CHAPTER EIGHT
TEMPERATURE

Macroscopic Description of an Ideal Gas

It is convenient to express the amount of gas in a given volume in terms of the number of moles (n).

One (mole) is: the amount of substance that contains (Avogadro's number, $\mathbf{N_A}$=6.022*10^{23}) of constituent particles (atoms or molecules).

* n = m / M

m = mass of object & M = molar mass of the substance (gr/mol)

example: the mass of the (He) atom is (4 u), so the molar mass of (He) is (4 g/mol).

Boyle's law: when the gas is kept at a constant temperature, it's pressure is inversly proportional to its volume.

Charle's and Gay-Lussac: when the pressure of gas is kept constant, it's volume is directly proportional to the temperature.

Equation of state for ideal gas:

P.V = n.R.T

R = constant or universal gas constant

R = 8.314 J/mol.k = 0.08214 L.atm/mol.k

In SI units, pressure is expressed in (pascal = N/m^2)

* The product of (pv) has units of (N.m) or (Jouls), (1J = 1N.m)

* The volume occupied by (1 mol) of any gas at atmospheric pressure and at (0 °c or 273 k) is **22.4 L**

The ideal gas law:

$\mathbf{P.V = n.R.T = (N/N_A)R.T}$

$\mathbf{P.V = N.K_B.T}$

N = total number of molecules

K_B = Boltzmann's constant = R / N_A = 1.38*10^{-23} J/k

Example 3: A spray can containing a propellant gas at twic atmpsoheric pressure (202 Kpa) and having a volume of (125 cm^3) is at (22 °c). It's then tossed into an open fire. When the temperature of the gas in the can reaches (195 °c).

(a) what is the pressure inside the can? Assume any change in the volume of the can is negligible.

(b) If we include a volume change due to the thermal expansion of the steel can as the temperature increases. Does this alter out answer for the final pressure significantly?

Solution:

(a) $\mathbf{P_i.V_i / T_i = P_f.V_f / T_f}$

Because $V_i = V_f$ then

$\mathbf{P_i / T_i = P_f / T_f}$

$\mathbf{P_f = (T_f / T_i) P_i}$ = (468k/295k)(202kpa) = 320Kpa

(b) because (steel) is very small, we do not expect much of an effect on our final answer.

The change in volume of the can is:

$\Delta V = \beta.Vi.\Delta T = 3\alpha.Vi.\Delta T = 3\ (11*10^{-6}/°c)\ (125\ cm^3)\ (173\ °c) = 0.71\ cm^3$

The final volume of the can is (125.71 cm^3).

$P_f = (T_f / T_i)(V_i / V_f)\ P_i$

$V_i / V_f = (125\ cm^3) / (125.71\ cm^3) = 99.4\%$

Thus the final pressure will differ by only (0.6 %) from the value we calculated with out considering the thermal expansion of the can.

The final pressure = 318 kpa

H.W: A cube (10 cm) on each side contains air [with equivalent molar mass = 28.9 g/mol at atmosphiric pressure and temperature of (300 k°)]. Find (a) the mass of gas? (b) its weight? (c) the force exerts on each face of the cube?

H.W: The triple point of of neon and carbon dioxide are (24.57 k and 216.55 k), respectively. Express these temperatures on the celsius and fehrenheit scales?

H.W: A steel tape (1 m) long is correctly calibrated for a temperature of (27 °c). The length of a steel rod measured by this tape is found to be (63 cm). On a hot day when the temperature is (45 °c). What is the actual length of the same steel rod on a day when the temperature is (27 °c)? Take: $\boldsymbol{\alpha_{st}} = 12*10^{-6}/\ °c$