum possible. This is how we can experimentally determine <u>Absolute zero</u>



Gay-Lussac's Law: $P \propto T$ at a constant volume



$P \propto T$

$P = (\text{constant})\,t$

Putting all three laws together

$$V \cdot P = \text{constant}_1$$
$$V = \text{constant}_2 \cdot T$$
$$P = \text{constant}_3 \cdot T$$

These constants are all different

We get $PV = \text{constant}_4 \cdot T$

This constant is ηR

STP (Standard Temperature and Pressure)

$T = 273.15\,K \; (0°C)$

$P = 1.00 \text{ ATM} = 1.013 \cdot 10^5 \frac{N}{m^2} = 1.013\,kPa$