UNIVERSITY OF ESWATINI

MAIN EXAMINATION 2019/2020

TITLE OF PAPER:	ANALYTICAL CHEMISTRY II
COURSE NUMBER:	CHE 638
PROGRAMME	MASTERS IN TEXTILE AND CONSUMER SCIENCE
TIME ALLOWED:	TWO (2) HOURS
INSTRUCTIONS:	THERE ARE FOUR (4) QUESTIONS IN THIS PAPER. ANSWER QUESTION ONE (TOTAL 50 MARKS) AND ANY TWO OTHER QUESTIONS (EACH QUESTION IS 25 MARKS)

A PERIODIC TABLE AND OTHER USEFUL DATA HAVE BEEN PROVIDED WITH THIS EXAMINATION PAPER

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QUESTION ONE [50 MARKS]

a) Define the term chromophore. [1]

b) Identify the chromophore in each of the following molecules which give rise to the lowest energy transition and state which kind of transition it undergoes [2]

i.

ii. CH_3OH

c) Draw a well labelled diagram of a sinusoidal wave and define each characteristic of the wave. [3]

d) Several analytical techniques are based on the measurement of light absorbed from the different parts of the electromagnetic spectrum. The following diagram shows part of the electromagnetic spectrum;

X-rays	P	Visible	Q	Microwave	Radiowaves

i. Identify the type of electromagnetic radiation found in the regions labelled P and Q. [2]

ii. Identify which one of the five regions has radiation of the lowest frequency. [1]

e) Calculate the following;

i. The frequency in hertz of a photon at 324.7 nm. [3]

ii. The frequency in hertz of an infrared absorption peak at 3.75 um. [2]

iii. The wavelength in cm of a photon with a wave number of 1375 cm^{-1}. [2]

f) Calculate the wavenumber of a beam of infra-red radiation with a wavelength of 5μm. What is the energy in joules of one photon of this radiation described? [4]

g) Discuss how $n \rightarrow \pi^*$ transitions differ from π-π^*, use an energy level diagram and also illustrate using a spectrum. [4]

h) State the Beer-Lambert's law and define all the terms appearing in it. [4]

i) A complex formed between Fe (II) and 1,10-phenanthroline has a molar absorptivity of 7000 L cm^{-1} mol^{-1} at the wavelength of maximum absorption of 435 nm. Calculate

   i. the absorbance of a 6.77 x 10^{-5} M solution of the complex when measured in a 1 cm cell? [2]

   ii. The % transmittance of the solution described in (i) above? [2]

   iii. The pathlength through a 3.40 x 10^{-5} M solution of a complex that is needed for an absorbance that is the same as the solution described in (i) above. [2]

j) The ultraviolet spectrum of benzonitrile shows a primary absorption band at 224 nm. If a solution of benzonitrile in water, with a concentration of 1x 10^{-4} molar, is examined at a wavelength of 224 nm, the absorbance is determined to be 1.30. The cell length is 1 cm. What is the molar absorptivity of this absorption band? [4]

k) UV-Visible spectroscopy is routinely used in analytical chemistry for the quantitative determination of different analytes, such as dyes and biological macromolecules. For a particular assay, your plot of absorbance versus concentration was not linear. Explain the possible reasons for this [6]

l) With the aid of a well labelled diagram, describe the operation of the photomultiplier tube used as a detector in the UV-Visible spectrophotometer. [6]

QUESTION TWO [25 MARKS]

a) Define the following terms as used in spectroscopy

   i. Triplet and singlet states [2]

   ii. Quenching [1]

   iii. Intersystem crossing [1]

   iv. Attenuation [1]

b) Explain in details why phosphorescence takes longer than fluorescence [2]

c) Discuss what bathochromic and hypsochromic shifts are in the UV-Visible spectrophotometry. What causes these shifts? [4]

d) Sketch and label the basic components of a double beam spectrophotometer. Explain its advantages over the single beam spectrophotometer. [6]

e) Most spectroscopy based instruments require a source of radiation to be directed at the sample to be analysed. State any three (3) light sources used in UV-Visible spectrophotometry and explain how each one of them work, give their advantages and limitations. [3]

f) With the aid of a well labelled diagram discuss how a grating monochromator works [5]

QUESTION THREE [25 MARKS]

a) Sketch the main components of a Gas Chromatography (GC) and explain the function of each of the components identified. [6]

b) Which kind of compounds are separated by gas chromatography? [2]

c) What are the requirements for a carrier gas in GC. Name three (3) gases that are used as carrier gases in GC analysis. [4]

d) Explain why the injector (inlet) of a GC must be maintained at 50°C higher than the compound with the lowest boiling point. [2]

e) Explain the differences between split and splitless injection mode in GC explaining a suitable application for each mode of injection. [4]

f) Discuss any three (3) properties of an ideal GC detector [3]

g) Explain the principle of gel permeation/size exclusion chromatography [4]

QUESTION FOUR [25 MARKS]

a) Define the following terms as used in Chromatography.

i. Chromatography [1]

ii. Stationary phase [1]

iii. Adjusted retention time [1]

iv. Mobile phase [1]

b) Describe the basic principle underlying all chromatographic processes. [3]

c) Discuss the factors that causes band broadening in chromatography. [6]

d) Differentiate between the following terms as used in Chromatography

i. Isocratic and gradient elution [2]

ii. Isothermal and temperature programming [2]

e) During the chromatographic analysis of a mixture of chlorinated pesticides in which a 2.0 m long column was used, a peak with a retention time (t_R) of 8.68 min and a baseline width of 0.36 min was identified to be dieldrin.

i. Calculate the capacity factor, K, for dieldrin if the dead time, t_m, for the column is 0.30 min [1]

ii. An adjacent peak to that of dieldrin has a retention time, t_R, of 9.76 min and a baseline width of 0.62 min. Calculate the resolution between the two peaks. Is this resolution sufficient for quantitative analysis, explain. [3]

f) Given the HPLC chromatogram below for a mixture of barbiturates; assuming that barbital is more polar than phenobarbital which is more polar than Aprobarbital, etc. Was this experiment run under normal or reverse phase conditions? Explain [4]