

Clase 39 7 octubre 2015

Título de la nota

06/10/2015

Ecuación de Berthelot (1907)

$$P = \frac{RT}{\bar{v}-b} - \frac{a}{\bar{v}^2 T}$$

obtener a y b ✓

I) Método I para obtener a y b

en el punto crítico $\left(\frac{\partial P}{\partial \bar{v}}\right)_{P.C.} = 0$ $\left(\frac{\partial^2 P}{\partial \bar{v}^2}\right)_{P.C.} = 0$

$$\left(\frac{\partial P}{\partial \bar{v}}\right)_{P.C.} = \frac{-RT_c}{(\bar{v}_c - b)^2} + \frac{2a}{T_c \bar{v}_c^3} = 0$$

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$$\left(\frac{\partial P}{\partial \bar{v}}\right)_{P.C.} = \frac{-RT_c}{(\bar{v}_c - b)^2} + \frac{2a}{T_c \bar{v}_c^3} = 0$$

$$\left(\frac{\partial^2 P}{\partial \bar{V}^2}\right)_{P.C.} = \frac{2RT_c}{(\bar{V}_c - b)^3} - \frac{6a}{T\bar{V}_c^4} = 0$$

igualando y sustituyendo

$$\left[\frac{-RT_c}{(\bar{V}_c - b)^2} + \frac{2a}{\bar{V}_c^3 T_c} \right] \frac{3}{\bar{V}_c} = 0 \quad \frac{-3RT_c}{(\bar{V}_c - b)^2 \bar{V}_c} + \frac{\cancel{6a}}{\bar{V}_c^4 T_c} = 0$$

$$\left[\frac{2RT_c}{(\bar{V}_c - b)^3} - \frac{6a}{T\bar{V}_c^4} \right] = 0 \quad \frac{2RT_c}{(\bar{V}_c - b)^3} + \frac{\cancel{6a}}{\bar{V}_c^4 T_c} = 0$$

$$\frac{-3RT_c}{(\bar{V}_c - b)^2 \bar{V}_c} + \frac{2RT_c}{(\bar{V}_c - b)^3} = 0$$

$$\frac{2RT_c}{(\bar{V}_c - b)^3} = \frac{3RT_c}{\bar{V}_c(\bar{V}_c - b)^2}$$

$$\frac{2\bar{V}_c}{3} = \bar{V}_c - b \quad \therefore \quad \frac{2}{3}\bar{V}_c = \frac{3}{3}\bar{V}_c - b$$

$$b = \frac{3}{3}\bar{V}_c - \frac{2}{3}\bar{V}_c = \frac{1}{3}\bar{V}_c$$

Obtención de a

a partir de un sistema de 3 ecuaciones

$$P_c = \frac{RT_c}{\bar{V}_c - b} - \frac{a}{\bar{V}_c^2 T_c}$$

$$P_c - \frac{RT_c}{\bar{V}_c - b} + \frac{a}{\bar{V}_c^2 T_c} = 0$$

Sumando las anteriores parciales

$$\frac{-RT_c}{(\bar{V}_c - b)^2} + \frac{2a}{\bar{V}_c^3 T_c} = 0 = \left(\frac{\partial P}{\partial \bar{V}} \right)_{P.C.}$$

$$\frac{2RT_c}{(\bar{V}_c - b)^3} - \frac{6a}{\bar{V}_c^4 T_c} = 0 = \left(\frac{\partial^2 P}{\partial \bar{V}^2} \right)_{P.C.}$$

Arreglando

$$\left[P_c - \frac{RT_c}{\bar{V}_c - b} + \frac{a}{\bar{V}_c^2 T_c} = 0 \right] \frac{3}{(\bar{V}_c - b)^2}$$

$$\left[\frac{-RT_c}{(\bar{V}_c - b)^2} + \frac{2a}{\bar{V}_c^3 T_c} = 0 \right] \frac{1}{(\bar{V}_c - b)}$$

$$\left[\frac{2RT_c}{(\bar{V}_c - b)^3} - \frac{6a}{\bar{V}_c^4 T_c} \right] 2$$

Se obtiene

$$\frac{3P_c}{(\bar{V}_c - b)^2} - \frac{3RT_c}{(\bar{V}_c - b)^3} + \frac{3a}{\bar{V}_c^2 T_c (\bar{V}_c - b)} = 0$$

$$- \frac{RT_c}{(\bar{V}_c - b)^3} + \frac{2a}{\bar{V}_c^3 T_c (\bar{V}_c - b)} = 0$$

