ΚΕΦΑΛΑΙΟ 1

Εισαγωγικά προβλήματα:

A 1.1) Ισόθερμη $\Rightarrow$ $n, T =$ σταθερ. ισχύει νόμος του Boyle

$\Delta V = -2,20\ dm^3$

$V_f = 4,65\ dm^3$

$P_f = 3,78 \times 10^3$ Torr

$P_i = ?$

$\Delta V = V_f - V_i \Rightarrow V_i = V_f - \Delta V = (4,65 + 2,20)\ dm^3 = 6,85\ dm^3$

Νόμος του Boyle $P_i V_i = P_f V_f \Rightarrow P_i = \dfrac{P_f V_f}{V_i}$

$$P_i = \frac{3,78 \times 10^3 (torr) \cdot 4,65 \cancel{(dm^3)}}{6,85 \cancel{(dm^3)}} = 2,57 \times 10^3\ torr$$

$$P_i = 2,57 \times 10^3 \cancel{(Torr)} \left(\frac{1\ atm}{760\ \cancel{Torr}}\right) = 3,38\ atm$$

A 1.2) Ισοβαρής $\Rightarrow$ $n, P =$ σταθ. ισχύει νόμος Charles

$T_i = 340 K$

$V_f = 1,18 V_i$

$T_f = ;$

$$\frac{V_i}{T_i} = \frac{V_f}{T_f} \Rightarrow T_f = \frac{V_f \cdot T_i}{V_i} = \frac{1,18 \cancel{V_i} \cdot 340 (K)}{\cancel{V_i}} = 401\ K$$

A 1.3) αέριο Ne ⇒ Ιδανικό $P \cdot V = n \cdot R \cdot T$

$m = 255\ mg$

$V_i = 3.00\ dm^3$

$T_i = 122\ K$

$P = ?$

$$n = \frac{m}{M} = \frac{255\ mg}{20{,}18\ (g/mol)} = \frac{255 \cdot 10^{-3}\ \cancel{g}}{20{,}18\ (\cancel{g}/mol)} = 0{,}0126\ mol$$

$$P = \frac{n \cdot RT}{V} = \frac{0{,}0126\ (mol) \cdot 8{,}314\ \left(\frac{J}{K \cdot mol}\right) \cdot 122\ (K)}{3.00\ \cancel{dm^3}\left(\frac{10^{-3}\ m^3}{1\ \cancel{dm^3}}\right)}$$

$$= 4272\ Pa = 4{,}27\ KPa$$

$[\ 1\ dm = 10^{-1}\ m \quad 1\ dm^3 = 10^{-3}\ m^3\ ]$

A 1.4) $m_{CH_4} = 320\ mg$

$m_{Ar} = 175\ mg$

$m_{Ne} = 225\ mg$

$P_{Ne} = 66{,}5\ Torr$

$T = 300\ K$

α) $V = ?$

β) $P_{Ar} = ?$

γ) $P_{total} = ?$

(α) Το αέριο καταλαμβάνει όλο τον χώρο $V_{tot} = V_{Ne}$

$$V_{Ne} = \frac{n \cdot RT}{P} = \frac{m \cdot R \cdot T}{M \cdot P}$$

$$V = \frac{225\,mg \cdot 8,314\left(\frac{J}{K \cdot mol}\right) \cdot 300\,(K)}{20,18\left(\frac{g}{mol}\right) \cdot 66,5\,(Torr)\left(\frac{133322\,(N/m^2)}{1\,Torr}\right)}$$

$$V = \frac{225 \cdot 10^{-3}\,(g) \cdot 8,314\left(\frac{N \cdot m}{K \cdot mol}\right) 300\,K}{20,18\left(\frac{g}{mol}\right) \cdot 66,5\,(Torr)\left(\frac{133322\,(N/m^2)}{1\,Torr}\right)}$$

$V_{tot} = 3,14 \times 10^{-3}\,m^3$ ή $3,14\,dm^3$

(β) $P_{Ar} = \frac{n \cdot RT}{V_{Ar}} \Rightarrow P_{Ar} = \frac{n \cdot R \cdot T}{V_{tot}}$

$$P_{Ar} = \frac{175 \times \cancel{10^{-3}}\,(\cancel{g}) \cdot 8,314\,(J/\cancel{K \cdot mol}) \cdot 300\,\cancel{K}}{39,95\,(\cancel{g}/\cancel{mol}) \cdot 3,14 \times \cancel{10^{-3}}\,(m^3)} = 3,48 \times 10^3\,Pa$$

