INDIAN INSTITUTE OF SCIENCE EDUCATION & RESEARCH MOHALI

CHM 201, 1st Mid Semester Examination **September 10, 2018**

1. Attempt all questions. Total number of questions: 5 **Time: 1 hour**
2. Show clearly all the steps in your calculations. **Total Marks: 25**

Useful data

$h = 6.626\ 068 \times 10^{-34}$ Js	$m(^{12}C) = 12.000$ u
$c = 2.997\ 925 \times 10^{8}$ ms^{-1}	$m(^{1}H) = 1.008$ u
$k = 1.380\ 650 \times 10^{-23}$ JK^{-1}	$m(^{14}N) = 14.007$ u
$R = 8.314\ 472$ Jmol^{-1}K^{-1}	$m(^{35}Cl) = 34.969$ u
$N = 6.022\ 142 \times 10^{23}$ mol^{-1}	$m(^{16}O) = 15.999$ u

$1\text{eV} = 8065.479\ \text{cm}^{-1} = 23.06\ \text{kcal/mol} = 1.602\ 1892 \times 10^{-19}\text{J}$

1. The microwave spectrum of $^{12}C^{14}N$ observed from a certain source, shows the strongest intensity for the J=9→J=10 transition. Given that the C-N bond length is 1.17 Å, estimate the temperature of the source. (5)

2. Smith et al. performed an infrared spectroscopy analyses of the vibrational transitions in $^{12}C^{16}O$ and reported the value of the vibrational frequency to be 1.302×10^{14} Hz. a) Express the vibrational frequency in units of cm^{-1}. (2)

   Watson et al. performed a microwave spectroscopy analyses of the rotational transitions of $^{12}C^{16}O$ and arrive at the following equation for the energies of the rotational levels, E_J:

   $$E_J = 1.931\ [J(J+1)] - 6.116 \times 10^{-6}\ [J(J+1)]^2$$

   b) Do you think that the data obtained from the microwave (Watson et al.) and infrared experiments (Smith et al.) are consistent with each other or not? Justify your answer. (3)

3. Classify the following molecules as symmetric top, spherical top and asymmetric top. Justify your classification using symmetry arguments.
   a) BF_3 **b)** SF_6 **c)** m-dichlorobenzene **d)** CL_4 **e)** CH_2Br_2 (5)

4. The ClO diatomic species is of great importance in the chemistry of the atmosphere. A spectroscopist observed the fundamental band (v=0→v=1) for the $^{35}Cl^{16}O$ molecule at 842.6 cm^{-1}, and a hot band (v=1→v=2) at 831.6 cm^{-1}.
   a) Using the data given above, calculate ω_e and $\omega_e x_e$ for $^{35}Cl^{16}O$? (2)
   b) Assuming that a Morse potential adequately represents the above problem, calculate the dissociation energies, $\mathcal{D}_e$ and $\mathcal{D}_0$ for $^{35}Cl^{16}O$. (3)

5. SiH_4 is a tetrahedral molecule with no dipole moment and hence cannot be expected to show a rotational spectra. However, in 1974, Rosenberg and Ozier reported the rotational spectra for this molecule (!) corresponding to transitions between J levels, involving ***only large*** values of J. No rotational spectra were observed for small values of J. How will you rationalize this observation? (5)