PHYS2332-Modern Physics II
Winter 2020, Assignment #3

Due on Friday February 7, 2020

Q1 Problem 10 chapter 10

Q2 Repeat question Q1, but in this case for heavy water D_2O , where the deuteron mass is twice the hydrogen mass, $m_D = 2m_H$.

Q3 Consider the rotational energy spectrum of carbon monoxide (CO): $E_\ell = \ell(\ell+1)\frac{\hbar^2}{2I}$. The average number of particles in a state ℓ is given by the Maxwell-Boltzman distribution: $n(E_\ell) = B(2\ell+1)\exp\left(-\beta\ell(\ell+1)\frac{\hbar^2}{2I}\right)$, where $\beta = \frac{1}{kT}$. A) Find the most probable ℓ state at temperature T = 300 K and 800K. B) The most probable ℓ corresponds to the most intense line in the rotational spectrum of CO. Do a schematic plot of the intensity I vs the energy of the rotational spectrum of CO at T = 300 K and at T = 800 K. C) Atmospheric gases consist of N_2, O_2, argon, CO, and water vapor. Which of these gases can be detected by **pure rotational (microwave or far-infrared) spectroscopy**? Why? **Data**: The bond length of CO is 0.113 nm.

Q4 Answer Question 7 Chapter 10 on page 386.

Q5 Problem 7 Chapter 10

Q6 Assume that the NO molecule behaves exactly like a harmonic oscillator with a force constant 1530 N/m. (A) Find the energy (in eV) that corresponds to its ground and first excited vibrational states. (B) Find the vibrational quantum number that approximately corresponds to its 7.0 eV dissociation energy. (C) Can NO be detected with infrared spectroscopy? Why?

NOTE: In all problems, sufficient work must be shown to receive full marks.