ή $3,48\,KPa$

(γ) Ισχύει ο νόμος του Dalton

$P_{tot} = P_{CH_4} + P_{Ar} + P_{Ne} \Rightarrow$

Πρώτα υπολογίζουμε τη μερική πίεση του CH_4

$$P_{CH_4} = \frac{m_{CH_4} \cdot R \cdot T}{MW \cdot V} = \frac{320 \times \cancel{10^{-3}}\,(g) \cdot 8,314\left(\frac{J}{\cancel{K \cdot mol}}\right) \cdot 300\,\cancel{K}}{16,042\,(\cancel{g}/\cancel{mol}) \cdot 3,14 \times \cancel{10^{-3}}\,(m^3)}$$

$P_{CH_4} = \underline{15,8 \times 10^3\,Pa}$ ή $\underline{15,8\,KPa}$

$$P_{tot} = 15,8\ KPa + 3,48\ KPa + 66,5\ \cancel{Torr}\left(\frac{0,133322\ KPa}{1\ \cancel{Torr}}\right)$$

$$P_{tot} = \underline{\underline{28,1\ KPa}}$$

A 1.5) $\rho = 1,23\ g/dm^3$

$T = 330\ K$

$P = 150\ Torr$

$$P \cdot V = n RT \Rightarrow P \cdot V = \frac{m}{M} \cdot RT$$

$$\Rightarrow M = \frac{m}{V} \cdot \frac{RT}{P} \Rightarrow M = \rho \cdot \frac{RT}{P}$$

$$M = 1,23\left(\frac{g}{\cancel{dm^3}}\right)\left(\frac{\cancel{dm^3}}{10^{-3}\ m^3}\right) \frac{8,314\left(\frac{J}{\cancel{K}.mol}\right) \cdot 330\ (\cancel{K})}{150\ (\cancel{Torr}) \cdot \frac{101325\ (N/m^2)}{760\ (\cancel{Torr})}}$$

$$M = 169\ \frac{g}{mol}$$

A 1.6) $T = 250\ K$

$P = 15\ atm$

$V'_m = 0,88\ V_m$

a) $Z = ?$

α' τρόπος : $Z = \frac{P \cdot V_m}{RT}$ για ιδανικό αέριο $Z = 1$

$$\Rightarrow V_m = \frac{R \cdot T}{P} = \frac{8,314\left(\frac{J}{\cancel{K}.mol}\right) \cdot 250\ (\cancel{K})}{15\ \cancel{atm}\left(\frac{101\ 325\ Pa}{1\ \cancel{atm}}\right)} = 1,367 \times 10^{-3}\ \frac{m^3}{mol}$$

Έτσι $V'_m = 0,88 \times 1,367 \times 10^{-3} \left(\frac{m^3}{mol}\right)$

$= 1,203 \times 10^{-3} \left(\frac{m^3}{mol}\right)$

$$Z = \frac{P \cdot V'_m}{RT} = \frac{15\,\cancel{atm}\left(\frac{101325\ Pa}{1\cancel{atm}}\right) \cdot 1,203 \times 10^{-3}\left(\frac{m^3}{\cancel{mol}}\right)}{8,314\left(\frac{J}{\cancel{K \cdot mol}}\right) \cdot 250\,\cancel{(K)}}$$

$Z = 0,88$

<u>β' τρόπος</u>: για ιδανικά αέρια ισχύει $PV_m = RT$ (1)

για μη ιδανικό αέριο $\left.\begin{array}{l} Z = \dfrac{P \cdot V'_m}{RT} \\ \text{ξέρουμε ότι } V'_m = 0,88 V_m \end{array}\right\} \Rightarrow$

$$Z = \frac{P \cdot V_m \cdot 0,88}{RT} \overset{(1)}{\Longrightarrow} Z = \frac{R \cdot T}{R \cdot T} \cdot 0,88 \Rightarrow Z = 0,88$$

β) $V'_m = ?$ $\quad V'_m = \frac{Z \cdot RT}{P} = \frac{0,88 \times 8,314\left(\frac{J}{\cancel{K \cdot mol}}\right) \cdot 250\,\cancel{(K)}}{15\,\cancel{atm}\left(\frac{101325\ Pa}{1\,\cancel{atm}}\right)}$

$V'_m = 1,2 \times 10^{-3}\ \frac{m^3}{mol}$

Ο γραμμομοριακός όγκος του αερίου είναι μικρότερος από αυτό του ιδανικού αερίου έτσι οι δυνάμεις μεταξύ των σωματιδίων του αερίου είναι <u>ελκτικές</u>. Αυτό προκαλεί συστολή του αερίου και μείωση του V_m.

