



COLLEGE OF SCIENCE, TECHNOLOGY AND APPLIED ARTS OF TRINIDAD AND TOBAGO

School of Nursing, Health and Environmental Sciences DEPARTMENT OF NATURAL & LIFE SCIENCES

**“Transforming Lives, Transforming Communities, Transforming the Nation... One Student at a Time
CHEM 210: ANALYTICAL CHEMISTRY**

VISION:

To be a student-centered, dynamic and innovative, world-class and multi-campus college, promoting excellence in teaching and learning, serving diverse communities and producing lifelong learners who can compete globally.

MISSION:

To be the premier educational institution in: providing high quality, affordable and accessible education programmes serving the needs of business, industry and the diverse campus communities and facilitation the personal and professional development of its students, faculty and staff.

The Institution’s motto “Transforming Lives, Transforming Communities, Transforming the Nation... One Student at a Time.” is embodied in our Core Curriculum as well as Programme Curriculum through ten competencies which students will understand, practice and demonstrate upon successful completion of their programmes of study at the College. These competencies are as follows:

Programme Curriculum Competencies
KNOWLEDGE
A clear understanding of the principles and concepts of related theories and models of the particular discipline and the relationship to other disciplines through study, education and experience.
EFFECTIVE COMMUNICATION
The ability to accurately transfer thoughts and meaning through interpersonal skills using appropriate registers.
ANALYTICAL ABILITY
The ability to systematically gather relevant data and make appropriate deductions, inferences and connections with a view to judiciously solve problems.
TECHNOLOGICAL EXPERTISE
Utilization of current tools and techniques with the view to achieving efficiency and improving functionality.
COLLABORATION
Proficiency in working cohesively with other stakeholders with the view to achieving common goals.
CREATIVITY
The ability to explore issues and generate solutions from an innovative perspective.
PROFESSIONALISM
A life-long engagement in reflective, moral, ethical and best practices in all spheres.
DIVERSITY
The ability to recognize and respect uniqueness, worth and dignity of others whilst developing one’s own belief system.
SOCIAL AND GLOBAL RESPONSIBILITY
A conscientious approach that reflects social and global accountability, commitment, caring and integrity.
ENTREPRENEURSHIP
The ability to recognize and take advantage of legitimate opportunities for innovation and social improvement, whilst accepting the related risks.

Course Code:	CHEM 210
Course Title:	Analytical Chemistry
Number of Credits:	3
Semester:	2
Track:	
Co-requisites:	
Prerequisite:	General Chemistry II (Grade C and above)
Prerequisite for:	
Number of Contact Hours:	45 (Class) + 9 (Lab)
Delivery:	Learning is accomplished through a combination of face to face teaching and practical experiences supported by resources on the e-classroom
Instructor:	
Office:	
Office Hours:	
Telephone:	
Email:	

COURSE DESCRIPTION AND GOAL:

The course teaches the fundamental concepts of analytical chemistry. Topics include statistical treatment of data, laboratory techniques, advanced concepts of equilibrium (solubility, acid-base, complex ion, and electrochemical), gravimetric analysis, titration methods, volumetric analysis, spectrophotometric analysis, and chromatographic analysis.

The competencies addressed in this course are **Knowledge** at the **Immersion** and **Intermediate** levels, **Effective Communication** at the **Intermediate** level, **Analytical Ability** at the **Immersion**, **Intermediate** and **Advanced** levels, **Technological Expertise** at the **Intermediate** level, **Professionalism** at the **Intermediate** level and **Creativity** at the **Intermediate** level. The general objectives for this course are listed by Competency:

General Objectives for Analytical Chemistry

KNOWLEDGE

Immersion Level: **Demonstrates comprehension of the relevant and significant ideas across disciplines and can make comparisons and draw conclusions about them.**

Students should be able to:

