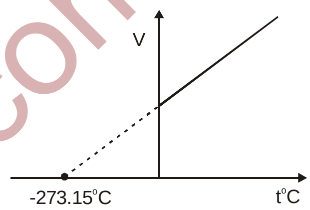
Expansion of Gases

1. Since the expansion of gases is much more than that of liquid, all the expansions of gases are real.
2. A gas has two types of coefficients of expansions.

   i) Volume expansion coefficient and ii) Pressure expansion of coefficient

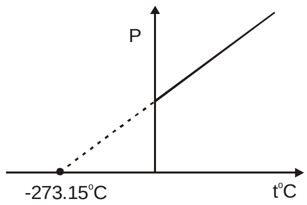
3. **Volume coefficient of a gas (α):** At constant pressure the ratio of increase of volume per 1°C rise in temperature to its original volume at 0°C is called volume coefficient of a gas.



$\alpha = \frac{V_t - V_0}{V_0 t}$ or $\alpha = \frac{V_2 - V_1}{V_1 t_2 - V_2 t_1}$ Or $V_t = V_0(1+\alpha t)$

Unit of α : $°C^{-1}$ or K^{-1}.

4. **Pressure coefficient of a gas (β):** At constant volume the ratio of increase of pressure per 1°C rise in temperature to its original pressure at 0°C is called pressure coefficient of gas.



$\beta = \frac{P_t - P_0}{P_0 t}$ or $\beta = \frac{P_2 - P_1}{P_1 t_2 - P_2 t_1}$ Or $P_t = P_0(1+\beta t)$

. Unit: $°C^{-1}$ or K^{-1}

5. Regnault's apparatus is used to determine the volume coefficient of a gas.
6. Jolly's bulb apparatus is used to determine the pressure coefficient of a gas.
7. Volume coefficient and pressure coefficient of a gas are equal and each equal to $\frac{1}{273}$/°C or 0.0036/°C for all gases.
8. **Absolute scale of temperature**

   a) P-t graph or V-t graph is straight line intersecting the temperature axis at −273.15°C. This temperature is called absolute zero. (0 K)

   b) Absolute zero is the temperature at which the volume of a given mass of a gas at constant pressure or the pressure of the same gas at constant volume becomes zero.

   c) The lowest temperature attainable is −273.15°C or 0 K.

d) The scale of temperature on which the zero corresponds to 273°C and each degree is equal to the Celsius degree is called the absolute scale of temperature or thermodynamic scale of temperature.

T K = t+273.15°C.

e) There is no negative temperature on Kelvin scale.

9. Boyle's law

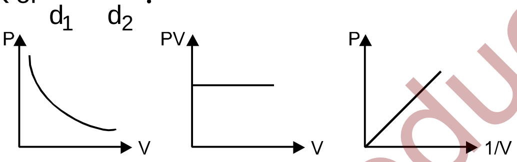
a) At constant temperature, the pressure of a given mass of a gas is inversely proportional to its volume.

$P \alpha \frac{1}{V}$ or PV = K (n, T are constant) or $P_1V_1 = P_2V_2$.

b) The value of K depends on the mass and temperature of the gas and the system of units.

c) At constant temperature, the pressure of a given mass of gas is directly proportional to its density.

$P \alpha d$ or $\frac{P}{d} = K$ or $\frac{P_1}{d_1} = \frac{P_2}{d_2}$.



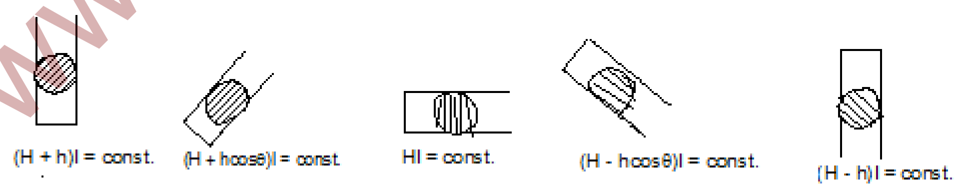
d) P-V graph at a constant temperature (isothermal) is a rectangular hyperbola.

e) PV-V graph is a straight line parallel to volume axis.

f) $P-\frac{1}{V}$ graph is a straight line passing through the origin.

g) Many gases obey Boyle's law only at high temperatures and low pressures.

