$$dU = d\cancel{Q}^{\,0} + dW$$

$$\therefore dU = \underline{C_v\,dT} = dW = \underline{-P\,dV}$$

$$C_v = C_p - R = (A-R) + BT + CT^2 + DT^{-2}$$

$$\therefore \left[(A-R) + BT + CT^2 + DT^{-2}\right] dT = -P\,dV = -\frac{RT}{V}\,dV$$

$$P = \frac{RT}{V}$$

$$\therefore \left[\frac{A-R}{T} + B + CT + \frac{D}{T^3}\right] dT = -R\,\frac{dV}{V}$$

Integrating from T_1, V_1 to T_2, V_2

$$\int_{T_1}^{T_2} \left[\frac{A-R}{T} + B + CT + \frac{D}{T^3}\right] dT = -R \int_{V_1}^{V_2} \frac{dV}{V}$$

$$(A-R)\ln\frac{T_2}{T_1} + B(T_2 - T_1) + \frac{C}{2}(T_2^2 - T_1^2) - \frac{D}{2}\left(\frac{1}{T_2^2} - \frac{1}{T_1^2}\right)$$

$$\frac{V_2}{V_1} = \frac{P_1}{P_2}\,\frac{T_2}{T_1}$$

$$\therefore \oplus : \left(\frac{A-R}{R}\right)\ln\frac{T_2}{T_1} + \frac{B}{R}(T_2 - T_1) + \frac{C}{2R}(T_2^2 - T_1^2) - \frac{D}{2R}\left(\frac{1}{T_2^2} - \frac{1}{T_1^2}\right) = \ln\left(\frac{P_2}{P_1}\cdot\frac{T_1}{T_2}\right)$$

$$= \ln\frac{P_2}{P_1} - \ln\frac{T_2}{T_1}$$

$$\therefore \frac{A}{R}\ln\frac{T_2}{T_1} + \frac{B}{R}(T_2 - T_1) + \frac{C}{2R}(T_2^2 - T_1^2) - \frac{D}{2R}\left(\frac{1}{T_2^2} - \frac{1}{T_1^2}\right) = \ln\frac{P_2}{P_1}$$

$$\ln\left(\frac{T_2}{T_1}\right)^{A/R} + \exp\left[\frac{B}{R}(T_2 - T_1) + \frac{C}{2R}(T_2^2 - T_1^2) - \frac{D}{2R}\left(\frac{1}{T_2^2} - \frac{1}{T_1^2}\right)\right] = \ln\frac{P_2}{P_1}$$

$$\boxed{\therefore \frac{P_2}{P_1} = \left(\frac{T_2}{T_1}\right)^{\frac{A}{R}} \cdot \exp\left[\frac{B}{R}(T_2 - T_1) + \frac{C}{2R}(T_2^2 - T_1^2) - \frac{D}{2R}\left(\frac{1}{T_2^2} - \frac{1}{T_1^2}\right)\right]}$$ Ans