- K1.** Summarize the role of an analytical chemist
- K2.** Interpret the terminology associated with analytical chemistry
- K3.** Outline and justify the use of specific analytical techniques and laboratory equipment
- K4.** Justify the diverse storage methods for different chemicals

Intermediate Level: **Makes connections between disciplinary content and professional expectations.**

Students should be able to:

- K5.** Explain the difference between qualitative and quantitative analysis

EFFECTIVE COMMUNICATION

Intermediate Level: **Selects, adapts, and combines communication strategies in relation to disciplinary frameworks and theories.**

Students should be able to:

E1. Use Standard English to write logical and concise essays in Analytical Chemistry using labeled diagrams, equations, and calculations to support answers.

ANALYTICAL ABILITY

Immersion Level: **Analyses structures and organizations and perceives and makes relationships.**

Students should be able to:

A1. Recognize the correct laboratory procedures and chemicals for chemical analyses

Intermediate Level: **Articulates problem solving processes and practices using disciplinary problem solving processes to approach problems.**

Students should be able to:

A2. Solve calculations using experimental data to obtain necessary values

Advanced Level: **Independently analyzes, selects, uses and evaluates various approaches to develop solutions and transfer understanding to professional frameworks, integrating them with personal perspectives.**

Students should be able to:

A3. Evaluate the effectiveness of storage methods for different chemicals

A4. Evaluate the effectiveness of different methods of quantitative analysis for specified tasks

A5. Evaluate the errors associated with a specified analytical process

TECHNOLOGICAL EXPERTISE

Intermediate Level: **Displays positive attitudes towards technology uses and independently selects appropriate tools that support productivity, collaboration, learning and personal pursuits.**

Students should be able to:

T1. Design and carry out quantitative analyses using the UV spectrophotometer

T2. Design quantitative analyses using other spectroscopic instruments- IR, Mass, AAS, AFS

T3. Carry out gravimetric and titrimetric analyses with a high level of accuracy

PROFESSIONALISM

Intermediate Level: **Demonstrates applications of best practices across disciplines.**

Students should be able to:

P1. Adhere rigidly to a strict code of ethics regarding the quality and integrity of results from quantitative analyses which they have performed

COLLABORATION

Entry Level: **Engages in collaboration when learning across disciplines.**

Students should be able to:

C1. Work in a group to solve calculation type problems

Immersion Level: **Student initiates cooperative learning activities by seeking out others for assistance and for building projects together and acts as an active facilitator.**

Students should be able to:

C2. Work in groups to gather, present and explain material pertaining to specific course topics

Intermediate Level: **Student values and incorporates others' ideas and other points of view and recognizes there is power in combining ideas.**

Students should be able to:

C3. Work in groups on topic specific research projects.

CREATIVITY

Intermediate Level: **Develops new ways to approach content and convey novel findings that demonstrate imaginative capacities.**

Students should be able to:

Cr1. Use existing procedures to design unique quantitative analyses

WEEKLY CLASS SCHEDULE AND TEACHING OBJECTIVES

Key:

Competency

K= Knowledge
 E= Effective Communication
 A = Analytical Ability
 T= Technological Expertise
 P= Professionalism
 C= Collaboration
 Cr= Creativity

