

ELECTRON GAS IN A 2-D INFINITE SQUARE WELL

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References: Griffiths, David J. (2005), Introduction to Quantum Mechanics, 2nd Edition; Pearson Education - Problem 5.34.

By analogy with the ideal gas in the 3-d infinite square well, we can work out the Fermi energy for a 2-d infinite square well. In this case, k -space occupies the first quadrant of the plane, and each cell in k -space occupies an area of $\pi^2/l_x l_y = \pi^2/A$, where A is the area of the square well and l_x and l_y are its dimensions.

If the space is filled with electrons in the ground state, they will fill the first quadrant of a circle with radius k_F . As before, the number of states required if we have N atoms with q electrons per atom is $Nq/2$ (divided by 2 because of the spin degeneracy) so the total area required is

$$(0.1) \quad \frac{Nq \pi^2}{2 A} = \frac{\pi k_F^2}{4}$$

$$(0.2) \quad k_F = \sqrt{2\sigma\pi}$$

$$(0.3) \quad \sigma \equiv \frac{Nq}{A}$$

The Fermi energy is then

$$(0.4) \quad E_F = \frac{\hbar^2 k_F^2}{2m}$$

$$(0.5) \quad = \frac{\hbar^2 \sigma \pi}{m}$$