(a) Probability of upper state after two measurements:

$$(1-\alpha t^2)^2 \approx 1 - 2\alpha t^2$$

Probability of upper state after $2t$:

$$1 - 4\alpha t^2$$

(b) The probability that the system is still in the upper state is

$$\left(1 - \frac{\alpha T^2}{n^2}\right)^n$$

Let y be the limit.

$$y = \lim_{n\to\infty}\left(1 - \frac{\alpha T^2}{n^2}\right)^n = \lim_{n\to\infty} e^{n\log\left(1-\frac{\alpha T^2}{n^2}\right)} = \lim_{n\to\infty}\exp\left[\frac{\log\left(1 - \frac{\alpha T^2}{n^2}\right)}{\frac{1}{n}}\right]$$

By the composition limit law

$$y = \exp\left[\lim_{n\to\infty}\frac{\log\left(1 - \frac{\alpha T^2}{n^2}\right)}{\frac{1}{n}}\right]$$

Apply l'Hôpital's rule.

$$y = \exp\left[\lim_{n\to\infty}\frac{\frac{d}{dn}\log\left(1 - \frac{\alpha T^2}{n^2}\right)}{\frac{d}{dn}\frac{1}{n}}\right] = \exp\left(\lim_{n\to\infty}\frac{\frac{2\alpha T^2}{n^3-\alpha T^2 n}}{-\frac{1}{n^2}}\right)$$

Hence

$$y = \exp\left(\lim_{n\to\infty}\frac{2\alpha T^2}{\frac{\alpha T^2}{n} - n}\right) = \exp(0) = 1$$