MACHAKOS UNIVERSITY

University Examinations 2021/2022

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YEAR SUPPLEMENTARY/SPECIAL EXAMINATION FOR BACHELOR OF SCIENCE (TELECOMMUNICATION INFORMATION TECHNOLOGY)

BACHELOR OF EDUCATION (SPECIAL NEEDS EDUCATION)

BACHELOR OF SCIENCE IN ANALYTICAL CHEMISTRY

BACHELOR OF SCIENCE (MATHEMATICS)

BACHELOR OF EDUCATION (SCIENCE)

SCH 203: THEORY OF SPECTROSCOPIC METHODS

DATE: 16/3/2022 **TIME: 2:00-4:00PM**

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

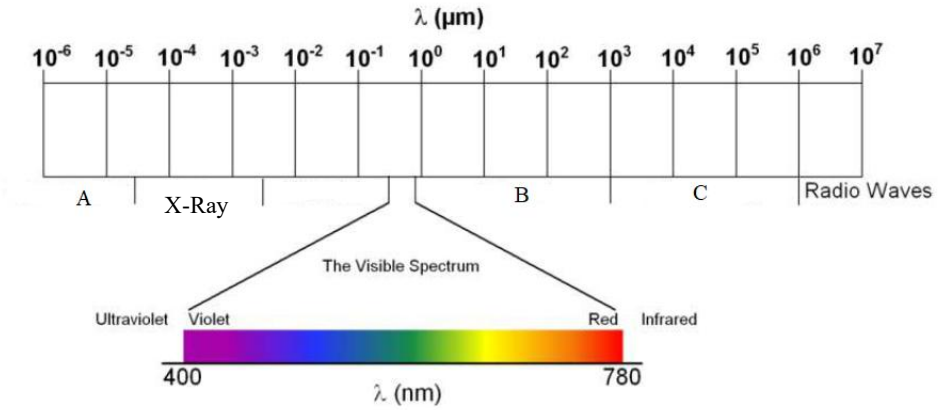
USEFUL CONSTANTS AND FORMULA

Given that, $B = \frac{h}{8\pi^2 Ic}$ and $I = \mu r_o^2$, $J_{max} = \sqrt{\frac{kT}{2Bhc}} - \frac{1}{2}$, where $h = 6.626 \times 10^{-34}$ Js, velocity of light, c = 2.998×10^8 m/s, Boltzmann constant, $k = 1.38 \times 10^{-23}$ J/K, Avogadros constant, $L = 6.023 \times 10^{23}$ particles and $\pi = 3.14$, $k = 4\pi^2 c^2 \mu \bar{\omega}_e^2$ where k is Force constant, 1Js = 1 Kgm^2s^{-1}, 1N/m = $10^3 g/s^2$.

SECTION A (COMPULSORY)
QUESTION ONE (30 MARKS)

a) Using the correct symbols deduce the relationship between wavelength, wavenumber and frequency of an electromagnetic wave. (5 marks)

b) All electromagnetic radiations are propagated with the same velocity but they differ in their wave length resulting to different regions of the electromagnetic spectrum as illustrated by the following diagram.



i) Define the underlined spectroscopic terms. (3 marks)

ii) Name the electromagnetic radiations labelled A, B, and C (3 marks)

iii) The red light at the Visible spectrum region is observed at 780 nm while the radio waves are heard at 10^6 μm. Convert

a) 780 nm to μm

b) 10^6 μm to centimeters (3 marks)

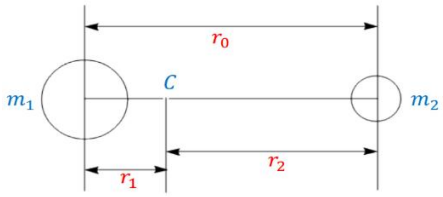
iv) The wavelength of the visible red light is 780 nm, calculate it's corresponding

a) Frequency (2 marks)

b) Wavenumber (2 marks)

c) Energy of the radiation (2 marks)

c) Rotational spectra are used to determine the bond lengths in diatomic molecules (AB). Such molecules have a permanent dipole moment and produce electric field while rotating. The first approximation in the study of the rotational spectrum of a diatomic molecule is that the molecule behaves like a rigid rotator. Using an illustration of a rigid rotator with two spherical particles of unequal atomic masses $\mathbf{m_1}$ and $\mathbf{m_2}$ and located at fixed distances $\mathbf{r_1}$ and $\mathbf{r_2}$ respectively from the center of gravity of the system C, derive systematically the equation, which can be used to calculate the moment of inertia, I and hence the bond length, r_0 in the diatomic molecule.
(10 marks)



SECTION B (ANSWER ANY TWO QUESTIONS)

QUESTION TWO (20 MARKS)

