In-class problem linked to lecture pages 108-116

For air at room temperature, the probability of one molecule being in an excited state is about 10^{-10} (i.e., $p=10^{-10}$). In a typical room there are about 10^{28} air molecules. Calculate the following:

a) the mean number of excited air molecules in a room at any time
b) the standard deviation of this value
c) the relative fluctuation about this value

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$N = 10^{28}$

$p = 10^{-10}$

$q = 1 - 10^{-10}$

a) $\bar{n} = Np = 10^{28} \cdot 10^{-10} = \boxed{10^{18}}$

b) $\sigma = \sqrt{Npq} = \left[10^{28} \cdot 10^{-10} \cdot (1 - 10^{-10})\right]^{1/2} \cong \boxed{10^{9}}$

c) $\frac{\sigma}{\bar{n}} = \frac{10^{9}}{10^{18}} = \boxed{10^{-9}}$