$$\frac{V}{V_c} = \phi \Rightarrow V = \phi V_c$$

and $T/T_c = \theta \Rightarrow T = \theta T_c$

where π, ϕ and θ are called the reduced pressure, the reduced volume and the reduced tempr respectively. Substing these values of P, V and T in the van der Waals eqn, we get -

$$\left(\pi P_c + \frac{a}{\phi^2 V_c^2}\right)(V_c\phi - b) = R\theta T_c \longrightarrow (1)$$

Putting $V_c = 3b$, $P_c = \frac{a}{27b^2}$ & $T_c = \frac{8a}{27Rb}$ in the above eqn we have

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

$$\Rightarrow \frac{a}{27b^2}\left(\pi + 3/\phi^2\right) \times b(3\phi - 1) = \frac{a}{27b} 8\theta$$

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

P.T.O

eq^n (2) is known as vander Waals reduced equation of state. Here in the constant a, b, P_c, V_c & T_c which are characteristics of a given gas, have all cancelled out. Hence it is applicable to all substances in liquid or gaseous state irrespective of their nature.

From the reduced eq^n of state, it is evident that when two substance have the same reduced temp^r and pressure, they will have the same reduced volume. These two substance are said to be in corresponding states and the above generalisation is termed the laws of corresponding states.