16.64. Model: Assume that the nitrogen gas is an ideal gas.

Solve: **(a)** The molar mass of N_2 gas is 28 g/mol. The number of moles is n = (5 g)/(28 g/mol) = 0.1786 mol. The initial conditions are p_1 = 3.0 atm and T_1 = 293 K. We use the ideal gas law to find the initial volume as follows:

$$V_1 = \frac{nRT_1}{p_1} = \frac{(0.1786\text{ mol})(8.31\text{ J/mol K})(293\text{ K})}{3.0\text{ atm} \times 101{,}300\text{ Pa/atm}} = 1.430 \times 10^{-3}\text{ m}^3 = 1430\text{ cm}^3$$

An isobaric expansion until the volume triples results in $V_2 = 3V_1 = 4290\text{ cm}^3$.

(b) After the expansion,

$$\frac{p_2 V_2}{T_2} = \frac{p_1 V_1}{T_1} \Rightarrow T_2 = \frac{p_2}{p_1}\frac{V_2}{V_1}T_1 = 1 \times 3 \times T_1 = 3T_1 = 879\text{ K} = 606°\text{C}$$

(c) A constant volume decrease at $V_3 = V_2 = 4290\text{ cm}^3$ back to $T_3 = T_1 = \frac{1}{3}T_2$ results in the following:

$$\frac{p_3 V_3}{T_3} = \frac{p_2 V_2}{T_2} \Rightarrow p_3 = \frac{T_3}{T_2}\frac{V_2}{V_3}p_2 = \frac{1}{3} \times 1 \times p_2 = \frac{1}{3} \times 3.0\text{ atm} = 1.0\text{ atm}$$

(d) An isothermal compression at $T_4 = T_3$ back to the initial volume $V_4 = V_1 = \frac{1}{3}V_3$ results in the following:

$$\frac{p_4 V_4}{T_4} = \frac{p_3 V_3}{T_3} \Rightarrow p_4 = \frac{T_4}{T_3}\frac{V_3}{V_4}p_3 = 1 \times \frac{1}{\frac{1}{3}} \times p_3 = 3 \times 1.0\text{ atm} = 3.0\text{ atm}$$

(e)