



Fig. 1. Comparison between the experimental values of viscosity and those calculated by Equations (5), (9), and (10).

$$X_i = \frac{(P\bar{V}_i/RT) - 1}{(b_0/\bar{V}_i)} \quad (8)$$

the following equations are available (10):

$$X_i = 1 + 0.625 \left(\frac{b_0}{\bar{V}_i} \right) + 0.2869 \left(\frac{b_0}{\bar{V}_i} \right)^2 + 0.115 \left(\frac{b_0}{\bar{V}_i} \right)^3 \quad (9)$$

$$\left(\frac{b_0}{\bar{V}_i} \right) = \frac{2}{3} \pi n_i \sigma_i^3 \quad (10)$$

n_i indicates the concentration of molecules i , having diameter σ_i .

By Equations (5), (9), (10) the viscosity of carbon monoxide and nitrogen has been calculated, utilizing the molar volume figures obtained by our P.V.T. data (see Table 3). Figure 1 shows that the agreement between

TABLE 2. EXPERIMENTAL VISCOSITIES OF CARBON MONOXIDE AND OF NITROGEN AT 50.0°C.

P Int'l. atm.	CO	Viscosity, 10 ⁶ poise N ₂	CO·N ₂ Equation (4)
6	186.7	187.0	186.86
11	188.6	190.3	189.55
51	195.9	196.6	196.1
101	206.4	207.9	207.15
201	232.8	235.7	234.25
301	264.3	267.4	265.35

calculated and experimental values of viscosity is satisfactory only up to 200 atm., as concluded from earlier measurements at 298°K. (11).

Beyond 200 atm., which appears to be the upper limit of the intermediate pressure region for both carbon monoxide and nitrogen, Equations (8) and (10) have been modified, substituting pressure P by the total pressure $P_{\text{tot.}}$, as given by (12):

$$P_{\text{tot.}} = T \left(\frac{\partial P}{\partial T} \right)_{\bar{V}} \quad (11)$$

and substituting virial coefficient b_{0i} by the pseudo-virial coefficient b_i , as given by (12):

$$b_i = \frac{1}{2.545} \left(\frac{\eta \bar{V}}{(\eta)_1} \right)_{i, \text{exp. min.}} \quad (12)$$

In Equation (12), $(\eta \bar{V}/(\eta)_1)_{i, \text{exp. min.}}$, indicating the minimum value of the term in brackets for a real gas, must be determined experimentally.

Thus, X_i becomes:

$$X_i = \frac{(\bar{V}_i/R) (\partial P/\partial T)_{\bar{V}_i} - 1}{(b/\bar{V})_i} \quad (13)$$

In order to check the above semiempirical formulae, P.V.T. measurements were carried out in the range from 293 to 373°K. With the experimental values of the compressibility factor, Z , (see Table 3) the slope $(\partial P/\partial T)_{\bar{V}_i} = P/T + (P/Z) (\partial Z/\partial T)_{\bar{V}_i}$ has been graphically determined by the method of residuals (13). The term b_i has been obtained from the minimum of the experimental curves reported in Figure 2.

Table 4 shows that the viscosity values calculated by Equations (5), (12), (13) agree with the experimental ones and agreement appears to improve as the pressure increases. In particular, the values of b_i appear to be substantially equal for both carbon monoxide and nitrogen.

Table 4 confirms the reliability of Equations (5), (12), (13) for predicting the viscosity of carbon monoxide and nitrogen and the reliability of Equation (6) for correlating viscosity a mass diffusivity of the carbon monoxide-nitrogen mixture. In Figure 4 the continuous curve collects the val-

TABLE 3. COMPRESSIBILITY FACTOR, Z , OF CARBON MONOXIDE AND OF NITROGEN FROM OUR P.V.T. MEASUREMENTS

P int'l. atm.	CO (Purity 0.9995) Compressibility factor, Z :					N ₂ (Purity 0.9999) Compressibility factor, Z :				
	0°C.	25°C.	50°C.	75°C.	100°C.	0°C.	25°C.	50°C.	75°C.	100°C.
1	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
51	0.978	0.991	0.9995	1.006	1.011	0.988	0.999	1.004	1.012	1.016
101	0.972	0.995	1.010	1.021	1.028	0.987	1.007	1.018	1.029	1.036
201	1.019	1.0435	1.062	1.0735	1.082	1.039	1.060	1.077	1.085	1.092
301	1.119	1.133	1.143	1.151	1.155	1.137	1.149	1.159	1.162	1.165
401	1.246	1.245	1.244	1.243	1.241	1.260	1.258	1.257	1.253	1.250
501	1.3825	1.364	1.354	1.342	1.332	1.395	1.3795	1.367	1.3515	1.341
601	1.5225	1.430	1.469	1.448	1.430	1.529	1.499	1.477	1.4535	1.435
701	1.661	1.620	1.585	1.553	1.529	1.665	1.6215	1.590	1.558	1.532
801	1.802	1.747	1.703	1.662	1.628	1.803	1.747	1.7035	1.6625	1.629
901	1.940	1.872	1.816	1.768	1.7265	1.936	1.8695	1.816	1.7675	1.726