54. (a) We use Eq. 20-54 with $V_f/V_i = \frac{1}{2}$ for the gas (assumed to obey the ideal gas law).

$$p_i V_i^\gamma = p_f V_f^\gamma \implies \frac{p_f}{p_i} = \left(\frac{V_i}{V_f}\right)^\gamma = 2^{1.3}$$

which yields $p_f = (2.46)(1.0\,\text{atm}) = 2.5$ atm. Similarly, Eq. 20-56 leads to

$$T_f = T_i \left(\frac{V_i}{V_f}\right)^{\gamma-1} = (273\,\text{K})(1.23) = 336 \text{ K} .$$

(b) We use the gas law in ratio form (see Sample Problem 20-1) and note that when $p_1 = p_2$ then the ratio of volumes is equal to the ratio of (absolute) temperatures. Consequently, with the subscript 1 referring to the situation (of small volume, high pressure, and high temperature) the system is in at the end of part (a), we obtain

$$\frac{V_2}{V_1} = \frac{T_2}{T_1} = \frac{273\,\text{K}}{336\,\text{K}} = 0.81 .$$

The volume V_1 is half the original volume of one liter, so

$$V_2 = 0.81(0.50\,\text{L}) = 0.41 \text{ L} .$$