10. Quill tube



11. Air bubble in a lake

An air bubble is reaching the top of a lake from the bottom (Temperature being constant), the depth of the lake is 'h'.

a) If the volume of the bubble becomes n times, h = H (n-1)

For the other liquid of density d, $h = \frac{76 \times 13.6}{d}(n-1)$

b) If radius (or) diameter of the bubble becomes n times $h = H(n^3 - 1)$

For other liquid of density d, $h = \frac{76 \times 13.6}{d}(n^3 - 1)$

c) If the surface area of the bubble becomes n times $h = H\left(n^{3/2} - 1\right)$

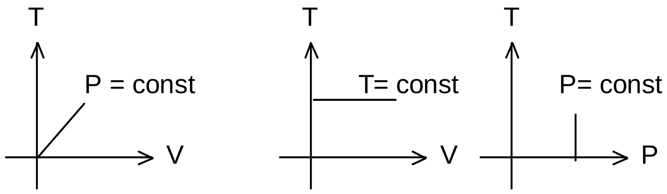
Where H is the atmospheric pressure

d) For other liquid of density d, $h = \frac{76 \times 13.6}{d}(n^{3/2} - 1)$

12. Charles' Law (I)

The volume of a given mass of a gas is proportional to its absolute temperature at constant pressure.

$V \alpha T$ (or) $\frac{V_1}{V_2} = \frac{T_1}{T_2}$ (P = const)



13. Charles' Law (II): The pressure of a given mass of a gas is proportional to its absolute temperature at constant volume. (Gay-lusacs' law) $P \alpha T$ (or) $\frac{P_1}{P_2} = \frac{T_1}{T_2}$ (V = const)

14. The constant volume gas thermometer works on the principle of Gay-lusacs' law.

15. Gas Equation

a) For 1 gm of a gas $\frac{PV}{T} = r$

For m grams of the gas $\frac{PV}{T} = mr$

'r' is the specific gas constant which depends on nature of the gas and amount of the gas and different for different gases.

b) For one mole of a gas $\frac{PV}{T} = R$

For n moles of a gas $\frac{PV}{T} = nR$

Where R is the universal gas constant, which is constant for all gases

$$r = \frac{R}{M}$$

c) Boltzmann constant $K = \frac{R}{N}$ where N is the Avogadro number.

$N = 6.023 \times 10^{23}$ and $K = 1.38 \times 10^{-23}$ J/k

16. Ideal Gases

a) A gas which obeys gas laws at all temperatures and pressures is called an ideal gas.

b) Ideal gas molecules have no specific shape (or) size. These are point masses.

c) These exist in gaseous state even at absolute zero.

d) There are no molecular forces of attractions and hence there is no PE for the ideal gas molecules.

They have only KE.

e) At absolute zero the internal energy of an ideal gas is zero.

e) Real gases obey gas laws at low pressure and high temperatures.

f) Values of R:

R = 8.31×10^7 erg/gm. mole/K

= 8.31J/gm mole/K

= 8.31×10^3J/kg mole/K

= 1.98 cal/gm mole/^{o}C

= 0.083litre atm/K

18. A sample of an ideal gas occupies a volume V at a pressure P and absolute temperature T. The mass of each molecule is m. If K is the Boltzmann constant, then the density of the gas is $d = \frac{Pm}{KT}$

19. If two vessels of equal volume containing same gas at temperature T_1 and T_2 and pressure P_1 and P_2 combine by a time capillary tube, the final common pressure is $P = \frac{P_1T_2 + P_2T_1}{T_1 + T_2}$

20. Two vessels of volumes V_1 and V_2 contain air pressures P_1 and P_2 respectively. If they are connected by a small tube of negligible volume then the common pressure is $P = \frac{P_1V_1 + P_2V_2}{V_1 + V_2}$.