Study of Gas Laws

Gas

Gas is the state of matter in which inter-particle space is large and inter-particle attraction is weak. Because of this, the particles become completely free to move randomly in the entire available space.

- **Kinetic molecular theory of gases**
  The kinetic molecular theory of a gas states that a gas is composed of molecules/particles which are in constant random motion. This theory helps in explaining the simple relationship of the pressure, volume and temperature of a gas.

Properties of gases

Gases

1. Do not have definite shape or volume
2. Are compressible
3. Can be expanded
4. Exert pressure in all the directions
5. Have low densities
6. Diffuse readily
7. Can be liquefied

Behaviour of Gases in Different Conditions

1. An increase in the pressure at a constant temperature decreases the volume of a gas.
2. A decrease in the pressure at a constant temperature increases the volume of a gas.
3. An increase in the temperature at a constant pressure increases the volume in a given mass of a gas.
4. A decrease in the temperature at a constant pressure decreases the volume in a given mass of a gas.

Gas Law

The behaviour of a gas under known conditions of temperature, pressure and volume is described by laws known as gas laws.
The standard variables used during gas laws are pressure (P), temperature (T) and volume (V).

Units of temperature	Units of volume	Units of pressure
Celsius (°C) Kelvin (K) Normal temperature: 273 K = 0°C Relationship between Celsius and Kelvin: K = °C + 273	1 litre = 1 dm^3 = 1000 cm^3 1 dm^3 = 1000 cm^3 = 1000 ml 1 cm^3 = 1 ml Millilitre (ml) Litre (l) Cubic centimetre (cm^3) Decimetre cube (dm^3) Relationship: 1 litre = 1000 ml = 1000 cm^3 1 ml = 1 cm^3	Atmosphere Torricelli (torr) cm of mercury (Hg) mm of mercury (Hg) Relationship: 76 cm of Hg = 760 mm of Hg 1 mm Hg = 1 torr

Pressure–Volume Relationship in Gases

At constant temperature, the volume of a fixed mass of a gas decreases when the pressure increases, and it increases when the pressure decreases.

Temperature–Volume Relationship in Gases

When the pressure is kept constant, the volume of a fixed mass of a gas increases with increase in temperature, measured in Kelvin or Absolute scale, and it decreases with decrease in temperature.

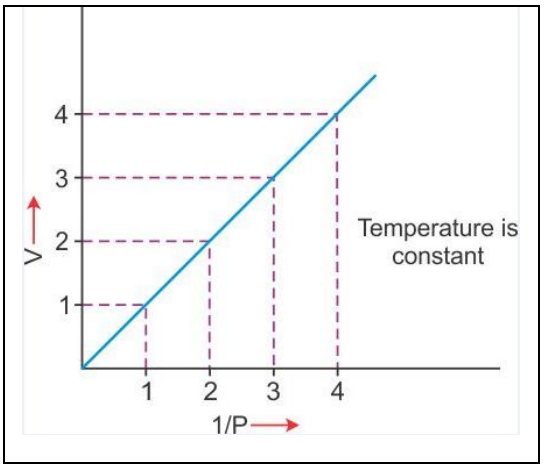
$$P_1V_1 = P_2V_2 = K\ (T = \text{Constant})$$

Boyle's Law

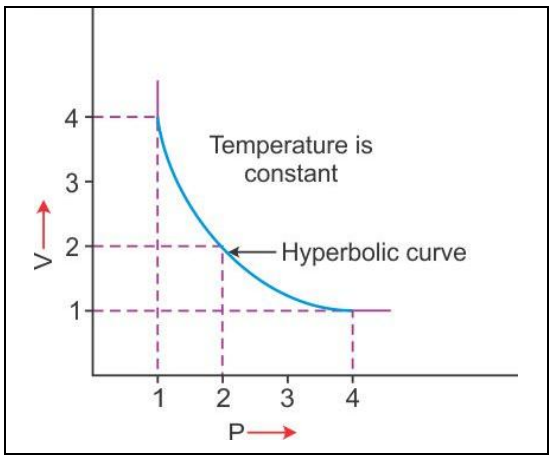
At constant temperature, the volume of a given mass of a dry gas is inversely proportional to its pressure.

