Example 2: show that the (β) for real gas can be given by the relation:

$$\beta = \frac{1}{T}\left(1 - \frac{b}{v}\right)$$

where the real gas equation

$$P(v - b) = RT$$

Solution:

$$P(v - b) = RT$$

$$Pv - Pb = RT$$

$$P\,dv + v\,dp - b\,dp = R\,dT \qquad \div dT$$

$$P\frac{dv}{dT} + v\frac{dp}{dT} - b\frac{dp}{dT} = R \qquad \div v$$

$$\frac{P}{v}\frac{dv}{dT} + \underbrace{\frac{v}{v}\frac{dp}{dT}}_{=0} - \underbrace{\frac{b}{v}\frac{dp}{dT}}_{=0} = \frac{R}{v}$$

ت الضغط $(dp = 0)$

$$\frac{P}{v}\frac{dv}{dT} = \frac{R}{v}$$

$$\underbrace{\frac{P}{v}\left(\frac{dv}{dT}\right)_P}_{=\beta} = \frac{R}{v}$$

$$P\beta = \frac{R}{v} \qquad \left(P = \frac{RT}{v - b}\right)$$

$$\frac{\cancel{R}T}{v - b}\,\beta = \frac{\cancel{R}}{v} \Rightarrow \beta = \frac{1}{T}\left(\frac{v - b}{v}\right)$$

Example 3: show that the (K) for ideal gas can be given by $K = \frac{1}{P}$

Solution:

$$K = -\frac{1}{\vartheta}\left(\frac{d\vartheta}{dp}\right)_T$$

$$P\vartheta = RT$$

$$P\,d\vartheta + \vartheta\,dp = R\,dT \qquad \div\, dp$$

$$p\,\frac{d\vartheta}{dp} + \vartheta\,\cancel{\frac{dp}{dp}} = R\,\frac{dT}{dp} \qquad \div\, \vartheta$$

$$\frac{P}{\vartheta}\cdot\frac{d\vartheta}{dp} + \frac{\vartheta}{\vartheta} = \frac{R}{\vartheta}\,\frac{\cancel{dT}^{\,=0}}{dp}$$

بثبوت درجة الحرارة $dT=0$

$$\frac{P}{\vartheta}\underbrace{\left(\frac{d\vartheta}{dp}\right)_T}_{=-K} + 1 = 0$$

$$\cancel{-}PK = \cancel{-}1$$

$$\therefore K = \frac{1}{P}$$

Example (4): show that the (K) for real gas can be given by relation

$$K = \frac{1}{p}\left(1 - \frac{b}{\upsilon}\right)$$

where real gas equation ($p(\upsilon - b) = RT$

Solution:

using the real gas equation:

$$p(\upsilon - b) = RT$$

$$p\upsilon - pb = RT$$

$$p\,d\upsilon - \upsilon\,dp - b\,dp = R\,dT \qquad \div dp$$

$$p\frac{d\upsilon}{dp} + \upsilon\frac{dp}{dp} - \frac{b\,dp}{dp} = R\frac{dT}{dp} \qquad \div \upsilon$$

$$\frac{p}{\upsilon}\frac{d\upsilon}{dp} + \frac{\upsilon}{\upsilon}\cancel{\frac{dp}{dp}}^{\,1} - \frac{b}{\upsilon}\cancel{\frac{dp}{dp}}^{\,1} = \frac{R}{\upsilon}\frac{dT}{dp}^{\,=}$$

ثبوت درجة الحرارة (dT=0)

$$\underbrace{\frac{p}{\upsilon}\left(\frac{d\upsilon}{dp}\right)_T}_{=-K} + 1 - \frac{b}{\upsilon} = 0$$

$$-pK + 1 - \frac{b}{\upsilon} = 0$$

$$pK = 1 - \frac{b}{\upsilon}$$

$$\therefore K = \frac{1}{p}\left(1 - \frac{b}{\upsilon}\right)$$

Example (5): show that β for real gas can be given by the relation:

$$\beta = \frac{1}{T + \frac{Pb}{R}}$$

if you know that the real gas equation

$$P(v - b) = RT \qquad \Bigg| \quad \beta = \frac{1}{v}\left(\frac{\partial v}{\partial T}\right)_P$$

Solution:

$$P(v - b) = RT$$

$$Pv - Pb = RT$$

$$P\,dv + v\,dP - b\,dP = R\,dT \qquad \div dT$$

$$P\frac{dv}{dT} + v\frac{dP}{dT} - b\frac{dP}{dT} = R \qquad \div v$$

$$\frac{P}{v}\frac{dv}{dT} + \frac{v}{v}\frac{dP}{dT} - \frac{b}{v}\frac{dP}{dT} = \frac{R}{v}$$

