779.

Problem 52.29 (RHK)

A particular (*hypothetical*) *atom has only two atomic levels, separated in energy by* 3.2 eV. *In the atmosphere of a star there are* 6.1×10^{13} *of these atoms per* cm^3 *in the excited* (*upper*) *state and* 2.5×10^{15} *atoms per* cm^3 *in the ground* (*lower*) *state. We have to calculate the temperature of the star's atmosphere.*

Solution:

Let the temperature of the star be T K. By the Boltzmann law, we have

$$\frac{\text{no of atoms per cm}^3 \text{ in the excited state}}{\text{no of atoms per cm}^3 \text{ in the ground state}} = e^{-\Delta E/kT},$$

where ΔE is the difference in energies of the excited state and the ground state. Therefore, we have

$$\frac{6.1\times10^{13}}{2.5\times10^{15}} = \exp\left(-\frac{3.2\times1.6\times10^{-19}}{1.38\times10^{-23}T}\right),$$

or

$$0.0244 = \exp\left(-\frac{3.71\times10^{4}}{T}\right).$$

Taking natural log of both sides in the above equation, we get

$$-3.71 = -\frac{3.71\times10^4}{T},$$

or

$$T = 10^4 \text{ K}.$$