$$\frac{4RT_c}{(\bar{V}_c - b)^3} - \frac{12a}{\bar{V}_c^4 T_c} = 0$$

Restando

$$\frac{3P_c}{(\bar{V}_c - b)^2} + \frac{3a}{\bar{V}_c^2 T_c (\bar{V}_c - b)} + \frac{2a}{\bar{V}_c T_c (\bar{V}_c - b)} - \frac{12a}{\bar{V}_c^4 T_c} = 0$$

ordenando y sabiendo que $b = \frac{1}{3} \bar{v}_c$

$$\left(\frac{3P_c}{\bar{v}_c - \frac{1}{3}\bar{v}_c} \right)^2 + \frac{3a}{\bar{v}_c^2 T_c (\bar{v}_c - \frac{1}{3}\bar{v}_c)^2} + \frac{2a}{\bar{v}_c^3 T_c (\bar{v}_c - \frac{1}{3}\bar{v}_c)} - \frac{12a}{\bar{v}_c^4 T_c} = 0$$

$$\left(\frac{3P_c}{\frac{2}{3}\bar{v}_c} \right)^2 + \frac{3a}{\bar{v}_c^2 T_c (\frac{2}{3}\bar{v}_c)^2} + \frac{2a}{\bar{v}_c^3 T_c (\frac{2}{3}\bar{v}_c)} - \frac{12a}{\bar{v}_c^4 T_c} = 0$$

$$\frac{3P_c}{4/9 \bar{v}_c^2} + \frac{3a}{4/9 \bar{v}_c^4 T_c} + \frac{2a}{2/3 \bar{v}_c^4 T_c} - \frac{12a}{\bar{v}_c^4 T_c} = 0$$

$$\frac{2}{3} = \frac{6}{9}$$

Reacomodando

$$\frac{3P_c}{4lq\bar{V}_c^2} = \frac{-3a}{4lq\bar{V}_c^4 T_c} - \frac{2a}{6lq\bar{V}_c^4 T_c} + \frac{12a}{\bar{V}_c^4 T_c}$$

$$3P_c = \frac{-3a(4lq\bar{V}_c^2)}{4lq\bar{V}_c^4 T_c} - \frac{2a(4lq\bar{V}_c^2)}{6lq\bar{V}_c^4 T_c} + \frac{12a(4lq\bar{V}_c^2)}{9lq\bar{V}_c^4 T_c}$$

$$3P_c = \frac{-3a}{\bar{V}_c^2 T_c} - \frac{2a\left(\frac{2}{3}\right)}{\bar{V}_c^2 T_c} + \frac{12a(4lq)}{\bar{V}_c^2 T_c}$$

$$3P_c = \frac{-3a - 4/3a + 48lqa}{\bar{V}_c^2 T_c}$$

Resolviendo la Fracción

$$-3a - \frac{4}{3}a + \frac{48}{9}a = \frac{-9(3)a - 4(3)a + 48a}{9}$$

$$= \frac{-27a - 12a + 48a}{36} = \frac{36a}{36} = a$$

por lo tanto

$$3P_c = \frac{a}{\bar{V}_c^2 T_c}$$

$$a = 3P_c \bar{V}_c^2 T_c$$

$$a = 3(\text{atm}) \left(\frac{\text{L}}{\text{mol}}\right)^2 (\text{K}) = \frac{\text{atm L}^2 \text{K}}{\text{mol}^2}$$

obtención de R

en la ecuación original

$$P_c = \frac{RT_c}{\bar{V}_c - b} - \frac{a}{\bar{V}_c^2 T_c}$$

por lo tanto

$$P_c + 3P_c = \frac{RT_c}{\frac{2}{3}\bar{V}_c}$$

$$P_c = \frac{RT_c}{(\bar{V}_c - \frac{1}{3}\bar{V}_c)} - \frac{\cancel{3P_c \bar{V}_c^2 T_c}}{\cancel{\bar{V}_c^2 T_c}}$$

$$4P_c = \frac{RT_c}{\frac{2}{3}\bar{V}_c}$$

$$P_c = \frac{RT_c}{\frac{2}{3}\bar{V}_c} - 3P_c$$

$$R = \frac{8}{3} \frac{P_c \bar{V}_c}{T_c} = \frac{\text{atm} \cdot \text{L}}{\text{mol} \cdot \text{K}}$$

el valor de R es semejante en la ecuación de Von der Waals.