Levels

En = Entry
 Im =Immersion
 It = Intermediate
 Ad = Advanced

Week	Unit	Content	Specific Objectives and Activities	Competency	Level
1	Unit 1 - Introduction to Analytical Chemistry	<ul style="list-style-type: none"> • Qualitative analysis, Quantitative analysis & Analytes • The role of analytical chemistry • Quantitative analytical methods • The use of Microsoft Excel in analytical chemistry 	<p>Students should be able to:</p> <ol style="list-style-type: none"> 1. Define and differentiate the following terms: Qualitative analysis, Quantitative analysis & Analytes 2. Define the role of analytical chemistry 3. Define quantitative analytical methods 4. Define the following terms: Heterogeneous materials, an assay, Replicate samples, Interference, Specific and Selective techniques and reactions, sample matrices and calibration 5. Discuss the process of quantitative analysis <p>Activities: READ:</p> <ol style="list-style-type: none"> 1. Fundamentals of Analytical Chemistry (8th Edition) – Chapter 1: The Nature of Analytical Chemistry, pages 2 - 16 <p>DISCUSS:</p> <ol style="list-style-type: none"> 1. A typical quantitative analysis – choosing a method, acquiring the sample, processing the sample, eliminating interferences, calibrating and measuring concentration, calculating results, evaluating results by estimating their reliability. <p><u>ASSIGNMENT 1 [10% of Assignment Mark]</u> CONSTRUCT (in groups of three to present to class):</p> <ol style="list-style-type: none"> 1. A flow diagram to show the steps involved in a typical quantitative analysis. 	<p>K2</p> <p>K1</p> <p>K2</p> <p>K2</p> <p>K2, K3, K5</p> <p>K1, K2, K3, K5</p> <p>K1, K2, K3, K5</p> <p>K1, K2, K3, K5, E1, C2</p>	<p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>Im, Im, It</p> <p>Im, Im, Im, It</p> <p>Im, Im, Im, It</p> <p>Im, Im, It, Im</p>

Week	Unit	Content	Specific Objectives and Activities	Competency	Level
2	Unit 2 - Operations of Analytical Chemistry (Chemicals, Apparatus & Units) and Calculations	<ul style="list-style-type: none"> The rules for handling reagents and solutions The cleaning and marking laboratory ware The Concentration of liquids Avogadro's Law Relationship between mole, particles & volumes. 	<p>Students should be able to:</p> <ol style="list-style-type: none"> Define and classify the following: reagent grade, Primary-Standard Grade and Special- Purpose Reagent Chemicals Describe the selection and handling of chemicals Outline the treatment of laboratory ware and liquid evaporation Describe the analytical balance and the following types of balances: macrobalance, semimicroanalytical balance, microanalytical balance Distinguish between the other types of analytical balances: Electronic, Single-Pan Mechanical and Auxiliary Analytical balances Describe the precautions and sources of errors in weighting Describe the equipment and procedures used in weighting, filtering and ignition Outline the units, apparatus and procedures used in measuring volume Use SI units of measurement and differentiate between mass (m) and weight (w) Distinguish between moles and millimoles Solve calculations using the amount of moles and millimoles Solve calculations converting between moles and millimoles Define concentration, density and specific gravity of a solution 	<p>K2</p> <p>K4</p> <p>K2</p> <p>K3</p> <p>K3</p> <p>K3</p> <p>K3</p> <p>K3</p> <p>A1</p> <p>K2</p> <p>A2</p> <p>A2</p> <p>K2</p>	<p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>It</p> <p>It</p> <p>Im</p>

			<p>14. Define and differentiate between the follow terms stoichiometry, empirical formulas, molecular formulas and structural formulas</p> <p>15. Solve calculations using stoichiometric values for mass, moles and concentration.</p> <p>Activities: READ:</p> <ol style="list-style-type: none"> Fundamentals of Analytical Chemistry (8th Edition) – Chapter 2: Chemicals, Apparatus, and Unit Operations in Analytical Chemistry, pages 20 – 53 & Chapter 4: Calculations Used in Analytical Chemistry, pages 71 - 89 <p>VIEW:</p> <ol style="list-style-type: none"> Weighing on an Analytical Balance, A Chemistry Lab Demo From Thinkwell – Thinkwell Video Tutorials http://www.youtube.com/watch?v=dNeNBx8nAyQ <p>DISCUSS:</p> <ol style="list-style-type: none"> The precautions and sources of errors in weighting The equipment and procedures used in weighting, filtering and ignition <p><u>ASSIGNMENT 2 [5% of Assignment Mark]</u> CALCULATE (in groups of three):</p> <ol style="list-style-type: none"> Worksheet on molar calculations <p><u>ASSIGNMENT 3 [5% of Assignment Mark]</u> CONSTRUCT ((in groups of three to present to class):</p> <ol style="list-style-type: none"> A electronic copy of a poster on safety in the laboratory <p><u>GROUP PROJECTS</u> Assignment of Group Projects. Due date: Week 14.</p>	<p>K2</p> <p>A2</p> <p>K2, K3, K4</p> <p>K2, A1</p> <p>K2, A1 K2, A1</p> <p>A2, C1</p> <p>K2, K3, K4, E1, C2</p> <p>A1-A5 (dependent on topic) E1, T1-T3, P1, C3, Cr1</p>	<p>Im</p> <p>It</p> <p>Im, Im, Im</p> <p>Im, It</p> <p>Im, It Im, It</p> <p>It, En</p> <p>Im, Im, Im, It, Im</p> <p>Im/It/Ad, It, It, Ad, It, It, It, It</p>
Week	Unit	Content	Specific Objectives and Activities	Competency	Level