A 1.7) $T = 300\,K$

$P = 20\,atm$

$Z = 0.86$

a) $V = ?$ αν $n = 8.2\,mmol$

$$Z = \frac{P \cdot V_m}{RT} \Rightarrow Z = \frac{P \cdot V}{nRT} \Rightarrow$$

$$V = \frac{n \cdot R \cdot T \cdot Z}{P} = \frac{8.2 \times 10^{-3}\,(\cancel{mol}) \cdot 8{,}314\left(\frac{J}{\cancel{K \cdot mol}}\right) \cdot 300\,(\cancel{K}) \cdot 0{,}86}{20\,(\cancel{atm}) \cdot \left(\frac{101325\,Pa}{1\,\cancel{atm}}\right)}$$

$$V = 8{,}7 \times 10^{-6}\,m^3 \Rightarrow \underline{\underline{V = 8{,}7\,cm^3}}$$

$$1m = 10^2\,cm \Rightarrow 1m^3 = 10^6\,cm^3 \Rightarrow 10^{-6}\,m^3 = 1\,cm^3$$

b) $B = ?$

$$P = \left(\frac{R \cdot T}{V_m}\right)\left(1 + \frac{B(T)}{V_m} + \frac{C(T)}{V_m^2} + \ldots\right)$$

$$P \simeq \frac{R \cdot T}{V_m} + \frac{RT}{V_m^2} B(T) \Rightarrow$$

$$P - \frac{RT}{V_m} \simeq \frac{RT}{V_m^2} B(T) \Rightarrow B(T) \simeq \frac{V_m^2}{RT}\left(P - \frac{RT}{V_m}\right)$$

$$B(T) \simeq \frac{(8.7 \times 10^{-6}\,m^3)^2}{(8.2 \times 10^{-3}\,mol)^2 \cdot 8{,}314\left(\frac{J}{\cancel{K} \cdot mol}\right) \cdot 300\,(\cancel{K})}\left[\frac{20\,atm\,(101325\,Pa)}{1\,atm} - \frac{8{,}314\left(\frac{J}{\cancel{K \cdot mol}}\right) \cdot 300\,(\cancel{K}) \cdot 8{,}2 \times 10^{-3}\,(\cancel{mol})}{8{,}7 \times 10^{-6}\,(m^3)}\right]$$

$$B(T) \simeq \frac{7{,}569 \times 10^{-11}\,m^6}{0{,}1677\,mol \cdot J}\left[2{,}026 \times 10^6\,Pa - 2{,}350 \times 10^6\,Pa\right]$$

$$= \frac{7{,}569 \times 10^{-11} \, (m^{\cancel{8}\,4})}{0{,}1677 \, (mol \cdot J)} \left[-0{,}324 \times 10^{6} \frac{N}{\cancel{m^2}} \right] =$$

$$= -1{,}462 \times 10^{-4} \frac{m^3}{mol}$$

$$B(T) \simeq -0{,}15 \times 10^{-3} \frac{m^3}{mol} \Rightarrow B(T) \simeq \underline{-0{,}15} \frac{dm^3}{mol}$$

