Answer on Question #75546, Physics / Molecular Physics | Thermodynamics

A molecule has a triply degenerate excited state lying at 300 cm^{-1} above the non-degenerate ground state. At what temperature will 20 percent of the molecule be in the upper (excited) level?

Solution:

The fraction of populations of the two states of a two-level system is

$$\frac{p_1}{p_2} = 3e^{-\frac{\Delta E}{kT}} = \frac{0.20}{1-0.20}$$

$$\Delta E = hc\tilde{v} = -kT \ln \frac{p_1}{3p_2}$$

So,

$$T = \frac{-hc\tilde{v}}{k \ln \frac{p_1}{3p_2}} = \frac{-(6.626 \times 10^{-34})(2.998 \times 10^{10})(300)}{(1.381 \times 10^{-23}) \times \ln\left(\frac{0.20}{3 \times (1-0.20)}\right)} = 173.7\ K$$

Answer: 174 K