3 & 4	Unit 3 - Chemical Equilibria	<ul style="list-style-type: none"> • Definitions with appropriate examples • The chemical compositions of aqueous solutions • The chemical equilibrium in a system • Calculations involving pH of a buffering system and the use of the basic formula • Review of mass-balance equation and charge balance equation • The solubility of different systems • The effect of pH and undissociated solute on precipitation and the effect of the solubility of the precipitates in association of a complexing agent 	<p>Students should be able to:</p> <ol style="list-style-type: none"> 1. Define the following: Electrolytes, Acid and Bases, Amphiprotic Species, Autoprotolysis, Strength of Acids and Bases 2. Define the equilibrium state, equilibrium-constant expression and the different types of equilibrium-constant observed in analytical chemistry 3. Solve calculations involving Ion-product constant of water, Solubility-product constant and Acid-base dissociation constant 4. Calculate pH of a buffer solution and appreciate the properties of a buffer solution 5. Solve the multiple-equilibrium problem using the systemic method 6. Use the systematic method to calculate solubility 7. Solve calculations involving the separation of ions by controlling the concentration of the precipitating agent <p>Activities:</p> <p>READ:</p> <ol style="list-style-type: none"> 1. Fundamentals of Analytical Chemistry (8th Edition) – Chapter 9: Aqueous Solutions and Chemical Equilibria, pages 225 – 266 <p>VIEW:</p> <ol style="list-style-type: none"> 1. Buffer Solutions – pH of a buffer – James Mungall Chemistry Tutorials http://www.youtube.com/watch?v=hWkXoHqHyfs <p>DISCUSS:</p> <ol style="list-style-type: none"> 1. The systemic method to solve the multiple-equilibrium problem 2. The separation of ions by controlling the concentration of the precipitating agent 	<p>K2</p> <p>K2</p> <p>A2</p> <p>A2</p> <p>A2</p> <p>A2</p> <p>A2</p> <p>K2</p> <p>A2</p> <p>A2</p> <p>A2</p>	<p>Im</p> <p>Im</p> <p>It</p> <p>It</p> <p>It</p> <p>It</p> <p>It</p> <p>Im</p> <p>It</p> <p>It</p> <p>It</p>
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Week	Unit	Content	Specific Objectives and Activities	Competency	Level
5	Unit 4 - Gravimetric Methods of Analysis	<ul style="list-style-type: none"> • Introduction to gravimetric analysis • Precipitation gravimetry • Calculations and examples of results from gravimetric data • Application of gravimetric method 	<p>ASSIGNMENT 4 [10% of Assignment Mark] CALCULATE (in groups of three):</p> <ol style="list-style-type: none"> 1. Worksheet on chemical equilibria <p>Students should be able to:</p> <ol style="list-style-type: none"> 1. Define the term gravimetric methods 2. Outline the concept of precipitation gravimetry 3. Summarize the properties of precipitates and precipitating agent 4. Explain the effect of particle size on the filterability of precipitates, colloidal precipitates and crystalline precipitates 5. Describe the precipitation of homogenous solution 6. Explain the drying and ignition of precipitates 7. Solve calculations from gravimetric data 8. Outline the application of gravimetric methods <p>Activities: READ:</p> <ol style="list-style-type: none"> 1. Fundamentals of Analytical Chemistry (8th Edition) – Chapter 12: Gravimetric Methods of Analysis, pages 311 – 336 <p>VIEW:</p> <ol style="list-style-type: none"> 1. Chemistry: Gravimetric Analysis – Mindbites.com http://www.youtube.com/watch?v=DqkJ6XftSa8 <p>DISCUSS:</p> <ol style="list-style-type: none"> 1. Applications of gravimetric analysis <p>ASSIGNMENT 5 [5% of Assignment Mark] CALCULATE (in groups of three):</p> <ol style="list-style-type: none"> 1. Worksheet on gravimetric analysis <p>ASSIGNMENT 6 [5% of Assignment Mark]</p>	<p>A2, C1</p> <p>K2</p> <p>K2</p> <p>K2</p> <p>K3</p> <p>K3</p> <p>K3</p> <p>A1</p> <p>K3, K5, A4</p> <p>K2, K3, K5</p> <p>K3, K5</p> <p>K3, K5</p> <p>A2, C1</p>	<p>It, En</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>It</p> <p>Im, It, Ad</p> <p>Im, Im, It</p> <p>Im, It</p> <p>Im, It</p> <p>It, En</p>

