

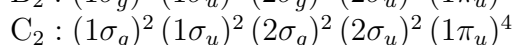
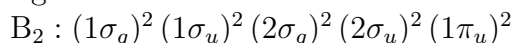


Course Name: Atomic and Molecular Physics
Date: 28.03.2018
Instructor: Bhas Bapat

Course Code: PHY420
Duration: 1h
Total Marks 20

Solve any *four* of following. Questions carry equal marks.

1. Determine the term symbol for the following ground state configurations (superscript signifies the number of electrons in that orbital, just like the atomic case)



2. Show that in the P and the R branches of the ro-vibrational spectrum of a diatomic molecule, the lines are equally spaced if ro-vibrational coupling is neglected. Show that the spacings depend quadratically on J if the ro-vibrational coupling is taken into account. You may show this for either the P or the R branch.
3. Show that the J quantum number of the highest populated rotational level of a rigid diatomic molecule is

$$J_{max} = \left[\frac{kT}{2Bhc} \right]^{1/2} - \frac{1}{2}$$

If the value of B for HCl is 10.6 cm^{-1} , which state would be the most populated (i) at room temperature, (ii) and at 100°C ? What would be the difficulty in determining the temperature of a sample by merely deducing J_{max} from the spectrum?

4. What is the dependence of the value of the centrifugal distortion term in the ro-vibrational spectrum of a diatomic molecule on the vibrational level?
5. Describe the rotational spectrum of the H_2 molecule. Obtain the approximate position (in wavenumbers) of its lowest line, and the spacing between the first and the second line. Is it right to ignore the ro-vibrational coupling for this molecule?
6. Lines in the vibrational spectrum of HCl lie at $2886, 5668, 8347, 10923 \text{ cm}^{-1}$. Are these values in agreement with the prediction based on the Morse potential? The Morse potential is given by

$$U(R) = D_e [1 - \exp(-\alpha(R - R_e))]^2.$$

which gives the energy eigenvalues

$$G(v) = \omega_e \left(v + \frac{1}{2} \right) - x_e \omega_e \left(v + \frac{1}{2} \right)^2$$