MACHAKOS UNIVERSITY

University Examinations 2019/2020Academic year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FOURTH YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF EDUCATION (SPECIAL EDUCATION)

BACHELOR OF EDUCATION (SCIENCE)

SCH 404: INSTRUMENTAL METHODS

DATE: **TIME:**

INSTRUCTIONS TO CANDIDATES

1. **This paper contains five (5) questions.**
2. **Answer question one (compulsory) and any other two questions.**

QUESTION ONE (30 MARKS)-COMPULSORY.

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) The analytical process is the science of taking measurements in an analytical and logical way. It involves identifying or quantifying an analyte in a complex sample. Clearly name and explain the main steps involved in an analytical process. (7 marks)

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

i. Chemical shift

ii. TMS

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) Ion chromatography (IC) is a subset of one of the modes of HPLC- ion-exchange chromatography. It uses ion-exchange resins to separate ions based on their interaction with the fixed groups on the resin. From the Ion Chromatography technique, differentiate between non-suppressed IC and suppressed IC. (3 marks)

QUESTION TWO (20 MARKS)

a) State the function of a mass analyzer and name three types which are used in mass spectroscopy. (4 marks)

b) Chromatography is one of the main techniques used in separation of a mixture into individual components. Several equipments are used in chromatographic techniques. With an aid of a diagram explain the main parts of a high-performance liquid chromatography. (6 marks)

c) An infrared (IR) spectrometer 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) Ultraviolet spectroscopy is a powerful instrument used in structural elucidation of compounds. Since various energy levels of molecules are quantized, a particular electronic excitation occurs only by the absorption of specific wavelengths of radiation corresponding to the required quantum of energy. Calculate the energy associated with an ultraviolet having wavelength 286 mm. Give the answer in Kcal/mol and also in KJ/Mole. (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. (4 marks)

c) Various atoms in a molecule may be regarded as balls of different masses and the covalent bonds between them as weightless tiny springs holding such balls together. Atoms in a molecule are not still but they vibrate. The two types (modes) of fundamental molecular vibrations known are: (a) stretching and (b) bending vibrations (deformations). Explain the working of two types of each mentioned modes of vibration. (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 four applications of Nuclear Magnetic Resonance as one of the equipment widely used in the developed countries. (4 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. (6 marks)

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

c) Since 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 lines are specific for the element being studied and contain information on its atomic structure. If energy is provided to an atom, there are three possible transitions. State and explain the three possible transitions occurring in atoms. (6 marks)

d) Differentiate between split and splitless techniques of sample injection in a Gas liquid chromatography technique. (4 marks)

QUESTION FIVE (20 MARKS)

a) Name any three 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) Name and state the two main laws governing photochemical reactions. (4 marks)

d) Briefly explain the working of a flame atomic absorption spectrometry and Graphite furnace atomic absorption spectrometry. (5 marks)

e) Name and explain the working of the three types of hydrostatic injection used in Capillary Electrophoresis technique. (3 marks)