PVT relationship for liquids

A generalized correlation to estimate the molar volume of saturated liquid proposed by Rackett

\[ V^{sat} = V_C Z_C^{(1-T_r)^{0.2857}} \]  \hspace{1cm} (1)


Lydrson and coworkers developed a general method for estimation of liquid volume based on the principles of corresponding state

\[ \rho_r = \frac{\rho}{\rho_C} = \frac{V_C}{V} \]  \hspace{1cm} (2)

\( \rho_r \) is reduced density, where \( \rho_C \) is density at critical point.

The generalized correlation is shown by below figure; this figure may be used directly with Eq. (1) for determination of liquid volumes if the value of the critical volume is known.
A better procedure is to make use of a single known liquid volume (state 1) by the identity,

$$V_2 = V_1 \frac{\rho_{r1}}{\rho_{r2}}$$

$V_2$ = required volume 
$V_1$ = known volume 
$\rho_{r1}, \rho_{r2}$ = reduced densities read from figure 

Example: 
a) Estimate the density of saturated liquid ammonia at 310K. 
b) Estimate the density of liquid ammonia at 310 K and 100bar.

$$T_r = \frac{310}{405.6} = 0.7643$$

$V_C = 72.5$ and $Z_C = 0.242$ (from App.B) we get

$$V^{Sat} = V_C Z_C^{(1-T_r)^{0.2857}} = (72.5)(0.242)^{(0.2357^{0.2857})} = 28.35 \text{ cm}^3 \text{ mol}^{-1}$$

$$\text{error}\% = \frac{\text{theoretical}}{\text{experimental}} = \frac{29.14 - 28.35}{29.14} = 2.71\%$$

b) The reduced conditions

$$T_r = 0.7643, \ \text{and} \ P_r = \frac{100}{112.8} = 0.887$$

From figure we have $\rho_r = 2.38$

$$V = \frac{V_C}{\rho_r} = \frac{72.5}{2.38} = 30.5 \text{ cm}^3 \text{ mol}^{-1}$$

$$\text{error}\% = \frac{30.5 - 28.6}{28.6} = 6.64\%$$

For saturated liquid at $T_r = 0.764$, we find from figure that $\rho_r = 2.34$. Substitution of known value into below equation

$$V_2 = V_1 \frac{\rho_{r1}}{\rho_{r2}} = (29.14) \left(\frac{2.34}{2.38}\right) = 28.65 \text{ cm}^3 \text{ mol}^{-1}$$