Alternativa de la ecuación de Berthelot para obtener a , b y R
(Metodo II)

en el punto crítico existen 3 raíces iguales $\bar{V}^I, \bar{V}^{II}, \bar{V}^{III} = \bar{V}_c$

este razonamiento indica que en el punto crítico

$$(\bar{V} - \bar{V}^I)(\bar{V} - \bar{V}^{II})(\bar{V} - \bar{V}^{III}) = 0$$

$$(\bar{V} - \bar{V}_c)^3 = 0 \quad \bar{V}^3 - 3\bar{V}^2\bar{V}_c + 3\bar{V}_c^2\bar{V} - \bar{V}_c^3 = 0$$

si se despeja \bar{V} de la ecuación de Berthelot

$$P = \frac{RT}{(\bar{V}-b)} - \frac{a}{\bar{V}^2 T}$$

$$\left(P + \frac{a}{\bar{V}^2 T} \right) = \frac{RT}{(\bar{V}-b)} \therefore \left(P + \frac{a}{\bar{V}^2 T} \right) (\bar{V}-b) = RT$$

$$\left(\frac{P\bar{V}^2 T + a}{\bar{V}^2 T} \right) (\bar{V}-b) = RT$$

$$\frac{P\bar{V}^3 T - P\bar{V}^2 T b + a\bar{V} - ab}{\bar{V}^2 T} = RT$$

$$\frac{P\bar{V}^3T - P\bar{V}^2Tb + a\bar{V} - ab}{T} = RT\bar{V}^2$$

$$P\bar{V}^3 - P\bar{V}^2b + \frac{a\bar{V}}{T} - \frac{ab}{T} - RT\bar{V}^2 = 0$$

$$P\bar{V}^3 - P\bar{V}^2b - RT\bar{V}^2 + \frac{a\bar{V}}{T} - \frac{ab}{T} = 0$$

$$\bar{V}^3 - \bar{V}^2\left(b + \frac{RT}{P}\right) + \frac{a\bar{V}}{PT} - \frac{ab}{PT} = 0$$

$$\bar{V}^3 - \bar{V}^2 \left(b + \frac{RT}{P} \right) + \frac{a\bar{V}}{PT} - \frac{ab}{PT} = 0$$

aplicando análisis dimensional

$$\left(\frac{L}{mol} \right)^3 - \left(\frac{L}{mol} \right)^2 \left[\frac{L}{mol} + \frac{\cancel{atm}L}{\cancel{mol}L} \frac{\cancel{K}}{\cancel{atm}} \right] + \left[\frac{\cancel{atm}L^2K}{mol^2} \left(\frac{L}{mol \cancel{atm}K} \right) \right] - \left[\frac{\cancel{atm}L^2K}{mol^2} \left(\frac{L}{mol \cancel{atm}K} \right) \right] = 0$$

$$\left(\frac{L}{mol} \right)^3 - \left[\left(\frac{L}{mol} \right)^2 \left(\frac{L}{mol} \right) \right] + \left[\frac{L^3}{mol^3} \right] - \left[\frac{L^3}{mol^3} \right]$$

$$\left(\frac{L}{mol} \right)^3 - \left(\frac{L}{mol} \right)^3 + \left(\frac{L}{mol} \right)^3 - \frac{L^3}{mol^3} = 0$$

correctas las dimensiones

Retomando

$$\bar{V}^3 - \bar{V}^2 \left(b + \frac{RT}{P} \right) + \frac{a\bar{V}}{PT} - \frac{ab}{PT} = 0 \dots \textcircled{1}$$

$$\bar{V}^3 - 3\bar{V}^2 V_c + 3\bar{V}_c^2 \bar{V} - \bar{V}_c^3 = 0 \dots \textcircled{2}$$

Rearreglando en condiciones críticas la ecuación 1 y 2

$$\bar{V}^3 = \bar{V}^3 \quad -3\bar{V}_c = -\left(b + R \frac{T_c}{P_c} \right)$$

$$-\bar{V}_c^3 = -\frac{ab}{P_c T_c} \quad 3\bar{V}_c^2 = \frac{a}{P_c T_c}$$

De lo anterior se obtiene

$$3 \bar{v}_c^2 = \frac{a}{P_c T_c} \therefore a = 3 P_c \bar{v}_c^2 T_c$$

Berthelot

resultado semejante con el método I

para obtener b

$$\bar{v}_c^3 = \frac{ab}{P_c T_c} \therefore \bar{v}_c^3 = \frac{(3 P_c \bar{v}_c^2 T_c) b}{P_c T_c}$$

$$\bar{v}_c^3 = 3 b \bar{v}_c^2$$

$$b = \frac{1}{3} \bar{v}_c$$

resultado semejante con el método I

Procesos reales

(Isotérmico) (Reversible = R Irreversible = IR)

