(9) $n = 8{,}77\ \text{mol}$

$T = 350\ \text{K}$

$V = 7{,}5\ \text{L} = 7{,}5\ \text{dm}^3 = 7{,}5 \cdot 10^{-3}\ \text{m}^3$

(a) $pV = nRT \longrightarrow p = \frac{nRT}{V}$

$$p = \frac{8{,}77\ \text{mol} \cdot 8{,}31446\ \frac{\text{kg}\,\text{m}^2}{\text{s}^2\,\text{mol}\,\text{K}} \cdot 350\ \text{K}}{7{,}5 \cdot 10^{-3}\ \text{m}^3}$$

$$p = 34{,}0283 \cdot 10^5\ \frac{\text{kg}}{\text{m}\,\text{s}^2}$$

$10^5\ \frac{\text{kg}}{\text{m}\,\text{s}^2} = 10^5\ \text{Pa} = 1\ \text{bar}$

$p = 34{,}0283\ \text{bar}$

$p = 34\ \text{bar}$

(b) $p = \frac{nRT}{V - nb} - a\left(\frac{n}{V}\right)^2$

$a = 5{,}537\ \text{bar}\ \frac{\text{L}^2}{\text{mol}^2}$

$1\ \text{bar} = 10^5\ \text{Pa}$

$1\ \text{L} = 10^{-3}\ \text{m}^3$

$\text{L}^2 = 10^{-6}\ \text{m}^6$

$$a = 5{,}537 \cdot 10^5\ \text{Pa} \cdot 10^{-6}\ \frac{\text{m}^6}{\text{mol}^2}$$

$$a = 0{,}5537\ \frac{\text{Pa}\,\text{m}^6}{\text{mol}^2}$$

$$b = 0{,}03049 \frac{L}{mol}$$

$$b = 3{,}049 \cdot 10^{-2} \cdot 10^{-3} \frac{m^3}{mol}$$

$$b = 3{,}049 \cdot 10^{-5} \frac{m^3}{mol}$$

$$p = \frac{8{,}77\,mol \cdot 8{,}31446 \frac{J}{mol\,K} \cdot 350\,K}{7{,}5 \cdot 10^{-3}\,m^3 - 8{,}77\,mol \cdot 3{,}049 \cdot 10^{-5} \frac{m^3}{mol}} - 0{,}5537 \frac{Pa\,m^6}{mol^2} \cdot \left(\frac{8{,}77\,mol}{7{,}5 \cdot 10^{-3}\,m^3}\right)^2$$

$$p = 35{,}286378 \cdot 10^5\,Pa - 7{,}570964 \cdot 10^5\,Pa$$

$$\frac{J}{m^3} = \frac{kg\,m^2}{s^2\,m^3} = Pa$$

$$p = 27{,}71541\,bar$$

$$p = 28\,bar$$

(c) $p = 35{,}3\,bar - 7{,}6\,bar$

$p_{ideal} = 34\,bar$

2. Term dominiert

$\Rightarrow$ anziehende Kräfte überwiegen

(10) $p_k = 217{,}7\,atm = 2{,}205954 \cdot 10^7\,Pa$

$T_k = 374{,}0\ °C = 647{,}15\ K$

(a) $V_{m,k} = 3b$

$T_k = \frac{8a}{27Rb}$

$p_k = \frac{a}{27b^2}$

} aus VL

$a = 27b^2 p_k$

$T_k = \frac{8(27b^2 p_k)}{27Rb} = \frac{8}{R} b p_k$

$b = \frac{R \cdot T_k}{8 \cdot p_k} = \frac{8{,}31446\ \frac{J}{mol\,K} \cdot 647{,}15\ K}{8 \cdot 2{,}205954 \cdot 10^7\ Pa}$

$b = 3{,}048966 \cdot 10^{-5}\ \frac{m^3}{mol}$

$\frac{J}{mol\,Pa} = \frac{N \cdot m \cdot m^2}{mol\,N} = \frac{m^3}{mol}$

$b = 3{,}049 \cdot 10^{-5}\ \frac{m^3}{mol}$

$a = 27b^2 \cdot p_k = 27 \cdot \left(3{,}048966 \cdot 10^{-5}\ \frac{m^3}{mol}\right)^2 \cdot 2{,}205954 \cdot 10^7\ Pa$

$a = 553{,}6883 \cdot 10^{-3}\ \frac{Pa\,m^6}{mol^2}$

$a = 0{,}5537\ \frac{Pa\,m^6}{mol^2}$

(b) Kovolumen = nb = Volumen von N Molekülen

$N = n \cdot N_A$

$$V_{\text{Molekül}} = \frac{nb}{N} = \frac{nb}{n \cdot N_A} = \frac{b}{N_A}$$

$$V_{\text{Molekül}} = \frac{3{,}049966 \cdot 10^{-5} \frac{m^3}{mol}}{6{,}02214 \cdot 10^{23} \frac{1}{mol}}$$

$$V_{\text{Molekül}} = 5{,}06293 \cdot 10^{-29}\ m^3$$

$$= 50{,}6293 \cdot 10^{-30}\ m^3$$

$1\,\text{Å} = 10^{-10}\ m$

$1\,\text{Å}^3 = 10^{-30}\ m^3$

$$V_{\text{Molekül}} = 50{,}6293\ \text{Å}^3$$

Näherung: $V = \frac{4}{3} r^3 \pi$

$$r = \sqrt[3]{\frac{3V}{4\pi}}$$

$$r = 2{,}295\ \text{Å}$$

$$r \approx 2\,\text{Å}$$

(11) $Z = 0{,}78$ $\qquad Z = \frac{V_{m,real}}{V_{m,ideal}} = \frac{V_{m,real}}{RT}\,p$

(a) $V_{m,real} = \frac{Z R T}{p}$

$$= \frac{0{,}78 \cdot 8{,}31446 \frac{J}{mol\,K} \cdot 400\,K}{2{,}0 \cdot 10^6\,Pa}$$

$$V_{m,real} = 1{,}297 \cdot 10^{-3} \frac{m^3}{mol}$$

$$V_{m,real} = 1{,}3 \cdot 10^{-3} \frac{m^3}{mol} = 1{,}3 \frac{L}{mol}$$

(b) $p = \frac{nRT}{V}\left(1 + B\frac{n}{V} + C\left(\frac{n}{V}\right)^2 + \dots\right)$

$$p = \frac{nRT}{V}\left(1 + B\frac{n}{V}\right)$$

$$1 + B\frac{n}{V} = \frac{p \cdot V_m}{RT}$$

$$B\frac{n}{V} = \frac{p V_m}{RT} - 1$$

$$B = \left(\frac{pV_m}{RT} - 1\right) \cdot V_m$$

$$B = \left(\frac{2 \cdot 10^6\,Pa \cdot 1{,}297 \cdot 10^{-3} \frac{m^3}{mol}}{\dots} - 1\right) \cdot 1{,}297 \cdot 10^{-3} \frac{m^3}{mol}$$

$$B = \left(\frac{2 \cdot 10 \; Pa \cdot 1{,}297 \cdot 10^{-3} \; \frac{m^3}{mol}}{8{,}3146 \; \frac{J}{mol\,K} \cdot 400 \; K} - 1 \right) \cdot 1{,}297 \cdot 10^{-3} \; \frac{m^3}{mol}$$

$$B = -0{,}28538 \cdot 10^{-3} \; \frac{m^3}{mol}$$

$$B = -2{,}9 \cdot 10^{-4} \; \frac{m^3}{mol}$$

$$\frac{Pa\,m^3}{J} = \frac{N\,m^3}{m\,N\,m}$$