MACHAKOS UNIVERSITY

University Examinations 2018/2019

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN APPLIED SCIENCE

BACHELOR OF EDUCATION (SPECIAL NEED EDUCATION)

BACHELOR OF EDUCATION

SCH 203: THEORY OF SPECTROSCOPIC METHODS

DATE: 3/5/2019 **TIME:**

INSTRUCTIONS TO CANDIDATES

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

SECTION A (COMPULSORY)

QUESTION ONE (30 MARKS)

a) Electromagnetic radiations consist of electrical and magnetic waves oscillating at right angles to each other. They travel away from the source with the velocity of light. The waves are characterized by frequency, wavelengths and wave number. Define the three terms which characterize magnetic waves and indicate the symbols used to represent each

(3 marks)

b) Rotational spectra are used to determine the bond lengths in heteronuclear molecules (A-B). Such molecules have a permanent dipole moment and produce electric field while rotating. Thus, electromagnetic radiations interact with these molecules and produce rotational spectra, which are observed in the far infrared and microwave regions. As a rule, a molecule can be excited to only the next higher rotational level by absorption of energy.

Derive systematically the equation, which can be used to calculate the bond length in a heteronuclear molecule. Assume the molecule is raised from quantum number j= 0 to j= 1 (7 marks)

c) Explain the following terms as used in nuclear magnetic resonance spectroscopy (5 marks)

i. Chemical shift

ii. Trimethylsilane

iii. Downfield shift

iv. Spin-spin coupling

v. (n+1) rule

d) An infrared (IR) spectrometer subjects a compound into infrared radiation in the 5000 – 667 cm^{-1} range. This radiation does supply sufficient energy for bonds in the molecule to vibrate by stretching or bending. As the molecule is subjected to the individual wavelengths in the 5000 – 667 cm^{-1} range, it absorbs only those possessing exactly the energy required to cause a particular vibration. Name and explain the two sections usually studied in an infrared spectrum (4 marks)

e) Under Raman spectra, when an intense beam of light is passed through a liquid or gas, some of the light is scattered by the molecules of the medium. Differentiate between the terms Rayleigh scattering and Raman scattering as used in Raman spectra (4 marks)

f) In mass spectroscopy, the ion source is where the sample of interest is ionized with a positive or negative charge and converted into the gas phase. Briefly explain the working of Electron Impact and Chemical ionization as applied in Mass Spectroscopy (4 marks)

g) When a beam of light of sufficiently high frequency is allowed to strike a metal surface in vacuum, electrons are ejected from the metal surface. This phenomenon is known as photoelectric effect. State two observations made under the phenomenon photoelectric effect (3 marks)

SECTION B (ANSWER ANY TWO QUESTIONS)

QUESTION TWO (20 MARKS)

a) Define the terms spectra and continuous spectrum as used in the field of electromagnetic spectrum (4 marks)

b) The spacing between the lines in the rotational spectrum of HCl is 20.68 cm^{-1}. Calculate the bond length. Mass of H is 1.008 g, Cl is 35.45 g and Avogadro number 6.02×10^{23} (6 marks)

c) An infrared (IR) spectrophotometer subjects a compound to infrared radiation in the 5000 – 667 cm^{-1} range. Provide the wavelength range for the following triple, double and single bonds, which is essential for determining the structure of organic molecules. C=C, C=O, C-N, C-O, O-H, S-H, CΞC and CΞN (4 marks)

d) To obtain a molecular spectrum, the substance under examination is exposed to electromagnetic radiations of a series of wavelengths. The series of wavelengths absorbed in each case gives a distinct molecular spectrum. Briefly explain the three main types of molecular spectra. (6 marks)

QUESTION THREE (20 MARKS)

a) State the Beer-Lambert law (2 marks)

b) The magnitude of a quantum or photon of energy is directly proportional to the frequency of the radiant energy, or is inversely proportional to its wavelength. Calculate the magnitude of the energy of the photon (or quantum) associated with light of wavelength 6057.8×10^{-8} cm. (5 marks)

c) As atoms cannot vibrate or rotate as a molecule does, when energy is absorbed, electronic transitions take place and are seen as sharp lines as opposed to broad bands or peaks in the molecular spectra. These spectra lines are specific for the element being studied and contain information on its atomic structure. Name and explain three possible transitions, which occur when energy is provided to an atom. (4 marks)

d) With the aids of diagrams, demonstrate the three types of internal energy of a molecule. (6 marks)

e) Spectrometric instruments and separation instruments are widely applied in laboratory analytical instrumentation both in developing and developed countries. Give two applications of Nuclear Magnetic Resonance as one of the equipment widely used in the developed countries. (3 marks)

QUESTION FOUR (20 MARKS)

a) Using an example in each case, briefly explain how the concept of fluorescence, phosphorescence and chemiluminescence works under photophysical processes. (9 marks)

b) The wavelength of a violet light is about 400 nm. Calculate its frequency and wave number (4 marks)

c) With the aid of a diagram, explain the Compton Effect as a proof of the quantum theory or photon theory. (4 marks)

d) Name and state the two main laws governing photochemical reactions. (4 marks)

QUESTION FIVE (20 MARKS)

a) Name any three class detectors used for the measurement of intensity of transmitted light (3 marks)

b) Ordinary reactions occur by absorption of heat energy from outside. The reacting molecules are energized and molecular collisions become effective. These brings about the reaction. The reactions which are caused by heat and in absence of light are called thermal reactions. On the other hand, some reactions proceed by absorption of light radiations. These belong to the visible and ultraviolet regions of the electromagnetic spectrum. The reactant molecules absorb photons of light and get excited. These excited molecules produce the photochemical reactions. Give five differences between photochemical reactions and thermochemical reactions. (5 marks)

c) With the aid of a diagram, explain how light intensity can be measured under the concept of photochemistry. (7 marks)

d) Using examples differentiate between a primary reaction and secondary reaction as applied in photochemical reactions. (5 marks)