Tipo Van der Waals

$$P = \frac{RT}{\bar{V} - b} - \frac{a}{\bar{V}^2}$$

Obtener ecuaciones para \bar{U} , \bar{q} , $\Delta\bar{U}$, $\Delta\bar{H}$, $\Delta\bar{S}$ y $\Delta\bar{G}$

Relaciones de Maxwell

$$dU = Tds - p dv$$

$$dG = v dp - s dt$$

$$dH = du + v dp$$

$$dA = -p dv - s dt$$

Si se utilizan variables intensivas

$$d\bar{U} = T d\bar{s} - \bar{p} d\bar{v}$$

$$d\bar{G} = \bar{v} d\bar{p} - \bar{s} dt$$

$$d\bar{H} = d\bar{u} + \bar{v} d\bar{p}$$

$$d\bar{A} = -\bar{p} d\bar{v} - \bar{s} dt$$

$$d\bar{u} = T d\bar{s} - p d\bar{v}$$

$$\left(\frac{\partial \bar{u}}{\partial \bar{v}}\right)_T = T \left(\frac{\partial \bar{s}}{\partial \bar{v}}\right)_T - p$$

$$d\bar{a} = -p d\bar{v} - \bar{s} dT$$

$$\left(\frac{\partial \bar{s}}{\partial \bar{v}}\right)_T = \left(\frac{\partial p}{\partial T}\right)_V \quad \text{per lo tanto}$$

$$\left(\frac{\partial \bar{u}}{\partial \bar{v}}\right)_T = T \left(\frac{\partial p}{\partial T}\right)_V - p$$

Si el gas es ideal.

$$\left(\frac{\partial \bar{U}}{\partial \bar{V}}\right)_T = T \left(\frac{\partial P}{\partial T}\right)_{\bar{V}} - P$$

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

$$\left(\frac{\partial P}{\partial T}\right)_{\bar{V}} = \frac{R}{\bar{V}} \quad \text{por lo tanto}$$

$$\left(\frac{\partial \bar{U}}{\partial \bar{V}}\right)_T = T \left(\frac{R}{\bar{V}}\right) - \frac{RT}{\bar{V}} = 0 \quad \text{gas tipo perfecto}$$

o ideal ✓

$$\Delta \bar{U} = 0$$

Si el gas es tipo Von der Waals

$$\left(\frac{\partial \bar{u}}{\partial \bar{v}}\right)_T = T \left(\frac{\partial p}{\partial T}\right)_{\bar{v}} - p$$

$$p = \frac{RT}{\bar{v}-b} - \frac{a}{\bar{v}^2}$$

$$\left(\frac{\partial p}{\partial T}\right)_{\bar{v}} = \frac{R}{\bar{v}-b}$$

$$\left(\frac{\partial \bar{u}}{\partial \bar{v}}\right)_T = T \left(\frac{R}{\bar{v}-b}\right) - \left[\frac{RT}{\bar{v}-b} - \frac{a}{\bar{v}^2}\right]$$

$$\Delta \bar{u} = \int_{\bar{v}_1}^{\bar{v}_2} \frac{a}{\bar{v}^2} d\bar{v} = -a \left[\frac{1}{\bar{v}_2} - \frac{1}{\bar{v}_1} \right]$$

Checkar unidades

$$\Delta \bar{U} = -a \left[\frac{1}{\bar{v}_2} - \frac{1}{\bar{v}_1} \right]$$

$$\text{ó } \Delta \bar{U} = a \left[\frac{1}{\bar{v}_1} - \frac{1}{\bar{v}_2} \right]$$

$$\frac{\text{atm L}^2}{\text{mol}^2} \left[\frac{1}{\text{L/mol}} - \frac{1}{\text{L/mol}} \right]$$

$$= \left(\frac{\text{atm L}}{\text{mol}} \right) \left(\frac{1.01325 \times 10^5 \text{ N/m}^2}{1 \text{ atm}} \right) \left(\frac{1 \text{ m}^3}{10^3 \text{ L}} \right) = \frac{\text{J}}{\text{mol}} \quad \checkmark$$

de acuerdo a la anterior ecuación

en un proceso isotérmico de expansión $\bar{\Delta U} = +$ ✓

en un proceso isotérmico de compresión $\bar{\Delta U} = -$ ✓ Comportamiento real.

