DEPARTMENT OF CHEMISTRY
FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA
FIRST SEMESTER EXAMINATION: 2021/2022 SESSION

COURSE: CHM 313   **UNIT: 2**

COURSE TITLE: Molecular Properties
TIME ALLOWED: 1hour 30 minutes
INSTRUCTION: Answer any 3 Questions

CONSTANTS: $C = 3 \times 10^{10}$ cms^{-1}; Avogadro's constant = 6.022×10^{23} mol.$^{-1}$, $h = 6.266 \times 10^{-34}$ Js, $^{1}H = 1.673 \times 10^{-27}$ Kg, $\mu_{HCl} = 1.16148 \times 10^{-27}$ kg

1(a). In tabular form, discuss the diversity of spectroscopy based on:
     i.   Frequency region
     ii.   wavelength ranges and
     iii.   characteristics.   **(12 marks)**

1(b). The infra-red emission from a hot HF molecule appears as series of lines at 3960 (1 - 0), 3780 (2 -1) and 3600 (3 -2) cm^{-1}. Calculate the force constant of the HF bond.   **(8 marks)**

2(a). The spectrum of HX records intense absorption at 2888, 5669 and 8370 cm^{-1}. Determine the:
     i. ω_{osc}
     ii. x_e **(12 marks)**

2(b).   i.   Explain *band origin*
     ii.   Analysis of vibration-rotation spectrum of CO gives the P and R-branches as follows: $P_1 = 2128.54$, $P_2 = 2124.66$, $P_3 = 2120.74$ and $R_0 = 2136.19$, $R_1 = 2161.97$, $R_2 = 2143.61$ cm^{-1}. The first overtone of CO is obtained at 4260.04 cm^{-1}. Calculate the dissociation energy of CO.   **(8 marks)**

3(a).   i.   What is spectroscopy?
     ii.   State the basic differences between atomic and molecular spectroscopy.
     iii.   Rotational constant, R, can be expressed as $\dfrac{h}{8\pi^2 Mv}$. Define h, M and v.
     iv.   Using the expression in a iii, deduce the reduced mass μ ratio of isotopic substitutes like in ^{12}CO and ^{13}CO.   **(12 marks)**

3(b). Give account, with examples, the moment of inertia of each of the following molecular classes:

      i. Linear molecule
      Ii. Spherical tops
      ii. Symmetric tops
      iii. Asymmetric tops   **(8 marks)**

4(a). Derive the expression of bond length $r_0 = [I/\mu]^{1/2}$ of a rigid diatomic molecule.
      (10 marks)

4(b). What is Stark effect in microwave analysis? Highlight its significance.
      (4 marks)

4(c). Rotational absorption lines for hydrogen chloride molecule were found at the following positions: 86.12, 106.99, 127.22 and 145.78cm^{-1}. Find the moment of inertia and bond length of the HCl molecule.   **(6 marks)**