A 1.8) $V_{m,c} = 160 cm^3/mol$

$P_c = 40 atm$

a) $T_c = ?$

$$V_{m,c} = 3b \Rightarrow b = \frac{V_{m,c}}{3} = \frac{160 \, cm^3}{3 \quad mol} = 53{,}\bar{3} \frac{cm^3}{mol}$$

$$P_c = \frac{1}{12}\left(2a \cdot R / 3b^3\right)^{\frac{1}{2}} \Rightarrow (12 P_c)^2 = \frac{2aR}{3b^3}$$

$$a = \frac{3b^3 (12 P_c)^2}{2R} = \frac{3\left(53{,}\bar{3} \frac{cm^3}{mol}\right)^3 (12 \cdot 40 \, atm)^2}{2 \cdot 8{,}314 \, (J/K \cdot mol)}$$

$$a = 6{,}294 \times 10^{9} \frac{cm^9}{mol^{\cancel{3}\,2}} \cdot \frac{atm^2 \cdot K \cdot \cancel{mol}}{J}$$

$$a = 6{,}294 \times 10^{9} \frac{cm^9 \cdot atm^2 \cdot K}{mol^2 \cdot J}$$

$$T_c = \frac{2}{3}\left(\frac{2a}{3Rb}\right)^{\frac{1}{2}} = \frac{2}{3}\left(\frac{2 \times 6{,}294 \times 10^{9} \frac{cm^{\cancel{9}\,6} \cdot atm^2 \cdot K}{\cancel{mol^2} \cdot J}}{3 \cdot 8{,}314 \left(\frac{J}{K \cdot \cancel{mol}}\right) \cdot 53{,}3 \left(\frac{\cancel{cm^3}}{\cancel{mol}}\right)}\right)^{\frac{1}{2}}$$

$$T_c = \frac{2}{3}\left(3077{,}21 \frac{cm^3 \cdot atm \cdot K}{J}\right) =$$

$$T_c = 2051,47 \frac{\cancel{cm^3}.\cancel{atm}.K}{J} \cdot \left(\frac{10^{-6} m^3}{1 \cancel{cm^3}}\right) \cdot \left(\frac{101325 \, Pa}{1 \cancel{atm}}\right)$$

$$T_c = 208 K$$

Ο όγκος ενός σωματιδίου δίνεται από:

$$b = \frac{53,3 \, cm^3 . \cancel{mol^{-1}}}{6,022 \times 10^{23} \cancel{mol^{-1}}} = 8,85 \times 10^{-23} cm^3 \Rightarrow b = \frac{4}{3}\pi r^3 \Rightarrow$$

$$r = \sqrt[3]{\frac{3b}{4\pi}} = \sqrt{\frac{3 \cdot 8,85 \times 10^{-23}}{4\pi}} = 2,76 \times 10^{-8} cm = 276 \, pm$$

A 1.9) $T = 350K$

$P = 2,30 atm$

Cl_2

$V_m = ?$

a) $$PV_m = RT \Rightarrow V_m = \frac{R.T}{P} = \frac{8,314 \left(\frac{J}{\cancel{K}.mol}\right) . 350 (\cancel{K})}{2,30 (\cancel{atm}) . \frac{101325 (Pa)}{1 \cancel{atm}}}$$

$$\Rightarrow V_m = 0,0124 \frac{m^3}{mol} \Rightarrow V_m = 12,48 \frac{dm^3}{mol}$$

b) $$P = \frac{RT}{V_m - b} - \frac{a}{V_m^2} \quad (1)$$

σελ. 363 του βιβλίου σας υπάρχουν οι σταθερές Van der Waals για διάφορα αέρια. Για το μοριακό χλώριο $a = 6,493 \frac{dm^6 . atm}{mol^2}$ $b = 5,622 \times 10^{-2} \frac{dm^3}{mol}$

$$(1) \Rightarrow P(V_m - b) V_m^2 = R \cdot T \cdot V_m^2 - a(V_m - b)$$

$$\Rightarrow (V_m - b) V_m^2 = \frac{R \cdot T}{P} V_m^2 - \frac{aV_m}{P} + \frac{ab}{P}$$

$$\Rightarrow V_m^3 - bV_m^2 = \frac{R \cdot T}{P} V_m^2 - \frac{aV_m}{P} + \frac{ab}{P}$$

(5)

$$\Rightarrow \boxed{V_m^3 - \left(\frac{R\cdot T}{P} + b\right) V_m^2 + \frac{a}{P} V_m - \frac{ab}{P} = 0}$$

Επειδή γνωρίζουμε περίπου την τιμή του V_m από την εξίσωση των ιδανικών αερίων η εξίσωση αυτή μπορεί να λυθεί με τη μέθοδο των διαδοχικών προσεγγίσεων.

