Class ⇒ B.Sc. (Part-1) Hons.
Subject ⇒ chemistry
Chapter ⇒ Gaseous State
Topic ⇒ Law of Corresponding states and reduced equation of State.

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Law of Corresponding States and Reduced Equation of State

If the pressure, volume and temperature of a gas are expressed in terms of critical pressure, volume and temperature respectively then we may write

$$P = \pi P_c \;,\; V = \phi V_c \;,\; T = \theta T_c$$

Thus the quantities π, ϕ and θ may be defined as

$$\pi = \frac{P}{P_c} \;,\; \phi = \frac{V}{V_c} \text{ and } \theta = \frac{T}{T_c}$$

Where π, ϕ and θ are called reduced pressure, reduced volume and reduced temperature respectively.

If now we replace P, V and T by πP_c, ϕV_c and θT_c respectively in Vander Waal eqn.

$$\left(P + \frac{a}{V^2}\right)(V-b) = RT \text{, we get}$$

$$\left(\pi P_c + \frac{a}{\phi^2 V_c^2}\right)(\phi V_c - b) = R\theta T_c$$

Further, substituting the values of P_c, T_c and V_c in terms of van der waals constants

$$V_c = 3b$$

$$P_c = \frac{a}{27b^2}$$

$$T_c = \frac{8a}{27Rb}$$

we get

$$\left(\frac{\pi a}{27b^2} + \frac{a}{9\phi^2 b^2}\right)(3\phi b - b) = R\theta \frac{8a}{27Rb}$$

Dividing this equation throughout by $\frac{a}{27b^2}$, we get

$$\boxed{\left(\pi + \frac{3}{\phi^2}\right)(3\phi - 1) = 8\theta}$$

This equation is called Reduced equation of state OR Van der waals Reduced equation of state.

This equation does not involve the constants a, b and R, and hence is applicable to all substances in the liquid and the gaseous state.

from this equation, it is clear that "If two substances have the same reduced Pressure and the same reduced temperature, they must have the same reduced volume."

This statement is called Law of corresponding states. and the substances having the same reduced pressure and same reduced temperature and hence the same reduced volume are said to be in the corresponding states.