1. A drop of poison is placed into the middle of a long narrow pipe carrying water. The poison then diffuses away from the initial position, \( x = 0 \), toward \( x = \pm \infty \). The diffusion equation is
\[
\frac{\partial \rho}{\partial t} = D \frac{\partial^2 \rho}{\partial x^2},
\]
where \( \rho \) is the number of poison molecules per unit length. If the net number of molecules is \( N \), find an expression for \( \rho(x, t) \) in terms of \( N \) and \( D \).

2. Consider a non-accelerating Hubble expansion, where freezeout occurs for both photons and the mythical spartino at a temperature of \( T_0 = 3 \times 10^5 \) K, when the age of the universe is \( \tau_0 = 1.4 \times 10^5 \) years. The phase space density of the photons at this time is thermal with temperature \( T_0 \). The spartino is an extremely massive fermionic particle, whose phase space density at freeze-out was also thermal and was given by:
\[
f_{\text{spartino}}(p, \tau_0) = \exp\left(\frac{\mu_0}{T_0} - \frac{p^2}{2mT_0}\right)\frac{1}{1 + \exp\left(\frac{\mu_0}{T_0} - \frac{p^2}{2mT_0}\right)}.
\]
Later, at a time \( \tau \), the spartino’s phase distribution is
\[
f_{\text{spartino}}(p, \tau) = \frac{\exp\left(\mu/T - \frac{p^2}{2mT}\right)}{1 + \exp\left(\mu/T - \frac{p^2}{2mT}\right)}.
\]
For time \( \tau = 1.4 \times 10^{10} \) years, find
(a) The temperature describing the spectrum of photons.
(b) The temperature \( T \) describing the spartino spectrum above
(c) In terms of \( \mu_0 \), what is the new chemical potential \( \mu \)?