$$\frac{R\cdot T}{P} + b = \frac{8{,}314 \left(\frac{J}{\cancel{K}\cdot mol}\right) \cdot 350\,\cancel{(K)}}{2{,}3\,(\cancel{atm}) \cdot \frac{101325\ Pa}{1\,\cancel{atm}}} + 5{,}622\times 10^{-2}\ \frac{dm^3}{mol}$$

$$= 0{,}01248 \left(\frac{m^3}{mol}\right)\left(\frac{dm^3}{10^{-3}\,m^3}\right) + 5{,}622\times10^{-2}\ \frac{dm^3}{mol}$$

$$= 12{,}486\ \frac{dm^3}{mol} + 5{,}622\times10^{-2}\ \frac{dm^3}{mol}$$

$$= 12{,}542\ \frac{dm^3}{mol}$$

$$\frac{a}{P} = \frac{6{,}493\ \frac{dm^6\ \cancel{atm}}{mol^2}}{2{,}3\ \cancel{atm}} = 2{,}823\ \frac{dm^6}{mol^2}$$

$$\frac{ab}{P} = \frac{6{,}493 \left(\frac{dm^6\cdot \cancel{atm}}{mol}\right) \cdot 5{,}622\times10^{-2}\left(\frac{dm^3}{mol}\right)}{2{,}3\ \cancel{atm}}$$

$$= 0{,}1587 \left(\frac{dm^9}{mol^2}\right)$$

$$\boxed{V_m^3 - 12,542\left(\frac{dm^6}{mol}\right)V_m^2 + 2,823\left(\frac{dm^6}{mol}\right)V_m - 0,1587\left(\frac{dm^9}{mol^2}\right)} = 0$$

για ιδανικά αέρια $V_m = 12,48\left(\frac{dm^3}{mol}\right)$

για $V_m = 12,48\left(\frac{dm^3}{mol}\right) \Rightarrow 25,41$

για $V_m = 12,3\left(\frac{dm^3}{mol}\right) \Rightarrow -2,04$

$V_m = 12,4\left(\frac{dm^3}{mol}\right) \Rightarrow 13,012$

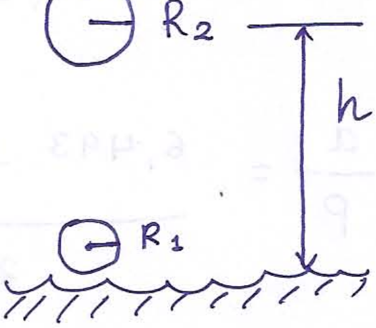
$V_m = 12,32\left(\frac{dm^3}{mol}\right) \Rightarrow 0,924$

$V_m = 12,314\left(\frac{dm^3}{mol}\right) \Rightarrow 0,0310$

1.7) $R_1 = 1m$ $\quad R_2 = 3m$

$T_1 = 25°C$ $\quad T_2 = -20°C = 273,15 - 20 = 253,15\,(K)$

$P_1 = 1atm$ $\quad P_2 = ?$



$$V = \frac{4}{3}\pi R^3$$

$$V_1 = \frac{4}{3}\pi R_1^3 = \frac{4}{3}\pi(1m)^3 = \frac{4}{3}\pi\,(m^3)$$

$$V_2 = \frac{4}{3}\pi(R_2)^3 = \frac{4}{3}\pi(3m)^3 = 36\pi\,(m^3)$$

Από το νόμο των ιδανικών αερίων $P < 1atm$

$$\frac{P_1 . V_1}{\cancel{R} . T_1} = \frac{P_2 . V_2}{\cancel{R} . T_2} \Rightarrow P_2 = \frac{P_1 . V_1 . T_2}{V_2 . T_1}$$

$$P_2 = \frac{1\,(atm)\cdot \frac{4}{3}\cancel{\pi}\,\cancel{(m^3)}\cdot 253{,}15\,\cancel{(K)}}{36\,\cancel{\pi}\,\cancel{(m^3)}\cdot 298{,}15\,\cancel{(K)}} = 0{,}03\,atm$$

1.23) Εξίσωση VdW: $P = \frac{RT}{V_m - b} - \frac{a}{V_m^2}$

Εξίσωση Virial: $P = \frac{RT}{V_m}\left\{1 + \frac{B(T)}{V_m} + \frac{C(T)}{V_m^2} + \dots\right\}$

