

**CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ**

Autumn Examination 2009/10

Module Title: BioAnalytical Science III

Module Code: CHEA6003

School: School of Science

Programme Title: Bachelor of Science in Applied Bio Sciences

Programme Code: SBIOS-7-Y2

External Examiner(s): Prof. Gary Walsh

Internal Examiner(s): Dr. Rosamund Hourihane, Ms. Eva Norris.

Instructions: Attempt BOTH sections A and B
Answer a total of four questions
All questions carry equal marks
Show all Calculations in the Examination Script

Duration: 2 Hours

Sitting: Autumn 2010

Requirements for this examination: Periodic Tables

Note to Candidates: Please check the Programme Title and the Module Title to ensure that you have received the correct examination paper.
If in doubt please contact an Invigilator.

Section A

Attempt any 8 of the following 10 parts. All carry equal marks.

Q1.

- (i) Explain what is meant by bond order, how is it calculated? What does a value of three signify?
- (ii) (a) On a simple energy level diagram illustrate the following molecular orbitals, π , π^* , σ , σ^* and n .
(b) Identify the bonding and anti-bonding molecular orbitals and two possible allowed transitions.
- (iii) What is meant by the isosbestic point? When and why is it used?
- (iv) Define the term "Partition in Chromatography".
- (v) Identify what happens within a molecule when (a) microwave and (b) infrared radiation is absorbed. A simple illustration is required.
- (vi) Distinguish, giving examples in each case, between the following classifications of electrons:
 - (a) closed shell electrons;
 - (b) covalent single bond electrons;
 - (c) paired non-bonding outer shell electrons;
 - (d) pi electrons.
- (vii) In relation to spectroscopic analysis, state three basic methods of wavelength selection.
- (viii) Suggest three properties of an ideal photo detector that is sensitive to visible light.
- (ix) Why is (a) the shape and (b) the material of a sample cuvette important?
- (x) Give a brief description of electromagnetic radiation. What is the wavelength range of the visible part of the electromagnetic spectrum?

(25 marks)

Section B

Q2. (a) (i) Distinguish between a chromophore and an auxochrome in ultra violet spectroscopy.

(ii) Consider the data in the following table.

Compound	λ \ nm	ϵ
(1) $\text{CH}_2 = \text{CH}_2$	180	103
$\text{CH}_2 = \text{CHNH}_2$	220	104
(2) C_6H_6	255	23
$\text{C}_6\text{H}_5\text{NH}_2$	280	143

- Name and explain the Spectral change (s) the NH_2 substituent is causing in (1) and (2) above.
- What is the NH_2 in each scenario?
- Identify two other substitutes which may cause similar effects.

(10 marks)

(b) (i) List at least three characteristics of an ideal solvent for use in spectroscopy.

(ii) Explain the effect on the resulting Spectrum of changing from a non polar solvent to a polar solvent.

(5 marks)

(c) A solution containing 1.00mg of sodium in 250mL of water was observed to transmit 65% of the incident light compared to the appropriate blank.

(i) What is the absorbance of the solution at this wavelength?

(ii) What would be the transmittance value of the solution of sodium which is half as concentrated?

(10 marks)

Q3. Attempt three of the following:

- (i) (a) Describe the function of a spectrometer.
(b) Name the four key components that make up a spectrophotometer and provide an appropriate labelled diagram that describes how these components are arranged.
(c) Suggest *two* applications for a spectrometer.
- (ii) Write a note detailing the method of ion exchange chromatography. In your discussion mention typical types of mobile and stationary phases used, as well as sample types. What is meant by the exchange capacity? Diagram required.
- (iii) Explain, giving examples of, the purpose of a complexation\ chelating reagent in ultra violet, (UV) spectrometry. List and explain three characteristics of an ideal complexation reagent.
- (iv) What is meant by the term ion selective electrode (ISE)? List four main types. The pH electrode is a member of one of these categories. Discuss the pH electrode mentioning and explaining two errors associated with pH measurements.
- (v) What is the column efficiency required to give complete separation to two components with retention times of 25 and 26 seconds? Assume the width of both peaks is the same.

(25 marks)

- Q4. (a)** Describe concisely the method of Fluorescence spectrometry. In your description:
- give a brief account of the background theory
 - identify structural features essential to the successful application of this method
 - draw a well labeled energy level diagram for the process. (10 marks)
- (b) A sample of atmospheric water was analysed for iron content using molecular ultraviolet spectroscopy. To this end, a series of standards were prepared from a 100 ppm iron stock solution. Their absorbance values were measured at 510 nm. The water sample was treated according to literature methods and its absorbance value was also determined. The data for both sample and standard is contained in the data table below. As can be seen from the data, the absorbance value for the water sample is outside the range of the standards. The water sample was diluted to 10% of its original concentration, and re-analysed.

The absorbance of the diluted sample is shown on the data table too.

- Plot the appropriate calibration curve.
- Determine the concentration of iron in the **original** water sample.

Absorbance	[Fe] /ppm
0.009	1.00
0.028	3.00
0.048	5.00
0.067	7.00
0.096	10.00
0.900	Water sample
0.081	Diluted water sample

(10 marks)

- (c) The standards listed in the table were prepared from 100 ppm iron stock solution. What volume of this stock is required to prepare:
- 100 cm³ of the 7 ppm standard solution
 - 25 cm³ of the 1 ppm standard solution

(5 marks)

- Q5.** (a) What is analytical chemistry? Outline the steps involved in any analytical process. (4 marks)
- (b) Sampling is the process of selecting a representative bulk sample from the lot. Sample preparation is the process that converts a bulk sample into a homogenous laboratory sample. Sometimes in analysis it is necessary to mask an interfering species. Explain the underlined terms. (10 marks)
- (c) Identify the analytical methods, (i) and (ii), from the description below:
- (i) “a process by which an analyte is determined through its ability to undergo oxidation and / or reduction.”
- (ii) “determination of the concentration of a solution by causing it to react with another solution of known concentration.” (4 marks)
- (d) (i) Draw a simple, labelled energy level diagram to illustrate the process of absorption and emission of electromagnetic radiation.
- (ii) Identify three processes by which a molecule in the ground state can undergo excitation, rank these processes in order of increasing energy. (7 marks)

IA	VIII															
1 H 1.01	2 He 4.00															