Consider a hypothetical 2D semiconductor with a density of states (1/cm²) for the conduction band given by:

\[ D(E) = \frac{2(E-E_C)}{\pi \hbar^2 v_F^2} \quad (E \geq E_C) \]

\[ D(E) = 0 \quad (E < E_C) \]

Answer the following questions.

1) Write down an expression for the areal density of electrons in the conduction band for a given location of the Fermi level, \( E_F \). (20 pts)

2) Evaluate the expression and obtain the areal density of electrons for \( T = 0 \) K assuming that \( E_F > E_C \). (20 pts)

3) Simplify the expression in 1) and evaluate the areal density of electrons for \( T > 0 \) K assuming non-degenerate (Maxwell-Boltzmann) carrier statistics. (10 pts)

4) Write down an expression for the average kinetic energy per electron for electrons in the conduction band. (20 pts)

5) Evaluate the expression and obtain the average kinetic energy per electron for \( T = 0 \) K assuming that \( E_F > E_C \). (20 pts)

6) Simplify the expression in 4) and evaluate the average kinetic energy per electron for \( T > 0 \) K assuming non-degenerate (Maxwell-Boltzmann) carrier statistics. (10 pts)

The following integrals may be useful.

\[ \int e^{ax} \, dx = \frac{1}{a} e^{ax} \quad \int x e^{ax} \, dx = e^{ax} \left( \frac{x}{a} - \frac{1}{a^2} \right) \quad \int x^2 e^{ax} \, dx = e^{ax} \left( \frac{x^2}{a} - \frac{2x}{a^2} + \frac{2}{a^3} \right) \]