Πολλαπλασιασμός και διαίρεση VdW με $\frac{RT}{V_m}$ και $\frac{V_m}{RT}$ αντίστοιχα.

$$P = \frac{RT}{V_m}\left(\frac{V_m}{RT}\,\frac{RT}{V_m - b} - \frac{V_m}{RT}\cdot\frac{a}{V_m^2}\right)$$

$$P = \frac{RT}{V_m}\left(\frac{V_m}{V_m - b} - \frac{a}{RT}\cdot\frac{1}{V_m}\right)$$

$$P = \frac{RT}{V_m}\left(\frac{1}{1 - \frac{b}{V_m}} - \frac{a}{RTV_m}\right)$$

Έχει τη μορφή:

$$\frac{1}{1-x} = 1 + x + x^2 + \dots$$

$$P = \frac{RT}{V_m}\left[1 + \frac{b}{V_m} + \frac{b^2}{V_m^2} - \frac{a}{RTV_m} + \dots\right]$$

$$P = \frac{RT}{V_m}\left[1 + \left(b - \frac{a}{RT}\right)\frac{1}{V_m} + \frac{b^2}{V_m^2} + \dots\right]$$

σύγκριση αυτής της εξίσωσης με την εξ. Virial

$\boxed{B(T) = b - \frac{a}{RT}}$ $\boxed{C(T) = b^2}$

Α. 26.1

Η μέση ταχύτητα ιδανικού αερίου δίδεται από τη σχέση $\bar{c} = \sqrt{\dfrac{8KT}{\pi m}}$

$T = 650\,K$ αέριο $= Xe$

$$m_{Xe} = \frac{M_{Xe}}{N_A} = \frac{131{,}29\ g/mol}{6{,}022 \times 10^{23}\ mol^{-1}} = 2.180 \times 10^{-22}\ g$$
$$= 2{,}180 \times 10^{-25}\ Kg$$

$$\bar{c} = \left[\frac{8 \times 1{,}38066 \times 10^{-23}\left(\frac{J}{\cancel{K}}\right) . 650\ (\cancel{K})}{\pi .\ 2{,}180 \times 10^{-25}\ (Kg)}\right]^{\frac{1}{2}}$$

$$\bar{c} = \left(104829\ \frac{J}{Kg}\right)^{\frac{1}{2}} = \left(104829\ \frac{\cancel{Kg} . m^2}{\cancel{Kg} . s^2}\right)^{1/2}$$

$$\bar{c} = 324\ \frac{m}{s}$$

A 26.3 $A = 2{,}5 \times 3{,}0\ mm^2 = 7{,}5\ mm^2 \left(\frac{1\ m^2}{10^6\ mm^2}\right) = 7{,}5 \times 10^{-6}\ m^2$

$P = 90\ Pa$, $T = 500K$, αέριο = Ar , $\Delta t = 10s$

Οι κρούσεις σωματιδίων του αερίου δίδονται από τη σχέση:

$$\left.\begin{array}{l} Z_W = \dfrac{P}{(2\pi m K T)^{1/2}} \\ \\ m = \dfrac{M}{N_A} \end{array}\right\} \Rightarrow Z_W = P \cdot \left(\frac{N_A}{M \cdot 2\pi K T}\right)^{1/2}$$

$$Z_W = 90\,(Pa) \cdot \left[\frac{6{,}022 \times 10^{23}\,(\cancel{mol^{-1}})}{39{,}948\left(\frac{g}{\cancel{mol}}\right)\cdot\left(\frac{Kg}{10^3 \cancel{g}}\right) \cdot 2 \cdot \pi \cdot 1{,}38066 \times 10^{-23}\left(\frac{g}{\cancel{K}}\right) \cdot 500\,(\cancel{K})}\right]^{1/2}$$

$$Z_W = 90\left(\frac{N}{m^2}\right)\left[3{,}475 \times 10^{44}\left(\frac{1}{Kg \cdot N \cdot m}\right)\right]^{1/2}$$

$$Z_W = 90\left(\frac{Kg \cdot \cancel{m}}{m^{\cancel{2}} \cdot s^2}\right)\left[3{,}475 \times 10^{44}\left(\frac{1}{Kg \cdot Kg \cdot \frac{m \cdot m}{s^2}}\right)\right]^{1/2}$$

