Chapter 17 Problem 37 [†]

Given

$h = 100\ cm = 1.00\ m$
$D = 20.0\ cm$
$r = 10.0\ cm = 0.10\ m$
$T_0 = 20°C = 293\ K$
$P_0 = 180\ atm$

Solution

a) Find the number of moles of air in the cylinder.

Convert the pressure into pascals.

$$P_0 = (180\ atm)\left(\frac{1.013 \times 10^5\ Pa}{1\ atm}\right) = 1.82 \times 10^7\ Pa$$

Next calculate the volume of the cylinder. Since the diameter is given, the cross-sectional area of the cylinder is that of a circle.

$$A = \pi r^2 = \pi(0.10\ m)^2 = 0.0314\ m^2$$

The volume is the cross-sectional area multiplied by the height

$$V = A \cdot h = (0.0314\ m^2)(1.0\ m) = 0.0314\ m^3$$

Now use the ideal gas law to find the number of moles

$$PV = nRT$$

$$n = \frac{PV}{RT} = \frac{(1.82 \times 10^7\ Pa)(0.0314\ m^3)}{(8.31\ J/mol \cdot K)(293\ K)} = 235\ mol$$

b) What volume would this air occupy if at 1 atm?

If the temperature and number of moles remains constant, then

$$P_0V_0 = const = P_fV_f$$

The final volume is then

$$V_f = \left(\frac{P_0}{P_f}\right)V_0 = \left(\frac{180\ atm}{1\ atm}\right)(0.0314\ m^3) = 5.65\ m^3$$

[†]Problem from Essential University Physics, Wolfson