Week	Unit	Content	Specific Objectives and Activities	Competency	Level
			WRITE (individually): 1. Design a lab procedure to determine % purity using a gravimetric method	E1, A4, Cr1	It, It, It
6	Unit 5 - Titrimetric Method; Precipitation Titrimetry	<ul style="list-style-type: none"> Explanation of titrimetric method The role of the standard solution Volumetric calculations Gravimetric titrimetry Determination of titration curves in the titrimetric method. 	<p>Students should be able to:</p> <ol style="list-style-type: none"> 1. Explain titrimetric analysis 2. Define the following terms: titrimetry, volumetric titrimetry, coulometric titrimetry 3. Define the following terms: standard solution, back-titration, equivalence point, end point, primary solution, secondary solution 4. Solve standard solution calculations and volumetric calculations 5. Solve gravimetric titrimetry calculations 6. Use titration curves in titrimetric method 7. Describe precipitation titrimetry 8. Solve calculations involving titrimetric analysis <p>Activities: READ: 1. Fundamentals of Analytical Chemistry (8th Edition) – Chapter 13: Titrimetric Methods; Precipitation Titrimetry, pages 337 – 367</p> <p>VIEW: 1. 11. Titration techniques and standard solutions (HSC chemistry) – Lets Learn Science http://www.youtube.com/watch?v=Lf7H83ryrII 2. Acid Base Titration – Khan Academy http://www.youtube.com/watch?v=XjFNmfLv9_Q</p> <p>DISCUSS: 1. The terms associated with titrations</p>	K3 K2 K2 A2 A2 A2 A2 A2 K2, K3 K2, K3 A2 K2	Im Im Im It It It It Im, Im Im, Im It Im