Graphical verification of Boyle's Law

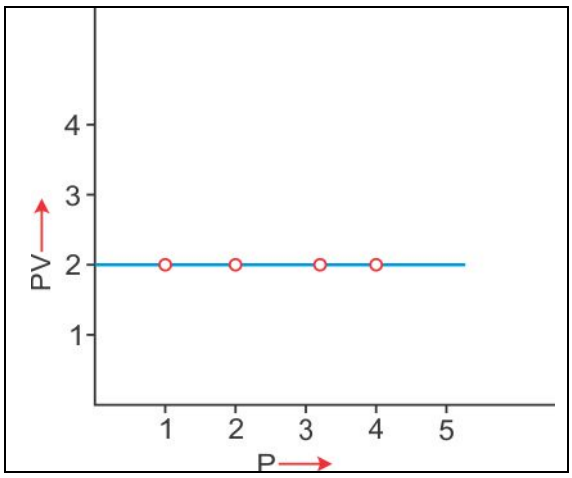
1. **V *vs* 1/P:** When variation in volume (V) is plotted against (1/P) at a constant temperature, a straight line passing through the origin is obtained.



2. **V *vs* P:** When variation in volume (V) is plotted against pressure (P) at a constant temperature, a hyperbolic curve in the first quadrant is obtained.



3. **PV *vs* P:** When variation in PV is plotted against pressure (P) at a constant temperature, a straight line parallel to the X-axis is obtained.



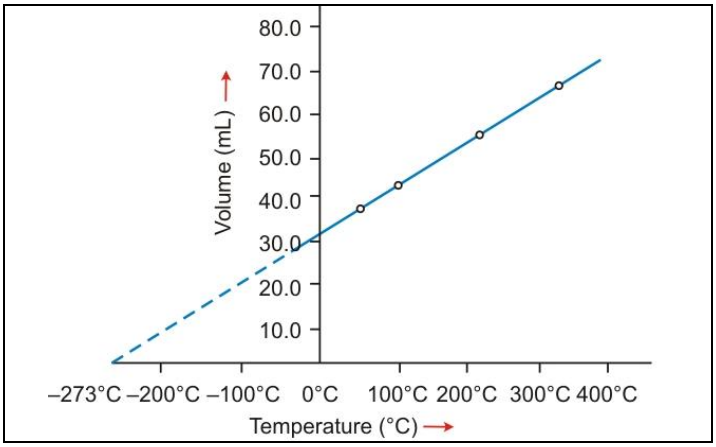
Charles's Law

At constant pressure, the volume of a given mass of a dry gas increases or decreases by 1/273 of its original volume at 0°C for each degree centigrade rise or fall in temperature.

$$\therefore \quad \frac{V_1}{T_1} = \frac{V_2}{T_2} = \text{Constant}$$

Graphical Representation of Charles's Law

T *vs* V: The relationship between the volume and the temperature of a gas can be plotted on a graph. A straight line is obtained.



Absolute Zero

The temperature −273°C is called absolute zero.

$$V = V_0\left(\frac{273+t}{273}\right)$$

$$\text{Volume at } -273^{\circ}C = V_0\left(\frac{273-273}{273}\right) = 0$$

Absolute or Kelvin scale of temperature

The temperature scale with its zero at −273°C and each degree equal to one degree on the Celsius scale is called Kelvin or the absolute scale of temperature.

Conversion of temperature from Celsius scale to Kelvin scale and *vice versa*

The value on the Celsius scale can be converted into Kelvin scale by adding 273 to it.
Example: **20°C = 20 + 273 = 293 K**

Gas Eequation

The gas equation is an equation used in chemical equations for calculating the changes in volume of gases when pressure and temperature both undergo a change, thereby giving a simultaneous effect of changes of temperature and pressure on the volume of a given mass of a dry gas.

$$\frac{P}{T} = \text{Constant}$$

- **Ideal gas:** It is an imaginary gas which follows all the gas laws and has 0 volume at 0 K.

Standard or Normal Temperature and Pressure (STP/NTP)

- Volumes of gases change with temperature and pressure. Thus, a standard value of temperature and pressure is chosen to which gas volumes are referred.
- Volumes of gases are converted to **S**tandard **T**emperature and **P**ressure (STP) conditions and then compared easily.
- The standard values chosen are 0°C or 273 K for temperature and 1 atmospheric unit (atm) or 760 mm of mercury for pressure.

Standard temperature = 0°C = 273 K

Standard pressure = 760 mm Hg

= 76 cm of Hg

= 1 atmospheric pressure (atm)