Law of Corresponding states :-

A reduced Vander Waal's equation in terms of reduced pressure (π), reduced temperature (θ) & reduced volume (ϕ) is known as law of corresponding state.

Vander Waal's eq^n for 1-mole of gas is written as -

$$\left(P + \frac{a}{V^2}\right)(V-b) = RT \quad \text{—(1)}$$

We know that —

$$V_c = 3b \quad \text{or} \quad b = \frac{V_c}{3}$$

$$P_c = \frac{a}{27b^2} = \frac{a}{27\left(\frac{V_c}{3}\right)^2} = \frac{a}{\frac{3\cancel{27}\, V_c^2}{\cancel{9}}} = \frac{a}{3V_c^2}$$

$$\text{or} \quad a = 3P_cV_c^2$$

$$\& \quad T_c = \frac{8a}{27bR} = \frac{8 \times 3 P_c V_c^2}{27 \frac{V_c}{3} R} = \frac{8P_cV_c}{3R}$$

$$\therefore R = \frac{8P_cV_c}{3T_c}$$

Putting all these values in eq^n —(1) we get.

$$\left(P + \frac{3P_cV_c^2}{V^2}\right)\left(V - \frac{V_c}{3}\right) = \frac{8P_cV_c}{3T_c} \cdot T$$

On dividing it by P_cV_c throughout, we get

$$\frac{\left(P + \frac{3P_cV_c^2}{V^2}\right)}{P_c} \frac{\left(V - \frac{V_c}{3}\right)}{V_c} = \frac{8}{3}\frac{\cancel{P_cV_c}}{\cancel{P_cV_c}} \times \frac{T}{T_c}$$

$$\text{or} \quad \left(\frac{P}{P_c} + \frac{\cancel{P_c}3}{\cancel{P_c}}\left(\frac{V_c}{V}\right)^2\right)\left(\frac{V}{V_c} - \frac{1}{3}\right) = \frac{8}{3}\frac{T}{T_c} \quad \text{—(2)}$$

putting $\frac{P}{P_c} = \pi$, $\frac{V}{V_c} = \phi$ & $\frac{T}{T_c} = \theta$ in eq^n —(2). We get

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

or

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

This eqⁿ (3) is independent of a, b & R and holds good for any mass of the substances. It has been assumed that molecular state remains the same throughout. It gives value of pressure, volume & temperature. This is known as law of Corresponding state.

* Test of law of Corresponding state :-

from eqⁿ (3)

$$\pi + \frac{3}{\phi^2} = \frac{8\theta}{3\phi - 1}$$

$$\pi = \frac{8\theta}{3\phi - 1} - \frac{3}{\phi^2}$$

if ϕ and number are constant. then,

$$\pi = \theta.$$

This eqⁿ suddenly state that there is a linear relationship between π and θ if ϕ is constant.

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