

NAME: \_\_\_\_\_

33-448 Solid State Physics      Midterm #1      Wednesday, Feb. 20, 2017

Please read each question carefully before answering. Do not do any unnecessary work - it will waste time and not gain you points. Be sure to attempt every part, as most can be solved independently.

1. Chemical potential of 2D electrons (adapted from Simon, #4.5)

(a) Derive the density of states  $D(E)$  of electrons in two dimensions.

(b) Write down an identity that relates the chemical potential  $\mu$  to the 2D density of electrons  $n$ . Your identity may contain derivatives, integrals or similar complicated features that you do not need to evaluate. All quantities utilized must be defined.

(c) Evaluate your expression from part (b) in the limit  $T \rightarrow 0$  to obtain an expression for  $\mu(T = 0)$ .

## 2. Problems involving electrons and impurities

### (a) (Matthiessen's rule)

Suppose a metal scatters electrons by two different mechanisms: impurities scatter electrons with mean free time  $\tau_i$ ; electrons scatter each other with mean free time  $\tau_e$ . Derive an expression for the conductivity. Note: the solution is very short but slightly tricky.

### (b) (Electron-impurity collisions)

Consider  $N_e$  electrons traveling at speed  $s$  in a material that contains  $N_i$  randomly placed impurities in a volume  $V$ . The impurities are atoms of radius  $R_i$ , and the electrons can be treated as point particles. Derive an expression for the electron mean free time due to impurity scattering,  $\tau_i$ . Hint: it might be easier to think of the electrons as stationary and the impurities as moving!