cálculo de $\bar{\Delta S}_R$ gas ideal

$$\left(\frac{\partial S}{\partial U} \right)_T = \left(\frac{\partial P}{\partial T} \right)_V = \frac{R}{V}$$

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

$$\bar{\Delta S}_R = \int_{V_1}^{V_2} \frac{R}{V} dV = R \ln \frac{V_2}{V_1} = (\text{J/molK}) \ln \frac{4 \text{ mol}}{1 \text{ mol}} = \text{J/molK} \checkmark$$

cálculo de $\overline{\Delta S}_R$ gas tipo Van der Waals.

$$\left(\frac{\partial S}{\partial U} \right)_T = \left(\frac{\partial P}{\partial T} \right)_U = \frac{R}{\bar{v}-b}$$

$$P = \frac{RT}{\bar{v}-b} - \frac{a}{\bar{v}^2}$$

$$\overline{\Delta S}_R = \int_{\bar{v}_1}^{\bar{v}_2} \frac{R}{\bar{v}-b} d\bar{v} = R \ln \left(\frac{\bar{v}_2-b}{\bar{v}_1-b} \right)$$

$$= \text{J/molK} \ln \frac{4\text{mol} - 4\text{mol}}{4\text{mol} - 4\text{mol}}$$

$$\overline{\Delta S}_R = \text{J/molK} \quad \checkmark$$

de acuerdo a la anterior ecuación

$\bar{\Delta S}$ en expansión isotérmica real $>$ $\bar{\Delta S}$ en expansión isotérmica ideal ✓

$|\bar{\Delta S}|$ en compresión isotérmica real $>$ $|\bar{\Delta S}|$ en compresión isotérmica ideal ✓

cálculo de $\bar{\Delta H}$ gas ideal

$$dH = TdS + \bar{V}dp$$

$$dG = \bar{V}dp - SdT$$

se pueden obtener las derivadas parciales

una mejor relación para obtener $\overline{\Delta H}$ es

$$\Delta H = \Delta U + \Delta PV$$

$$\overline{\Delta H} = \overline{\Delta U} + (p_2 \overline{V}_2 - p_1 \overline{V}_1)$$

donde p_1 y p_2 son de Van der Waals al igual que \overline{V}_1 y \overline{V}_2

Cálculo de ΔG

$$\overline{\Delta G} = \overline{\Delta H} - T \overline{\Delta S}$$

Obtención de \bar{w} para proceso isotérmico tipo Von der Waals
(reversible)

$$\delta \bar{w}_e = p d\bar{v} \quad p = \frac{RT}{\bar{v}-b} - \frac{a}{\bar{v}^2}$$

$$\delta \bar{w}_e = \left(\frac{RT}{\bar{v}-b} - \frac{a}{\bar{v}^2} \right) d\bar{v} \quad \text{Integrando}$$

$$\bar{w}_e = \int_{\bar{v}_1}^{\bar{v}_2} RT \frac{d\bar{v}}{\bar{v}-b} - a \int_{\bar{v}_1}^{\bar{v}_2} \frac{d\bar{v}}{\bar{v}^2} = RT \ln \left(\frac{\bar{v}_2-b}{\bar{v}_1-b} \right) + a \left[\frac{1}{\bar{v}_2} - \frac{1}{\bar{v}_1} \right]$$

Obtención de \bar{Q} para proceso isotérmico tipo Von der Waals
(reversible)

$$\bar{q}_R = \Delta\bar{U} + \bar{w}_R$$

$$\Delta\bar{U} = a \left[\frac{1}{\bar{v}_1} - \frac{1}{\bar{v}_2} \right]$$

$$\bar{w} = RT \ln \left(\frac{\bar{v}_2 - b}{\bar{v}_1 - b} \right) + a \left[\frac{1}{\bar{v}_2} - \frac{1}{\bar{v}_1} \right]$$

por lo tanto

$$\bar{g}_{TR} = RT \ln \left(\frac{\bar{v}_2 - b}{\bar{v}_1 - b} \right) + a \left[\frac{1}{\bar{v}_1} - \frac{1}{\bar{v}_2} \right] + a \left[\frac{1}{\bar{v}_2} - \frac{1}{\bar{v}_1} \right]$$

