

**CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ**

Semester 1 Examination 2009/10

Module Title: BioAnalytical Science III

Module Code: CHEM6003

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

Duration: 2 Hours

Sitting: Winter 2009

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 is compulsory

Section A

Q1. Attempt any 8 of the following 10 parts.

All carry equal marks.

- (i) Explain what is meant by bond order. What does a value of two signify?
- (ii) On a simple energy level diagram illustrate the following molecular orbitals, π , π^* , σ , σ^* and n . 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) Give the wavelength range of the Ultra Violet and visible regions of the electromagnetic spectrum. Identify any subdivisions where applicable. What types of cells are required for each region?
- (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 4 classifications of electrons: closed shell electrons; covalent single bond electrons; paired non-bonding outer shell electrons; π electrons.
- (vii) Name the four key components that make up a spectrophotometer and provide an appropriate diagram.
- (viii) Give an example of (a) a continuous-type light source and (b) a line-type light source that could be used in spectroscopy. What is 'blackbody radiation'?
- (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

Attempt any **three** of the following questions.

- Q2. (i) Describe the process of fluorescence emission spectroscopy. Draw an energy level diagram to illustrate the process. In your diagram include also the two non-radiative processes, which compete with fluorescence. Identify situations when these processes are most successful. (10 marks)
- (ii) A multi-vitamin tablet was analysed for riboflavin (vitamin B2) content according to literature methods. A series of standards were prepared from a 1.00ppm riboflavin stock solution. Their fluorescence intensity, (FI), values were determined and are given in the table below. The FI of the vitamin tablet sample was determined in triplicate and is also included below. As can be seen, the samples FI values are outside the range of the standards. The sample was diluted to bring it on scale, by taking 10cm³ of it and diluting it to 50cm³ in a volumetric flask. This diluted sample was reanalysed.
- (a) Draw the appropriate calibration curve and determine the concentration of riboflavin in the multi-vitamin tablet sample.
- (b) What volume of the stock solution is required to prepare 100cm³ of the 0.03mgdm⁻³ standard solution?

Fluorescence Intensity (FI)	Concentration / mgdm ⁻³
173.80	0.010
353.20	0.020
504.7	0.030
675.9	0.040
850.2	0.050

Sample Data

FI

multi-vitamin sample	999.9
	998.9
	999.7.
Diluted sample	313.2
	312.3
	314.1.

(15 marks)

Q3. Attempt **three** of the following

- (i) Provide a labelled sketch of a typical monochromator.
- (ii) Illustrate, with a well labelled diagram, the conductimetric titration curve obtained when a strong acid is titrated against a strong base. Detail the ions responsible for the conductivity before, at and after the endpoint of the titration. Show on your graph how the endpoint is determined.
- (iii) Explain the letters ISE. Name the four common types. List five particulars of ISE's. Comment on their reliability.
- (iv) (a) Analytical methods are classified according to sample size. Reproduce the follow table completed in your answer book.

Method	Sample Weight	Sample Volume
Macro		
Semi-micro		
Micro		
Ultra-micro		

- (b) How are constituents in a sample Classified?
- (c) Detectors are ranked using the following terms, sensitivity stability, linearity, universality and selectivity. Explain three of these terms.
- (v) Determine the volume required, in cm^3 , of concentrated sulphuric acid (H_2SO_4) 94% (g/100g solution), density 1.831 gcm^{-3} , to prepare 500cm^3 of a $0.100 \text{ mol dm}^{-3}$ solution. (25 marks)

- Q4.** (i) Explain the following chromatographic terms mobile phase; stationary phase; elution; retardation factor; solvent front.
- (ii) Compare and contrast Adsorption and Partition Chromatography under the following headings:
- (a) separation mechanism (diagrams required)
 - (b) typical mobile and stationary phases
 - (c) type of sample/compound most suited to the mechanism.
- (iii) List and explain briefly four factors which influence the ability of a chromatography column to resolve components of a mixture. (25 marks)

Q5. (i) Identify **three** conditions which, must be observed, when applying Beer's Law. Write a brief explanation on each.

(ii) Deviations from Beer's Law are related to:

(a) the concentration of the solution under investigation

and / or

(b) the quality of the instrument resulting in radiation problems.

Identify and discuss briefly **two** deviations, (one under each heading), from Beer's Law.

(iii) A solution containing 2.00 mg of sodium in 200mL of water was observed to transmit 30% of the incident radiation compared to the appropriate blank.

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

(b) What % of light would be transmitted by a solution twice as concentrated?

(c) What is the concentration in mol dm⁻³? (25 marks)