Measurable properties of gases.

(1) The characteristics of gases are described fully in terms of four parameters or measurable properties:

(i) The volume, V, of the gas.

(ii) Its pressure, P

(iii) Its temperature, T

(iv) The amount of the gas (i.e., mass or number of moles).

(2) **Volume:**

i) Since gases occupy the entire space available to them, the measurement of volume of a gas only requires a measurement of the container confining the gas.

(ii) Volume is expressed in liters (L), milliliters (mL) or cubic centimeters (cm^3) or cubic meters (m^3).

(iii) $1L = 1000\ mL$; $1\,mL = 10^{-3}\,L$

$$1\,L = 1\,dm^3 = 10^3\,cm^3$$

$$1\,m^3 = 10^3\,dm^3 = 10^6\,cm^3 = 10^6\,mL = 10^3\,L$$

(3) **Mass:**

(i) The mass of a gas can be determined by weighing the container in which the gas is enclosed and again weighing the container after removing the gas. The difference between the two weights gives the mass of the gas.

(ii) The mass of the gas is related to the number of moles of the gas i.e.

$$\text{Moles of gas (n)} = \frac{\text{Mass in grams}}{\text{Molar mass}} = \frac{m}{M}$$

(iii) Mass is expressed in grams or kilograms, $1\,Kg = 10^3\,g$

(4) **Temperature:**

(i) Gases expand on increasing the temperature. If temperature is increased twice, the square of the velocity (v^2) also increases two times.

(ii) Temperature is measured in centigrade degree $({}^oC)$ or Celsius degree with the help of thermometers. Temperature is also measured in Fahrenheit (F^o).

(iii) S.I. unit of temperature is kelvin (K) or absolute degree.

$$K = {}^oC + 273$$

(iv) Relation between F and ${}^oC$ is $\frac{{}^oC}{5} = \frac{F^o - 32}{9}$

(5) **Pressure:**

(i) Pressure of the gas is the force exerted by the gas per unit area of the walls of the container in all directions. Thus, Pressure (P) $= \frac{\text{Force}(F)}{\text{Area}(A)} = \frac{\text{Mass}(m) \times \text{Acceleration}(a)}{\text{Area}(a)}$

(ii) Pressure exerted by a gas is due to kinetic energy $(KE = \frac{1}{2}mv^2)$ of the molecules. Kinetic energy of the gas molecules increases, as the temperature is increased. Thus, **Pressure of a gas $\propto$ Temperature (T)**.

(iii) Pressure of a pure gas is measured by manometer while that of a mixture of gases by barometer.

(iv) Commonly two types of manometers are used,

(a) Open end manometer;

(b) Closed end manometer

(v) The S.I. unit of pressure, the pascal (Pa), is defined as 1 newton per meter square. It is very small unit.

$$1Pa = 1Nm^{-2} = 1kg\,m^{-1}s^{-2}$$

(vi) C.G.S. unit of pressure is dynes cm^{-2}.

(vii) M.K.S. unit of pressure is kgf/m^2. The unit kgf/cm^2 sometime called ata (atmosphere technical absolute).

(viii) Higher unit of pressure is bar, KPa or MPa.

$$1\,bar = 10^5\,Pa = 10^5\ Nm^{-2} = 100\,KNm^{-2} = 100\,KPa$$

(ix) Several other units used for pressure are,

Name	Symbol	Value
bar	bar	$1bar = 10^5\,Pa$
atmosphere	atm	$1\,atm = 1.01325 \times 10^5\,Pa$
Torr	**Torr**	$1\,Torr = \frac{101325}{760}\,Pa = 133.322\,Pa$
millimeter of mercury	**mm Hg**	$1\,mm\ Hg = 133.322\,Pa$

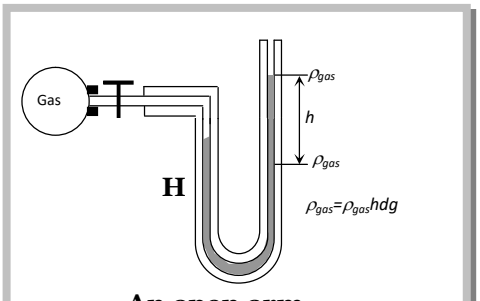
(x) The pressure relative to the atmosphere is called gauge pressure. The pressure relative to the perfect vacuum is called absolute pressure.

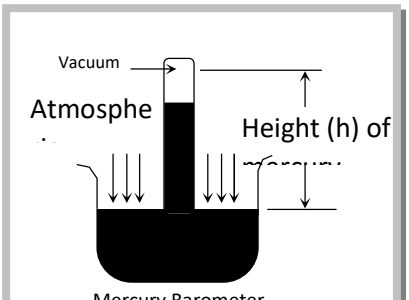
Absolute pressure = Gauge pressure + Atmosphere pressure.

(xi) When the pressure in a system is less than atmospheric pressure, the gauge pressure becomes negative, but is frequently designated and called vacuum. For example, 16 cm vacuum will be

$$\frac{76-16}{76} \times 1.013 = 0.80\ bar.$$

(xii) If 'h' is the height of the fluid in a column or the difference in the heights of the fluid columns in the two limbs of the manometer d the density of the fluid $(Hg = 13.6 \times 10^3\ Kg/m^3 = 13.6\,g/cm^3)$ and g is the gravity, then pressure is given by, $P_{\text{gas}} = P_{\text{atm}} + h\,dg$





(xiii) Two sets of conditions are widely used as 'standard' values for reporting data.

Condition	T	P	**V_m (Molar volume)**
S.T.P./N.T.P.	273.15 K	1 atm	22.414 L
S.A.T.P*.	298.15 K	1 bar	24.800 L

* Standard Ambient temperature and pressure.