بثبوت الضغط $(dP = 0)$

$$\frac{P}{v}\left(\frac{\partial v}{\partial T}\right)_P + \cancel{\frac{v}{v}\frac{dP}{dT}}^{\,0} - \cancel{\frac{b}{v}\frac{dP}{dT}}^{\,0} = \frac{R}{v}$$

$$P\,\frac{1}{v}\left(\frac{\partial v}{\partial T}\right)_P = \frac{R}{v}$$

$$P\beta = \frac{R}{v} \quad \text{------} (1)$$

using real gas equation:

$$P(v - b) = RT$$

$$Pv - Pb = RT$$

$$P v = RT + Pb$$

$$\therefore v = \frac{RT + Pb}{P} \quad \text{-----} (2)$$

نعوض من معادلة (2) في معادلة (1) فنحصل على :

$$P \beta = \frac{R}{\frac{RT + Pb}{P}}$$

$$\cancel{P} \beta = \frac{R \cancel{P}}{RT + Pb}$$

$$\beta = \frac{\cancel{R}}{\cancel{R}\left(T + \frac{Pb}{R}\right)}$$

$$\boxed{\therefore \beta = \frac{1}{T + \frac{Pb}{R}}}$$

الانضغاطية الايزوثيرمية ← K & β relation ← معامل التمدد الحجمي

we can give the relation between (K) and (β) by the expression:

$$\boxed{dp = \frac{\beta}{K}\, dT}$$

example: find the final pressure for a sample of a mercury have a constant volume and pressure (1 atm) and temprerature (0 °C) if the sample temperature increase (10 °C) if you know:

$\beta = 181 * 10^{-6}\ deg^{-1}$

$K = 3.87 * 10^{-6}\ atm^{-1}$

Solution:

$$dp = \frac{\beta}{K}\, dT$$

$$\int_{P_i}^{P_f} dp = \frac{\beta}{K} \int_{T_i}^{T_f} dT$$

$$P_f - P_i = \frac{\beta}{K}(T_f - T_i)$$

$$P_f - 1\ atm = \frac{181 * 10^{-6}\ deg^{-1}}{3.87 * 10^{-6}\ atm^{-1}} * 10\ deg$$

$P_f - 1\ atm = 467.7\ atm$

$$\boxed{P_f = 468.7\ atm}$$

example: a mass of certain material have a constant volume and it's temperature $275\ \mathring{K}$, and the pressure have change 300 atm. Find the final temperature for this mass if you know $\beta = 170 * 10^{-6}\ \mathring{K}^{-1}$ and $K = 3 * 10^{-6}\ atm^{-1}$

Solution:

$$\int_{P_i}^{P_f} dp = \frac{\beta}{K} \int_{T_i}^{T_f} dT$$

$$P_f - P_i = \frac{\beta}{K}(T_f - T_i)$$

$$300\ atm. = \frac{170 * 10^{-6}\ K^{-1}}{3 * 10^{-6}\ atm^{-1}} (T_f - 275$$

$$300\ \cancel{atm} = 56.66\ K^{-1}\ \cancel{atm}\ (T_f - 275$$

$$\frac{300}{56.66}\ \mathring{K} = T_f - 275\ \mathring{K}$$

$$\therefore T_f = 5.29 + 275 \Rightarrow \boxed{T_f = 280.29}$$

chapter 2

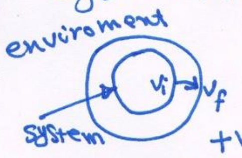
The work (الشغل)

هي عملية تحويل الطاقة الحرارية الى طاقة ميكانيكية ولكي ينجز النظام شغلاً يجب أن يكون متزن ثرموديناميكياً.

Type of the work أنواع الشغل

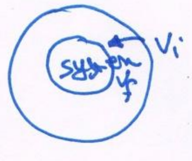
1. postive work (+ve)
2. negative work (-ve)
3. Internal work (zero)

(1) الشغل الموجب: هو الشغل المنجز من قبل النظام system على الوسط المحيط environment



+ve
(volume increase)

(2) الشغل السالب: هو الشغل ~~الشغل~~ المنجز ~~من~~ من قبل الوسط المحيط "environment" على النظام "system"



-ve

environment

(Volume decrease)

(3) الشغل الداخلي Internal work: هو الشغل المنجز من قبل جزء من النظام على بقية الأجزاء الأخرى