MEASURABLE PROPERTIES OF GASES

Gaseous State

1. Important Properties of Gases

(i) Mass: The mass in grams is equal to the product of moles and the molecular mass.

(ii) Volume: The volume of a gas corresponds to the space occupied by the gas within its container.

(iii) Temperature: The temperature of a gas is a measure of its kinetic energy, with kinetic energy being proportional to temperature.

(iv) Pressure: Gas pressure is characterized as the force exerted by the gas on the walls of its container. It is commonly assumed that pressure is isotropic, meaning it is the same in all three directions.

Pressure $= \frac{\text{Force}}{\text{Area}}$,

$$P = \frac{Mg}{A} = \frac{v \times d \times g}{A}$$

$$= \frac{A \times h \times d \times g}{A}$$

$$P = hdg$$

Where.... h = height of the mercury column supported by the barometer.
d = density of mercury.
g = acceleration due to gravity.

2. Units and Determination of Pressure of Gas

(a) In SI unit the unit of pressure is the pascal (N/m^2) instead, the unit bar, kPa or MPa is used.

$$1 \text{ bar} = 10^5 \text{ N/m}^2 = 100 \text{ kN/m}^2 = 100 \text{ kPa}$$

(b) Pressure is also stated in mm or cm of mercury.

$$1 \text{ atm} = 760 \text{ mm Hg} = 1.01325 \text{ bar} = 1.01325 \times 10^5 \text{ Pa}$$

$$= 101.325 \text{ KN/m}^2 = 1.0332 \text{ Kgf/cm}^2$$

$$1 \text{ Pa} = 1 \text{ Nm}^{-2} = 1 \text{ Kgm}^{-1} \text{ S}^{-1}$$

$$1\text{L} = 1\text{dm}^3 = 10^{-3} \text{ m}^3 \text{ (SI unit)}$$

$$1\text{L atm} = 101.325 \text{ J}$$

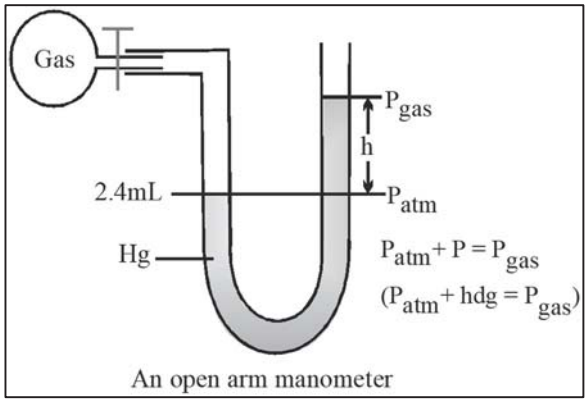
$$1 \frac{\text{KN}}{\text{m}^2} = 1 \times 10^3 \frac{\text{N}}{\text{m}^2} = \frac{1 \times 10^3 \times \text{kg}}{9.8 \times 10^4 \text{ cm}^2} = \frac{1}{98} \text{kgf/cm}^2$$

$$1\text{Torr} = \frac{101325}{760} \text{ Pa} = 133.322 \text{ Pa}$$

(c) Gauge pressure refers to the pressure measured in relation to the atmosphere, while absolute pressure is the pressure measured relative to a perfect vacuum. The formula for absolute pressure is the sum of gauge pressure and atmospheric pressure.

Absolute pressure = Gauge pressure + Atmosphere pressure

(d) In situations where the pressure within a system falls below atmospheric pressure, the gauge pressure can become negative and is commonly denoted and referred to as a vacuum.



An open arm manometer

For example, 16 cm vacuum will be:

$$\frac{76-1}{76} \times 1.013 = 0.80 \text{ bar}$$

(e) Pressure is quantified using a manometer, a straightforward apparatus featuring a horizontal arm and a U-tube containing mercury or another appropriate liquid.

Atmospheric Pressure

The actual magnitude of atmospheric pressure is contingent upon various factors such as temperature, geographical location, and prevailing weather conditions. Measurement of atmospheric pressure is facilitated by a device known as a barometer. The atmospheric pressure, thus measured, offers insights into the dynamic conditions of the atmosphere.

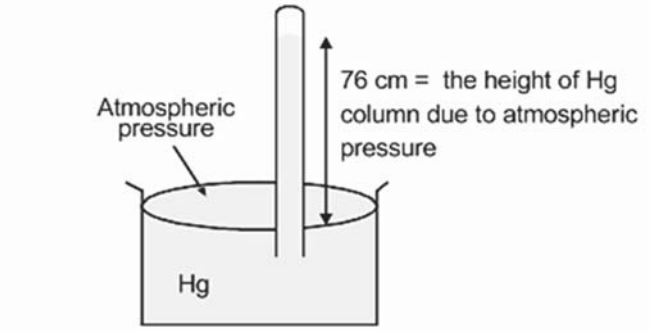


Fig.: Barometer, Measuring Atmospheric Pressure.

The standard atmospheric pressure, denoted as 1.0 atmosphere (atm), is defined as the pressure required to uphold a vertical column of mercury precisely 76 centimeters in height at 0 degrees Celsius at sea level.

This equivalence is expressed as 1 atm being equivalent to 76 centimeters or 760 millimeters of mercury (Hg). The relationship between pressure (P), force (F), area (A), density (ρ), gravitational acceleration (g), and height (h) is described by the formula $P = pgh$, where P is the pressure, ρ is the density, g is the gravitational acceleration, and h is the height of the column.

Ex. Calculate the mass of mercury in a uniform column 760 mm high and 1.00 cm^2 in cross-sectional area. Is there any change in.

(a) mass and

(b) pressure of column of same height but with 2.00cm^2 cross sectional area is taken? (density of Hg = 13.6 g/cm^3)

Sol. 760 mm = 76 cm

$\therefore$ $V = 76 \times 1 = 76\ cm^3$

$\therefore$ $Mass = V \times d = 76 \times 13.6 = 1033.6\ g$

(a) If area of cross-section is $2cm^2$ (doubled) then volume is also doubled hence,

$\therefore$ $Mass = 76 \times 2 \times 13.6 = 2067.2\ g$

(b) This mass would rest on twice the area and so exert the same pressure.