$$Z_W = 90\left(\frac{Kg}{m \cdot s^2}\right)\left[3{,}475 \times 10^{44}\left(\frac{s^2}{Kg^2 \cdot m^2}\right)\right]^{1/2}$$

$$Z_W = 90\left(\frac{\cancel{Kg}}{m \cdot s^{\cancel{2}}}\right) \cdot 1{,}86 \times 10^{22}\left(\frac{\cancel{s}}{\cancel{Kg} \cdot m}\right)$$

$$Z_W = 1{,}674 \times 10^{24}\left(\frac{1}{s m^2}\right)$$

Ο αριθμός κρούσεων στην επιφάνεια $= Z_w \cdot \Delta t \cdot A$

$= 1{,}674 \times 10^{24}\left(\frac{1}{sm^2}\right) \cdot 15(s) \cdot 7{,}5\times10^{-6}(m^2)$

$= 1{,}88 \times 10^{20}$ κρούσεις

A 26.4. $V = 5\,(dm^3)$

$n_A = 3{,}00\,(mmol)$ $\quad\sigma_A = 0{,}27\,(nm^2)$

$n_B = 1{,}50\,(mmol)$ $\quad\sigma_B = 0{,}43\,(nm^2)$

$P_{tot} = 2{,}00\,(KPa)$ $\quad M_A = 1{,}008\left(\frac{g}{mol}\right)$

$\Delta t = 1\,(ms)$ $\quad M_B = 28{,}013\left(\frac{g}{mol}\right)$

$Z_{AB} =$; $\quad T = 298\,(K)$

Η ενεργή διατομή κρούσης για μείγμα 2 αερίων δίνεται από τη σχέση:

$$\left.\begin{aligned}
&\sigma_{AB} = \pi d_{AB}^2 = \pi\left[\frac{1}{2}(d_A + d_B)\right]^2\\
&\sigma_A = \pi d_A^2 \Rightarrow d_A = \sqrt{\frac{\sigma_A}{\pi}} = \sqrt{\frac{0{,}27\,nm^2}{\pi}} = 0{,}29\,nm\\
&\sigma_B = \pi d_B^2 \Rightarrow d_B = \sqrt{\frac{\sigma_B}{\pi}} = \sqrt{\frac{0{,}43\,nm^2}{\pi}} = 0{,}37\,nm
\end{aligned}\right\} \Rightarrow$$

$$\sigma_{AB} = \pi\Big[\underbrace{\frac{1}{2}(0{,}29 + 0{,}37)\,nm}_{d_{AB}}\Big]^2 \Rightarrow \underline{\underline{\sigma_{AB} = 0{,}342\,nm^2}}$$

Η ανηγμένη μάζα δίνεται από τη σχέση:

$$\left.\begin{array}{l} \mu = \dfrac{m_A \cdot m_B}{m_A + m_B} \\ m_A = M_A \cdot n_A \\ m_B = M_B \cdot n_B \end{array}\right\} \Rightarrow \mu = \frac{M_A \cdot M_B \cdot n_A \cdot n_B}{n_A \cdot M_A + n_B \cdot M_B}$$

$$\mu = \frac{2{,}016\left(\frac{g}{\cancel{mol}}\right) \cdot 28{,}013\left(\frac{g}{\cancel{mol}}\right) \cdot 3{,}00\times10^{-3}(\cancel{mol}) \cdot 1{,}50\times10^{-3}(\cancel{mol})}{3{,}00\times10^{-3}(\cancel{mol}) \cdot 2{,}016\left(\frac{g}{\cancel{mol}}\right) + 1{,}50\times10^{-3}(\cancel{mol}) \cdot 28{,}013\left(\frac{g}{\cancel{mol}}\right)}$$

$$\mu = 5{,}29\times10^{-3}\,(g) \Rightarrow \underline{\underline{\mu = 5{,}29\times10^{-6}\ Kg}}$$

