Háskóli Íslands
Raunvísindadeild
Eðlisfræði

Haust 2015

# Eðlisfræði þéttefnis I

**Dæmablað 8**

**Skilafrestur 27. October 2015 kl. 15:00**

1. **Electron gas in two dimensions** (20)

   We consider a two dimensional gas of electrons of mass $m$ with $N$ electrons confined to an area $A$ so there is a density $n = N/A$ of electrons per unit area.

   (a) Express the Fermi wave vector magnitude $k_\mathrm{F}$ and the Fermi energy $\mathcal{E}_\mathrm{F}$ in terms of $n$

   (b) Express the density of levels $g(\mathcal{E})$

   (c) Write the Sommerfeld expansion for $n$ and conclude as to the relation between the chemical potential $\mu$ and the Fermi energy $\mathcal{E}_\mathrm{F}$

   (d) Obtain a relation between $\mu$ and $\mathcal{E}_\mathrm{F}$ directly from the relation

   $$n = \int_{-\infty}^{\infty} \mathrm{d}\mathcal{E} g(\mathcal{E}) f(\mathcal{E})$$

   where $f(\mathcal{E})$ is the Fermi-Dirac occupation factor (Hint: proceed with the change of variable $x = \mathrm{e}^{-(\mathcal{E}-\mu)/k_\mathrm{B}T}$). Write your result to the limit $k_\mathrm{B}T \ll \mathcal{E}_\mathrm{F}$.

   (e) Comment on the difference between your answers to question (c) and (d).

2. **Fermi temperature** (10)

   Calculate the Fermi temperatures $T_\mathrm{F}$ for Cu, Na, and Ag. Also calculate the ratio $T/T_\mathrm{F}$ in each case for $T = 300$ K. The effective mass of Cu and Na are 1.0 and 1.2 times $m_0$.

3. **Einstein and quantum theory** (10)

   Describe how Einstein used quantum theory to explain the low-temperature behavior of the specific heat in solids. Use more than four sentences in your response.