			<p>CALCULATE (in groups of three):</p> <ol style="list-style-type: none"> Worksheet on Titrations <p><u>ASSIGNMENT 7 [10% of Assignment Mark]</u></p> <p>WRITE (individually):</p> <ol style="list-style-type: none"> Design a lab procedure to determine % purity using a titrimetric method 	A2, C1	It, En
7	MIDTERM ASSESSMENT 1: UNITS 1 – 4 (15%) - See Appendix 1 for Table of Specifications				
Week	Unit	Content	Specific Objectives and Activities	Competency	Level
7	Unit 6 – Titration, neutralization, complex acid/bases system, application of neutralization	<ul style="list-style-type: none"> Acid/base titrations Titration curves Polyfunctional acids and bases Equilibrium concentration constant, acid/base & water equilibrium constant Neutralization titrations and application of neutralization Formation of complexes and titration Calculations involving equilibrium constants Application of Acid-base titrations 	<p>Students should be able to:</p> <ol style="list-style-type: none"> Describe the solution and indicators used in acid/base titrations Describe the titration of strong acid and bases Distinguish between the titration curves for weak acids Distinguish between the titration curves for weak bases Explain the composition of solutions during acid/base titration Identify components in mixtures of strong and weak acids or strong and weak bases Define polyfunctional acids and bases Describe buffering solutions involving polyfunctional acids and bases Explain the titration curve for polyfunctional acids Explain the titration curves for polyfunctional bases Explain the titration curves for amphoteric species Relate the composition of solution of a polyprotic acid to pH Discuss reagents used for neutralization titrations and application of neutralization titrations for the following: elemental analysis, inorganic substances organic 	<p>K2</p> <p>K3</p> <p>K3</p> <p>K3</p> <p>K3</p> <p>K3</p> <p>K2</p> <p>K2</p> <p>K3</p> <p>K3</p> <p>K3</p> <p>A2</p> <p>K3</p>	<p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p>

			<p>functional group and salts</p> <p>14. Discuss the formation of complexes and titration with inorganic complexing agent</p> <p>15. Discuss the use of organic complexing agent and aminocarboxylic acid titration (EDTA)</p> <p>Activities: READ:</p> <ol style="list-style-type: none"> Fundamentals of Analytical Chemistry (8th Edition) – Chapter 12: Principles of Neutralization Titrations, pages 368 – 394 <p>VIEW:</p> <ol style="list-style-type: none"> Chemistry: Acid-Base Titrations – MindBites.com http://www.youtube.com/watch?v=ISYZW3d-02w Calcium-EDTA Titration – C. R. Harrison http://www.youtube.com/user/crharrison <p>DISCUSS:</p> <ol style="list-style-type: none"> The different types of titration curves Neutralization titrations – reagents and applications The formation of complexes and the use of organic complexing agents <p><u>ASSIGNMENT 8 [10% of Assignment Mark]</u> CALCULATE (in groups of three):</p> <ol style="list-style-type: none"> Worksheet on Titration Calculations 	<p>K3</p> <p>K3</p> <p>K2, K3</p> <p>K2, K3</p> <p>K3</p> <p>K3</p> <p>K3</p> <p>K3</p> <p>A2, C1</p>	<p>Im</p> <p>Im</p> <p>Im, Im</p> <p>Im, Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>It, En</p>
Week	Unit	Content	Specific Objectives and Activities	Competency	Level
8	Unit 7 – Spectrochemical Analysis	<ul style="list-style-type: none"> The principle of electromagnetic radiation. The instruments used for optical spectrometry The use of flow diagram to represent the different types of instruments 	<p>Students should be able to:</p> <ol style="list-style-type: none"> Explain the properties of electromagnetic radiation Explain the interaction of radiation and matter Explain radiation absorption and the processes involved Demonstrate of the limits of Beer's law Explain the emission of electromagnetic radiation 	<p>K3</p> <p>K3</p> <p>K3</p> <p>A2</p> <p>K3</p>	<p>Im</p> <p>Im</p> <p>Im</p> <p>It</p> <p>Im</p>

