Clase 35 30 Sep 2015

Título de la nota 30/09/2015

Calcular a y b para el N_2 con los siguientes datos

$T_c = 126.15 K$

$P_c = 33.5 \text{ atm}$

$\delta_c = 0.31 g/cm^3$

Contrastar los valores de a y b calculados con los reportados en tablas

De tablas $a = 1.39 \text{ atm} L^2/mol^2$

$b = 0.03913 \text{ L/mol}$

Dependiente de $\bar{V}c$

$a = 3pc\bar{V}c^2 = 3(33.5\,atm)(0.0903\,L/mol)^2 = \boxed{0.8198\,atm\,L^2/mol^2}$

$b = 1/3\,\bar{V}c = 1/3\,(0.0903\,L/mol) = \boxed{0.0301\,L/mol}$

calcular $\bar{V}c = L/mol = \dfrac{MM}{\delta c \times 1000\,\frac{cm^3}{L}} = \dfrac{g/mol}{(g/cm^3)\left(\frac{1000\,cm^3}{L}\right)}$

$= \dfrac{28\,g/mol}{(0.31\,g/cm^3)(1000\,cm^3/L)} = \boxed{0.0903\,L/mol}$

Independiente de $\bar{V}_c$

$$a = \frac{27}{64}\frac{R^2 T_c^2}{P_c} = \frac{27}{64}\frac{(0.082\,atm\,L/mol\,K)^2(126.15\,K)^2}{33.5\,atm} = 1.3475\,atm\,L^2/mol^2$$

$$b = \frac{R T_c}{8 P_c} = \frac{(0.082\,atm\,L/mol\,K)(126.15\,K)}{8\,(33.5\,atm)} = 0.03859\,L/mol$$

al comparar

	dependiente de $\bar{V}_c$	independiente de $\bar{V}_c$	Tablas
a	0.8198 $atm\,L^2/mol^2$	1.3475 $atm\,L^2/mol^2$	1.39 $atm\,L^2/mol^2$
b	0.0301 L/mol	0.03859 L/mol	0.03913 L/mol

Regla

Para los cálculos los valores de a y b se toman por pares

Es posible checar la proporción

$$\frac{a \text{ independiente de } \bar{V}_c}{a \text{ dependiente de } \bar{V}_c} = \frac{1.3475 \text{ atm } L^2/mol^2}{0.8198 \text{ atm } L^2/mol^2} = 1.6443$$

$$\text{aquí } L^2/mol^2 = \sqrt{1.6443 \; L^2/mol^2} = 1.2820$$

$$\text{b independiente de } \bar{V}_c = (\text{b dependiente de } \bar{V}_c)(1.2820) = (0.0301 \; L/mol)(1.2820)$$

$$= 0.03859 \; L/mol$$

correspondencia adecuada

de la ecuación de Van der Waals obtener $\bar{v}$

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

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

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

$$p\bar{v}^3 + a\bar{v} - ab - bp\bar{v}^2 = \bar{v}^2 RT$$ arreglando

$$p\bar{V}^3 - \bar{V}^2(bp + RT) + \bar{V}a - ab = 0$$

dividiendo entre p

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

$$\left(\frac{L}{mol}\right)^3 - \frac{L^2}{mol^2}\left[\frac{L}{mol} + \frac{(atm\,L/mol\,K)(K)}{atm}\right] + \frac{L}{mol}\,\frac{atm\,L^2}{mol^2}\,\frac{1}{atm} - \frac{atm\,L^2/mol^2\,\frac{L}{mol}}{atm}$$

$$\frac{L^3}{mol^3} - \frac{L^3}{mol^3} + \frac{L^3}{mol^3} - \frac{L^3}{mol^3} = 0$$

correcto

obtener V a partir de

$$p = \frac{nRT}{V-nb} - \frac{an^2}{V^2} \qquad \left(p + \frac{an^2}{V^2}\right)\left(V-nb\right) = nRT$$

$$pV - pnb - \frac{an^3b}{V^2} + \frac{an^2V}{V^2} = nRT$$

$$pV - pnb - \frac{an^3b}{V^2} + \frac{an^2}{V} - nRT = 0$$

$$pV - (RT + pb)n + \frac{an^2}{V} - \frac{an^3b}{V^2} = 0$$

$$-\frac{an^3b}{V^2} + \frac{an^2}{V} - n(RT + pb) + pV = 0$$

sustituir $n = \frac{g}{M}$

$$-\frac{a\left(\frac{g}{M}\right)^3 b}{V^2} + \frac{a\left(\frac{g}{M}\right)^2}{V} - \frac{g}{M}\left[RT + pb\right] + pV = 0$$

$$-\frac{ag^3b}{M^3V^2} + \frac{ag^2}{M^2V} - \frac{g}{M}\left[RT + pb\right] + pV = 0$$

reacomodando y multiplicando por M^3

$$\left[-\frac{ag^3b}{M^3V^2} + \frac{ag^2}{M^2V} - \frac{g}{M}\left[RT + pb\right] + pV = 0\right] M^3$$

$$-\frac{ag^3b}{V^2} + \frac{ag^2M}{V} - gM^2\left[RT + pb\right] + pVM^3 = 0$$

reacomodando

$$PVM^3 - gM^2\left[RT + pb\right] + \frac{ag^2M}{V} - \frac{ag^3b}{V^2} = 0$$

Checar unidades

$$atm\,L\left(\frac{g}{mol}\right)^3 - g\left(\frac{g}{mol}\right)^2\left[(atm\,L/mol\,K)(K) + \frac{atm\,L}{mol}\right] + \frac{\frac{atm\,L^2}{mol^2}\,g^2\,\frac{g}{mol}}{L} - \frac{atm\,L^2/mol^2\,g^2\,L}{L\quad mol}$$

$$\frac{atm\,g^3L}{mol^3} - \frac{atm\,g^3L}{mol^3} + \frac{atm\,g^3L}{mol^3} - \frac{atm\,g^3L}{mol^3} = 0$$

OK

Primer caso 40 g gas 1atm $T = 298.15K$

$V = 20.2\ L$ gas = CO_2

Primero calcular a y b si se conoce el gas CO_2

o se pueden utilizar valores de tablas

de tablas

$$a = 3.592\ \frac{atm\ L^2}{mol^2}$$

$$b = 0.04267\ L/mol$$

Sustituyendo

$$\boxed{pVM^3 - mM^2\left[RT + pb\right] + \frac{am^2M}{V} - \frac{am^3b}{V^2} = 0}$$

$$(1atm)(20.2L)M^3 - 40g\,M^2\left[(0.082\,atm\,L/mol\,K)(298.15K) + 1atm\,(0.042674\,L/mol)\right]$$

$$+ M\frac{\frac{3.592\,atm\,L^2}{mol^2}(40g)^2}{20.2L} - \frac{3.592\,atm\,L^2/mol^2\,(40g)^3(0.042674\,L/mol)}{(20.2L)^2}$$

$$20.2M^3 - 979.6388M^2 + 284.5148M - 24.040096 = 0$$

resolviendo la ecuación

$$\text{raíces de } M \begin{cases} 48.21 \checkmark \text{ g/mol} \\ 0.15 + 0.06\,i \\ 0.15 - 0.06\,i \end{cases}$$

de acuerdo al modelo ideal

$$M = gRT/PV = \frac{(4.0\,g)(0.082\,atm\,L/mol\,K)(298.15\,K)}{(1\,atm)(20.2\,L)}$$

$$= 48.41 \text{ g/mol}$$

Tarea Justificar

este comportamiento

y utilizar sus resultados de Lab Ciencia Básica I

para obtener M_M de su experimento.