

6.12)

Since there are 3 excited states with energy higher than the ground state of $\Delta E = 0.47 \text{ meV}$, we know that

$$\frac{3}{10} = 3 \times e^{-\Delta E/kT}$$

Thus, $0.1 = e^{-\Delta E/kT}$ • Using $k = 86 \mu\text{eV/K}$
and $T = \frac{-\Delta E}{k \ln(0.1)}$ we get $T = \frac{-470}{86 \times (-2.303)} = 2.38 \text{ K}$.

This is close to the cosmic "furnace" temperature of 2.7 K : this is how cold the "universal oven" has become after the fiery big bang 13.8 billion years ago.