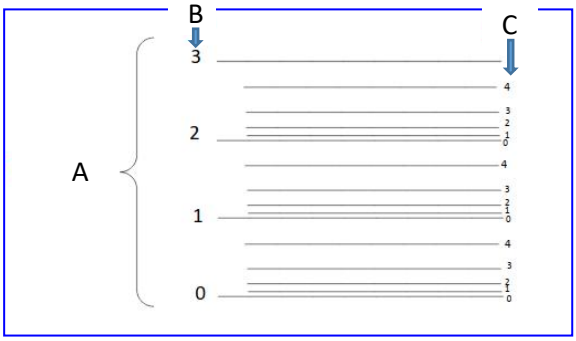
a) The rotational spectrum of ^{79}Br ^{19}F shows a series of lines, 2B = 0.71433 cm^{-1} apart. Calculate:

i. the rotational constant B (1 mark)

ii. the moment of inertia (4 marks)

iii. the bond length of the molecule. (4 marks)

b) The total energy of a molecule is the sum of translational, rotational, vibrational and electronic energies. The transitions of energies can take place only between the three quantized energy levels of a molecule resulting to a molecular spectrum. Using the diagram provided, identify the three quantized energy levels of a molecule.
(3 marks)



c) Differentiate between atomic and molecular spectroscopy. (8 marks)

QUESTION THREE (20 MARKS)

a) Define the term scattering as used in electromagnetic radiation. (2 marks)

b) When an intense beam of light is passed through a transparent medium, some of the light is scattered as a characteristic of the molecules of the medium. Describe the two possible types of scattering that can be observed. (5 marks).

c) Explain the following terms as used in Raman spectroscopy (9 marks)

i) Raman shift

ii) Anti-stokes' radiation

iii) Hot band transition

iv) Prolate ellipsoid

v) Polarizability

vi) Inelastic collision

d) Differentiate between fundamental and overtone transitions as used in Raman Spectroscopy. (4 marks)

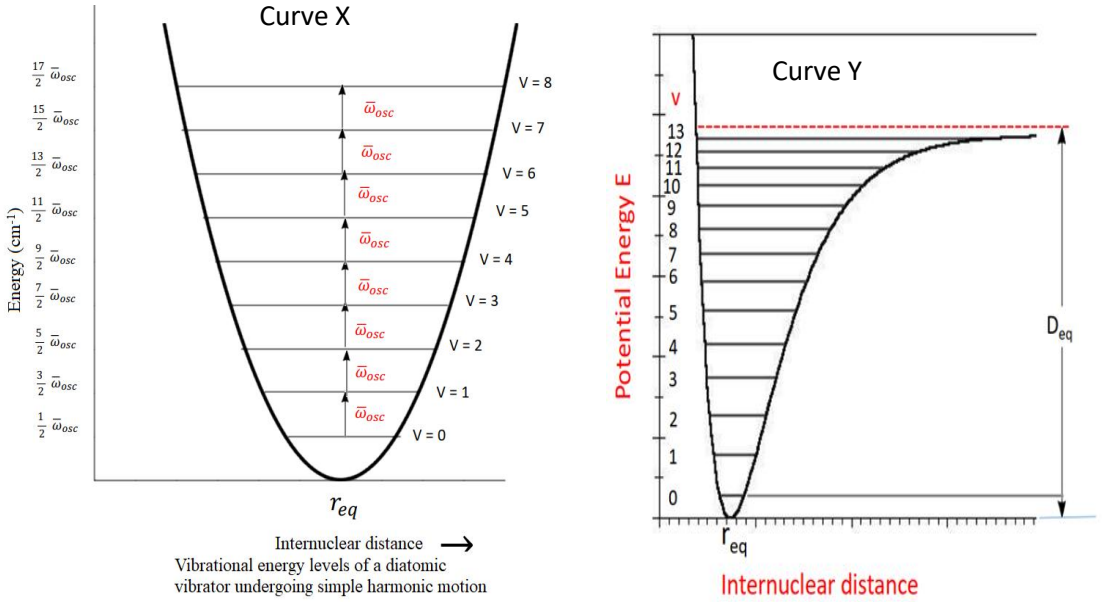
QUESTION FOUR (20 MARKS)

a) The IR spectrum of HCl shows a strong line at 2886 cm^{-1}, a weak one at 5668 cm^{-1} and a very weak one at 8347 cm^{-1}. Calculate the force constant of HCl. (10 marks)

b) Spectrometric instruments are widely applied in laboratory analytical instrumentation both in research and industrial institutions. Describe any four applications of Infra-Red spectroscopy. (10 marks)

QUESTION FIVE (20 MARKS)

a) By using the following potential energy curve diagrams, answer the following questions:



i. Identify the Morse curve and the Harmonic curve (2 marks)

ii. List any four characteristics of each function. (Curve X and Curve Y)(8 marks)

iii. Using an example in each case, briefly explain how the concept of fluorescence, phosphorescence and chemiluminescence works under photo physical processes.

(10 marks)