Ο συνολικός αριθμός A–B κρούσεων δίνεται από τη σχέση:

$$Z_{AB} = \sigma_{AB}\left(\frac{8KT}{\pi\mu}\right)^{1/2} \cdot N_A^2\,[A]\,[B] \Rightarrow$$

$$Z_{AB} = \sigma_{AB}\left(\frac{8KT}{\pi\mu}\right)^{1/2} N_A^2\,\frac{n_A \cdot n_B}{V^2} \Rightarrow$$

$$Z_{AB} = 0{,}342\,(\cancel{nm^2})\left(\frac{10^{-18}\,m^2}{1\,\cancel{nm^2}}\right)\left[\frac{8\times1{,}3806\times10^{-23}\left(\frac{J}{K}\right)\cdot 298\,(K)}{\pi\cdot 5{,}29\times10^{-6}\,(Kg)}\right]^{1/2} \cdot$$

$$\left[6{,}022\times10^{23}(mol^{-1})\right]^2 \cdot \frac{1{,}50\times10^{-3}(mol)\cdot 3{,}00\times10^{-3}(mol)}{\left[5dm^3\left(\frac{10^{-3}\,m^3}{1dm^3}\right)\right]^2} \Rightarrow$$

$$Z_{AB} = 0{,}342\times10^{-18}(m^2) \cdot 4{,}45\times10^{-8}\left(\frac{m}{s}\right) \cdot 6{,}52\times10^{46}\left(\frac{1}{m^6}\right)$$

$$\Rightarrow \underline{\underline{Z_{AB} = 9{,}92 \times 10^{20} \frac{1}{m^3 \cdot s}}}$$

Αριθμός κρούσεων ισούται με $Z_{AB} \cdot \Delta t \cdot V = 9{,}92 \times 10^{20} \cdot 1 \cdot 10^{-3} \cdot 5 \cdot 10^{-3}$

$= 4{,}96 \times 10^{15}$

Α.26.10

Δίνεται η ταχύτητα ροής του N_2

$$\frac{dV}{dt} = 9{,}5 \times 10^5 \left(\frac{dm^3}{h}\right) \cdot \left(\frac{10^{-3} m^3}{1 dm^3}\right)\left(\frac{1 h}{60 \times 60 s}\right) = 0{,}2638 \frac{m^3}{s}$$

$P_0 = 1 atm$

με χρήση του τύπου Poiseuille και λύνοντας ως προς P_2 βρίσκουμε ότι:

$$\frac{dV}{dt} = \frac{(P_1^2 - P_2^2) \cdot \pi R^4}{16 \cdot l \cdot n \cdot p_0} \Rightarrow \frac{16 \cdot l \cdot n \cdot P_0}{\pi R^4} \cdot \frac{dV}{dt} = P_1^2 - P_2^2$$

$$\Rightarrow P_1^2 = P_2^2 + \frac{16 \cdot l \cdot n \cdot P_0}{\pi R^4} \cdot \frac{dV}{dt}$$

αφού η έξοδος της σωλήνας βρίσκεται ελεύθερη στον ατμοσφαιρικό αέρα $P_2 = P_0 = 1 bar$

$$\left.\begin{aligned} P_1^2 &= P_0^2 + \frac{16 \cdot l \cdot n \cdot P_0}{\pi R^4} \cdot \frac{dV}{dt} \\ n &= 176 \mu P = 176 \times 10^{-7} \frac{Kg}{m \cdot s} \end{aligned}\right\} \Rightarrow$$

$$P_1^2 = (1 atm)^2 + \frac{16 \cdot 8{,}5 (m) \cdot 176 \times 10^{-7} \left(\frac{Kg}{m \cdot s}\right) \cdot 1 atm}{\pi (0{,}005 m)^4} \cdot 0{,}2638 \left(\frac{m^3}{s}\right)$$

$$P_1^2 = (1\,atm)^2 + 3,2158 \times 10^5 \left(\frac{Kg}{s^2 \cdot m}\right) \cdot 1\,atm$$

$$P_1^2 = (1\,atm)^2 + 3,2158 \times 10^5 \left(\frac{\overbrace{Kg \cdot m}^{N}}{s^2 \cdot m^2}\right) \cdot 1\,atm$$

$$P_1^2 = (1\,atm)^2 + 3,2158 \times 10^5 (\cancel{Pa}) \left(\frac{1\,atm}{101325\,\cancel{Pa}}\right) \cdot 1\,atm$$

$$P_1^2 = (1\,atm)^2 + 3,17\,atm^2 = 4,17\,atm^2$$

$$\Rightarrow \quad \underline{\underline{P_1 = 2,04\,atm}}$$