Homework 3
Due: Wednesday, February 7, in class

1. Problem 1.20 in Kasap (20 points).

2. Problem 1.22 in Kasap (20 points).

3. Problem 3.5 in Kasap (20 points).

4. (40 points) At temperature $T$, the probability for an atom to have energy in the small range $[E, E + dE]$ is $f_E(E)dE$, where the probability density function $f_E(E)$ is given by the following Maxwell-Boltzmann distribution:

$$f_E(E) = \frac{2}{\sqrt{\pi}} \left( \frac{1}{kT} \right)^{3/2} \sqrt{E} \exp \left( -\frac{E}{kT} \right).$$

The average energy of the atom is

$$\bar{E} \equiv \int_0^\infty E f_E(E)dE. \quad (1)$$

- Let $E_0$ be the most probable value of energy defined by $df_E(E)/dE|_{E=E_0} = 0$. Find $E_0$.
- Without evaluating any integral explicitly, use Eq. (1) to argue that $\bar{E}$ is proportional to $kT$.
- Now evaluate the integral and find an explicit expression for $\bar{E}$ in terms of $kT$.
  (Hint: $\int_0^\infty x^{3/2}e^{-x}dx = 3\sqrt{\pi}/4$).