Problem 1A.2

Estimation of the viscosity of methyl fluoride. Use Fig 1.3-1 to find the viscosity in $\mathrm{Pa \cdot s}$ of CH_3F at 370°C and 120 atm. Use the following values[1] for the critical constants: $T_c = 4.55$°C, $p_c = 58.0$ atm, $\rho_c = 0.300\ \mathrm{g/cm^3}$.

Solution

The viscosity μ can be calculated by $\mu = \mu_r \mu_c$, where μ_r is the reduced viscosity and μ_c is the critical viscosity. The latter can be determined by using one of the empirical formulas in the text (Equation 1.3-1a or 1.3-1b on page 22). Equation 1.3-1b will be used here.

$$\mu_c = 7.70 M^{1/2} p_c^{2/3} T_c^{-1/6} \tag{1.3-1b}$$

M is the molar mass of the chemical compound: $M = 12.01 + 3(1.008) + 19.00 = 34.034$ g/mol. T_c has to be in Kelvin, so add 273.15 to convert it. $T_c = 4.55 + 273.15 = 277.70$ K. Plugging in the numbers, we obtain

$$\mu_c = 7.70 \left(34.034\ \frac{\mathrm{g}}{\mathrm{mol}}\right)^{1/2} (58.0\ \mathrm{atm})^{2/3} (277.70\ \mathrm{K})^{-1/6}.$$

μ_c has units of micropoise.

$$\mu_c \approx 263.5 \text{ micropoise} = 2.635 \times 10^{-4} \text{ poise}$$

The aim now is to find μ_r. To do that we have to know T_r and p_r, the reduced temperature and reduced pressure, respectively, which are defined as

$$T_r = \frac{T}{T_c} \quad \text{and} \quad p_r = \frac{p}{p_c}.$$

To make the units consistent, convert the given temperature to Kelvin.
$T = 370 + 273.15 = 643.15$ K. Thus,

$$T_r = \frac{643.15\ \cancel{\mathrm{K}}}{277.70\ \cancel{\mathrm{K}}} \approx 2.32 \quad \text{and} \quad p_r = \frac{120\ \cancel{\mathrm{atm}}}{58.0\ \cancel{\mathrm{atm}}} \approx 2.07.$$

Now that we know T_r and p_r, we can use the graph on page 22 to determine μ_r.

[1] K. A. Kobe and R. E. Lynn Jr., *Chem. Revs.* **52**, 117-236 (1953), see p. 202.

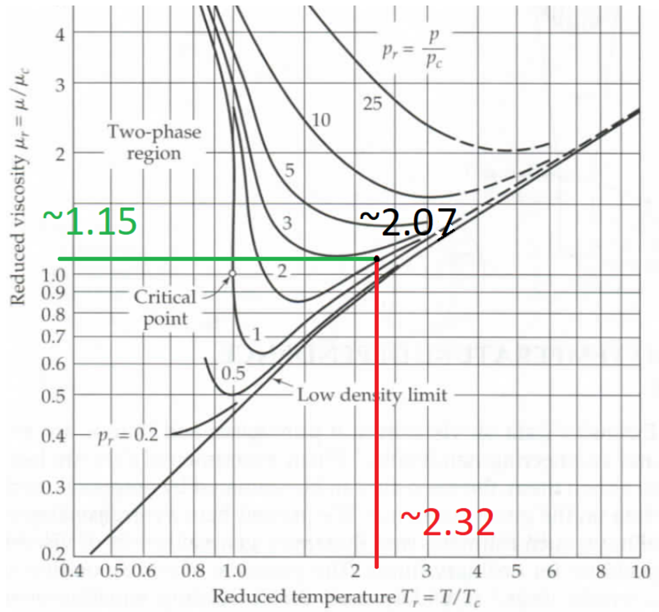

Figure 1: Use Fig. 1.3-1 in the text to determine μ_r.

We see that $\mu_r \approx 1.15$, so we have

$$\mu = \mu_r \mu_c \approx (1.15)(2.635 \times 10^{-4} \text{ poise}).$$
$$\approx 3.030 \times 10^{-4} \text{ poise}$$

To convert this to the desired units, use the conversion factor in Table F.3-4 on page 870, 1 poise $= 10^{-1}$ Pa · s.

$$\approx 3.030 \times 10^{-4} \cancel{\text{poise}} \times \frac{10^{-1} \text{ Pa} \cdot \text{s}}{1 \cancel{\text{poise}}} = 3.030 \times 10^{-5} \text{ Pa} \cdot \text{s}$$

Round this number to two signficant figures because of the given data, 370°C and 120 atm, in the problem statement. Therefore, the viscosity of methyl fluoride is

$$\mu \approx 3.0 \times 10^{-5} \text{ Pa} \cdot \text{s}.$$