16.25. Model: Treat the helium gas in the sealed cylinder as an ideal gas.

Solve: The volume of the cylinder is $V = \pi r^2 h = \pi(0.05\text{ m})^2(0.30\text{ m}) = 2.356\times10^{-3}\text{ m}^3$. The gauge pressure of the gas is $120\text{ psi}\times\dfrac{1\text{ atm}}{14.7\text{ psi}}\times\dfrac{1.013\times10^5\text{ Pa}}{1\text{ atm}} = 8.269\times10^5\text{ Pa}$, so the absolute pressure of the gas is $8.269\times10^5\text{ Pa} + 1.013\times10^5\text{ Pa} = 9.282\times10^5\text{ Pa}$. The temperature of the gas is $T = (273 + 20)\text{ K} = 293\text{ K}$. The number of moles of the gas in the cylinder is

$$n = \frac{pV}{RT} = \frac{(9.282\times10^5\text{ Pa})(2.356\times10^{-3}\text{ m}^3)}{(8.31\text{ J/mol K})(293\text{ K})} = 0.898\text{ mol}$$

(a) The number of atoms is

$$N = nN_A = (0.898\text{ mol})(6.02\times10^{23}\text{ mol}^{-1}) = 5.41\times10^{23}\text{ atoms.}$$

(b) The mass of the helium is

$$M = nM_{\text{mol}} = (0.898\text{ mol})(4\text{ g/mol}) = 3.59\text{ g} = 3.59\times10^{-3}\text{ kg}$$

(c) The number density is

$$\frac{N}{V} = \frac{5.41\times10^{23}\text{ atoms}}{2.356\times10^{-3}\text{ m}^3} = 2.30\times10^{26}\text{ atoms/m}^3$$

(d) The mass density is

$$\rho = \frac{M}{V} = \frac{3.59\times10^{-3}\text{ kg}}{2.356\times10^{-3}\text{ m}^3} = 1.52\text{ kg/m}^3$$