Keittel

3.1. We assume Bosons (which makes sense if He is made with 4 spin $\frac{1}{2}$ particles) so atoms can share wavefunction.

Method 1: Infinite Square Well.

We consider particle constrained in $[0, L]$, then the wavefunction is $\sqrt{\frac{2}{L}}\sin\left(\frac{\pi x}{L}\right)$ for G/M state.

This gives $p^2 = -\hbar^2\frac{\partial^2}{\partial x^2}\psi = \frac{\pi^2\hbar^2}{L^2}\psi$, thus

the zero-point energy is $\frac{p^2}{2m} = \boxed{\frac{\pi^2\hbar^2}{L^2\,2m}}$.

Method 2: For free particle, $E = \frac{\hbar^2k^2}{2m}$. using

$k = 2\pi/\lambda$, $E = \frac{\hbar^2 4\pi^2}{\lambda^2\,2m}$, substituting

$\lambda = 2L$ gives $E = \frac{\hbar^2\cancel{4}\pi^2}{\cancel{4}L^2\,2m} = \boxed{\frac{\hbar^2\pi^2}{L^2\,2m}}$.