1.20 The specific volume of 5 kg of water vapor at 1.5 MPa, 440°C is 0.2160 m^3/kg. Determine (a) the volume, in m^3, occupied by the water vapor, (b) the amount of water vapor present, in gram moles, and (c) the number of molecules.

KNOWN: Mass, pressure, temperature, and specific volume of water vapor.

FIND: Determine (a) the volume, in m^3, occupied by the water vapor, (b) the amount of water vapor present, in gram moles, and (c) the number of molecules.

SCHEMATIC AND GIVEN DATA:

m = 5 kg
p = 1.5 MPa
T = 440°C
v = 0.2160 m^3/kg

ENGINEERING MODEL:
1. The water vapor is a closed system.

ANALYSIS:
(a) The specific volume is volume per unit mass. Thus, the volume occupied by the water vapor can be determined by multiplying its mass by its specific volume.

$$V = mv = (5\,\text{kg})\left(0.2160\,\frac{\text{m}^3}{\text{kg}}\right) = \underline{\mathbf{1.08\ m^3}}$$

(b) Using molecular weight of water from Table A-1 and applying the appropriate relation to convert the water vapor mass to gram moles gives

$$n = \frac{m}{M} = \left(\frac{5\,\text{kg}}{18.02\,\frac{\text{kg}}{\text{kmol}}}\right)\left|\frac{1000\,\text{moles}}{1\,\text{kmol}}\right| = \underline{\mathbf{277.5\ moles}}$$

(c) Using Avogadro's number to determine the number of molecules yields

$$\#\,\text{Molecules} = \text{Avogadro's Number} \times \#\,\text{moles} = \left(6.022\times10^{23}\,\frac{\text{molecules}}{\text{mole}}\right)(277.5\,\text{moles})$$

$$\#\,\text{Molecules} = \underline{\mathbf{1.671\times10^{26}\ molecules}}$$