Answer on Question #67520, Physics / Mechanics | Relativity

4/ A 0.9 mol sample of an ideal gas undergoes an isothermal process. The initial volume is 0.20 m^3 and the final volume is 0.40 m^3. If the heat added to the gas is 2000 J, find the temperature of the gas.

Solution:

For an isothermal process, the expression for work is:

$$W = nRT \ln \frac{V_f}{V_i} = Q$$

where n is the number of moles of gas present and R is the ideal gas constant.

$$T = \frac{Q}{nR \ln \frac{V_f}{V_i}}$$

Substituting

$$T = \frac{2000\,J}{(0.9\,mol)\times(8.31\,J\,K^{-1}\,mol^{-1})\times \ln \frac{0.40}{0.20}} = 385.8\text{ K}$$

Answer. $T = 385.8\text{ K}$

5/ In an intestellar gas cloud (e.g., a star-forming region) at 20.0 K, the pressure is 1.0×10^{-8} Pa. Assuming that the molecular diameters of the gases in the cloud are all 15.0 nm, what is their mean free path?

Solution:

The mean free path λ of a gas molecule is its average path length between collisions and is given by

$$\lambda = \frac{1}{\sqrt{2}\pi d^2 N/V}$$

where N/V is the number of molecules per unit volume and d is the molecular diameter.

An ideal gas is one for which the pressure p, volume V, and temperature T are related by

$$pV = NkT,$$

where the Boltzmann constant k is 1.38×10^{-23} J/K.

Thus,

$$\frac{N}{V} = \frac{p}{kT} = \frac{1.0\times10^{-8}}{1.38\times10^{-23}\times20.0} = 3.62\times10^{13}\ molecules/m^3$$

$$\lambda = \frac{1}{\sqrt{2}\pi(15.0\times10^{-9})^2\times3.62\times10^{13}} = 27.6\text{ m}$$

Answer. $\lambda = 27.6\text{ m}$