HOMEWORK SET 20: MB AND FERMI-DIRAC STATISTICS
Due Friday, April 4, 2025

PROBLEM FROM SERWAY, MOSES & MOYER, *MODERN PHYSICS* (2nd ED.)[1]

SMM 1) Is Maxwell-Boltzmann statistics valid for hydrogen gas at standard temperature and pressure? (STP = 20° C & 1 ATM … a mole of ideal gas at STP occupies 22.4 liters)

PROBLEMS FROM OR AFTER AND TREX[2]

TRex 9.18) We went through this derivation in class, this is your chance to write it out to explain it to another student at your level.

M-B statistics are valid if the separation of particle (wave functions) is much larger than their wavelengths.

a) Use de Broglie's Relation, $\lambda = h/p$ to show that $\lambda = \dfrac{h}{(3mkT)^{1/2}}$

b) Use the fact that $N/V = 1/d^3$ to show that $\lambda \ll d$ can be expressed as

$$\frac{N}{V}\frac{h^3}{(3mkT)^{3/2}} \ll 1$$

c) Now use the condition to determine if Maxwell-Boltzmann statistics apply to Argon at room temperature, and to conduction electrons in Silver at T = 293 K (for the number density given in TRex Table 9.3)

TRex 9.21) The Fermi energy can be defined as the energy at which the Fermi factor, $F_{FD} = 0.5$. Using this definition, show that the constant, B_{FD} in Equation (9.30) is equal to $\exp(-\beta E_F)$ and that

$$F_{FD} = \frac{1}{B_{FD}e^{E/kT} + 1} \quad \text{(TRex 9.30)}$$

$$F_{FD} = \frac{1}{e^{\beta(E-E_F)} + 1}$$

[1] Serway, Moses, & Moyer, Modern Physics, 2nd Editon, Saunders, Harcort Brace College Publishers, 1997

[2] Thornton and Rex, *Modern Physics for Scientists and Engineers*, 3rd Editon, Cengage Learning, 2013