3) a) $$\mathcal{Z} = \lambda \exp\left(\tfrac{1}{2}\tfrac{\Delta}{\tau}\right) + \exp\left(\tfrac{1}{2}\tfrac{\delta}{\tau}\right) + \lambda^2 \exp\left(-\tfrac{1}{2}\tfrac{\delta}{\tau}\right)$$
$$+ \lambda \exp\left(-\tfrac{1}{2}\tfrac{\Delta}{\tau}\right).$$

b) $$\langle N \rangle = \lambda \frac{\partial}{\partial \lambda} \log \mathcal{Z}$$
$$= \frac{1}{\mathcal{Z}} \left[\lambda \exp\left(\tfrac{1}{2}\tfrac{\Delta}{\tau}\right) + 2\lambda^2 \exp\left(-\tfrac{1}{2}\tfrac{\delta}{\tau}\right)\right.$$
$$\left. + \lambda \exp\left(-\tfrac{1}{2}\tfrac{\Delta}{\tau}\right)\right]$$
$$= \frac{\lambda \exp\left(\tfrac{1}{2}\tfrac{\Delta}{\tau}\right) + 2\lambda^2 \exp\left(-\tfrac{1}{2}\tfrac{\delta}{\tau}\right) + \lambda \exp\left(-\tfrac{1}{2}\tfrac{\Delta}{\tau}\right)}{\lambda \exp\left(\tfrac{1}{2}\tfrac{\Delta}{\tau}\right) + \exp\left(\tfrac{1}{2}\tfrac{\delta}{\tau}\right) + \lambda^2 \exp\left(-\tfrac{1}{2}\tfrac{\delta}{\tau}\right) + \lambda \exp\left(-\tfrac{1}{2}\tfrac{\Delta}{\tau}\right)}$$

c) $$\langle N \rangle \overset{!}{=} 1$$
$$\Rightarrow \lambda \overset{1.}{\cancel{\exp\left(\tfrac{1}{2}\tfrac{\Delta}{\tau}\right)}} + 2\lambda^2 \exp\left(-\tfrac{1}{2}\tfrac{\delta}{\tau}\right) + \lambda \cancel{\exp\left(-\tfrac{1}{2}\tfrac{\Delta}{\tau}\right)}$$
$$= \lambda \overset{1.}{\cancel{\exp\left(\tfrac{1}{2}\tfrac{\Delta}{\tau}\right)}} + \exp\left(\tfrac{1}{2}\tfrac{\delta}{\tau}\right) + \lambda^2 \exp\left(-\tfrac{1}{2}\tfrac{\delta}{\tau}\right)$$
$$+ \lambda \overset{2.}{\cancel{\exp}}\left(-\tfrac{1}{2}\tfrac{\Delta}{\tau}\right)$$

$$\Leftrightarrow \lambda^2 \exp\left(-\tfrac{1}{2}\tfrac{\delta}{\tau}\right) = \exp\left(\tfrac{1}{2}\tfrac{\delta}{\tau}\right)$$

$$\Leftrightarrow \lambda^2 = \exp \frac{\delta}{\tau}$$

$$\Leftrightarrow \frac{2\mu}{\tau} = \frac{\delta}{\tau}$$

$$\underline{\underline{2\mu = \delta}}$$