$$\begin{aligned} \bar{g}_{TR} &= RT \ln \frac{\bar{v}_2 - b}{\bar{v}_1 - b} && (\text{atm L/mol K}) (K) \ln \frac{\text{L/mol}}{\text{L/mol}} \\ &= \left(\frac{\text{atm L}}{\text{mol}} \right) \left(\frac{1.01325 \times 10^5 \text{ N/m}^2}{\text{atm}} \right) \left(\frac{1 \text{ m}^3}{10^3 \text{ L}} \right) = \frac{\text{J}}{\text{mol}} \checkmark \end{aligned}$$

por otro lado

$$\bar{g}_{TR} = T \bar{\Delta S}_R = T R \left(\ln \frac{\bar{v}_2 - b}{\bar{v}_1 - b} \right)$$

cálculo semejante

Obtención de \bar{w} para proceso isotérmico tipo Von der Waals
(Irreversible)

$$\int \bar{w} = p_{op} d\bar{v} \quad p_{op, \text{Von}} = \frac{RT}{\bar{v}_2 - b} - \frac{a}{\bar{v}_2^2}$$

aquí se utiliza \bar{v}_2 (proceso de expansión o compresión)

$$\bar{w}_{IR} = p_{op, \text{Von}} (\bar{v}_2 - \bar{v}_1) = atm \left(\frac{L}{mol} - \frac{L}{mol} \right)$$

$$\left(\frac{atm \cdot L}{mol} \right) \left(\frac{101325 \times 10^5 \text{ N/m}^2}{atm} \right) \left(\frac{1 \text{ m}^3}{10^3 \text{ L}} \right) = \frac{J}{mol} \checkmark$$

$$\bar{w}_{1R} = \frac{RT}{\bar{v}_2 - b} - \frac{a}{\bar{v}_2^2} (\bar{v}_2 - \bar{v}_1)$$

Obtención de \bar{q}_{1R} para proceso isotérmico tipo Von der Waals (irreversible)

$$\bar{q}_{1R} = \Delta \bar{u} + \bar{w}_{1R} \quad \Delta \bar{u} = a \left[\frac{1}{\bar{v}_1} - \frac{1}{\bar{v}_2} \right]$$

$$\bar{q}_{1R} = a \left[\frac{1}{\bar{v}_1} - \frac{1}{\bar{v}_2} \right] + \frac{RT}{\bar{v}_2 - b} - \frac{a}{\bar{v}_2^2} (\bar{v}_2 - \bar{v}_1)$$

$$\Delta S_{\text{irrev}} = \frac{\bar{q}_{1R}}{T}$$

Tarea

obtener \bar{w} , \bar{q} , $\Delta\bar{U}$, $\Delta\bar{H}$, $\Delta\bar{S}$, $\Delta\bar{A}$ para un gas de compartamiento tipo Berthelot

$$P = \frac{RT}{\bar{v} - b} - \frac{a}{\bar{v}^2 T}$$

y comparar con el modelo ideal; si 10 moles de N_2 se encuentran en sistema cerrado a 300K y 40 atm y se comprime a la mitad del volumen inicial (utilizar modelo van der Waals y Berthelot)

Redlich - Kwong (1949)

$$p = \frac{RT}{\bar{v}-b} - \frac{a}{\bar{v}(\bar{v}+b)^{1/2}}$$

$$a = 0.4275 \frac{R^2 T_c^{5/2}}{p_c} \quad b = 0.0867 \frac{RT_c}{p_c}$$

Comparado a Van der Waals

$$\begin{aligned} a &= \frac{27}{64} \frac{R^2 T_c^2}{p_c} & b &= \frac{RT_c}{8p_c} \\ &= 0.4218 \frac{R^2 T_c^2}{p_c} & &= 0.125 \frac{RT_c}{p_c} \end{aligned}$$

Las diferencias no son tan grandes

si disminuye b aumenta a en Redlich-Kwong

de la anterior ecuación obtener T y \bar{v}

obtención de T

$$p = \frac{RT}{\bar{v}-b} - \frac{a}{\bar{v}(\bar{v}+b)T^{1/2}}$$

$$\left[p + \frac{a}{(\bar{v}^2 + \bar{v}b)T^{1/2}} = \frac{RT^{2/2}}{\bar{v}-b} \right] T^{1/2}$$

$$\left[pT^{1/2} + \frac{a}{\bar{v}^2 + \bar{v}b} = \frac{RT^{3/2}}{\bar{v}-b} \right] T \quad \text{Continuar de Torca}$$





