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Problem 53.12 (RHK)

The conduction electrons in a metal behave like an ideal gas if the temperature is high enough. In particular, the temperature must be such that kT ? E_F , *the Fermi energy. We have to find the temperatures that are required for copper* $\left(E_F = 7.06 \text{ eV}\right)$ *to satisfy this requirement. We have to compare our answer with the boiling point of copper, which is* $2567\ ^0\text{C}$. *We may note that as* $kT = E_F$ *the electron gas in metallic copper is not an ideal gas but a degenerate Fermi gas.*

Solution:

The Fermi temperature of copper, $E_F = 7.06 \text{ eV}$. We calculate the temperature T_F such that

$kT_F = E_F = 7.06 \text{ eV}.$

We find

$$T_F = \frac{7.06 \text{ eV}}{8.62 \times 10^{-5} \text{ eV K}^{-1}} = 81{,}902 \text{ K}.$$

Therefore, the temperatures at which the conduction electrons in copper will behave like an ideal gas is that $T \gg 81{,}902\ \mathrm{K}$.

As the boiling point of copper is $2567\ ^{0}\mathrm{C}$, at temperatures less than the boiling point of copper the conduction electrons are a degenerate Fermi-Dirac gas.