			<p>6. Describe the instrument used in optical spectrometry including: optical materials, spectroscopic sources, wavelength selectors, detecting and measuring radiant energy, signal processors and readout</p> <p>7. Discuss the ultraviolet-visible photometers and spectrophotometers using a single, double instruments and the multichannel instrument</p> <p>8. Discuss the use of infared spectrometers</p> <p>Activities: READ:</p> <ol style="list-style-type: none"> Fundamentals of Analytical Chemistry (8th Edition) – Chapter 24: Spectrochemical Analysis, pages 707 – 743 <p>VIEW:</p> <ol style="list-style-type: none"> Spectrophotometry Introduction – Khan Academy http://www.youtube.com/watch?v=qbcZbP6_j48 Spectrophotometer – Beer’s Law and Colorimetry Lab - Rene Rafael Vogt-Lowell http://www.youtube.com/watch?v=RcKn3uD3Z9Y <p>DISCUSS:</p> <ol style="list-style-type: none"> The instrument used in optical spectrometry Ultraviolet-visible photometers and spectrophotometers The use of infared spectrometers <p><u>ASSIGNMENT 9 [5% of Assignment Mark]</u> CALCULATE (in groups of three):</p> <ol style="list-style-type: none"> Worksheet on Spectrochemical Analysis <p><u>ASSIGNMENT 10 [5% of Assignment Mark]</u> CONSTRUCT (in groups of three to present to class):</p> <ol style="list-style-type: none"> A flow diagram to represent the different types of instruments 	<p>K3</p> <p>K3</p> <p>K3</p> <p>K3</p> <p>A2</p> <p>K3</p> <p>K3</p> <p>K3</p> <p>A2, C1</p> <p>K3, E1, C2</p>	<p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>It</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>It, En</p> <p>Im, It Im</p>
Week	Unit	Content	Specific Objectives and Activities	Competency	Level
9	Unit 8 - Molecular Absorption Spectrometry	<ul style="list-style-type: none"> Ultraviolet and visible molecular spectroscopy Effect of instrumental uncertainties and 	<p>Students should be able to:</p> <ol style="list-style-type: none"> Describe ultraviolet and visible molecular spectroscopy Describe the absorbing species and the qualitative and 	<p>K3</p> <p>K3</p>	<p>Im</p> <p>Im</p>

			4. The application of flow injection analysis 5. Infrared absorption spectroscopy <u>ASSIGNMENT 11 [5% of Assignment Mark]</u> CALCULATE (in groups of three): 1. Worksheet on molecular absorption spectrometry <u>ASSIGNMENT 12 [5% of Assignment Mark]</u> WRITE (individually): Design of lab procedure for determination of concentration of an unknown using calibration curves	K3 K3 A2, C2 E1, A2, A4, A5, Cr1	Im Im It, Im It, It, Ad, Ad It
Week	Unit	Content	Specific Objectives and Activities	Competency	Level
10	Unit 9 - Molecular Absorption Spectroscopy	<ul style="list-style-type: none"> Molecular fluorescence. The fluorescence instrument and the application of the instrument Molecular phosphorescence spectroscopy 	Students should be able to: <ol style="list-style-type: none"> Explain the theory of molecular fluorescence Describe relaxation processes and fluorescence species Outline the effect of concentration on fluorescence Discuss the fluorescence instruments Discuss the applications of fluorescence method Explain molecular phosphorescence spectroscopy Illustrate the use of chemiluminescence method <p>Activities: READ:</p> <ol style="list-style-type: none"> Fundamentals of Analytical Chemistry (8th Edition) – Chapter 26: Molecular Absorption Spectrometry, pages 784 – 824 <p>VIEW:</p> <ol style="list-style-type: none"> Time Resolved Fluorescence Spectrometer : The FLS920 with TCSPC – Edinburg Instruments http://www.youtube.com/watch?v=-tlp_mqPbiM <p>DISCUSS:</p> <ol style="list-style-type: none"> Fluorescence instruments Application of fluorescence method 	K3 K3 K3 K3 K3 K3 K3 A1, A2 K3 K3 K3 K3	Im Im Im Im Im Im Im Im, It Im Im Im Im

Week	Unit	Content	Specific Objectives and Activities	Competency	Level
			ASSIGNMENT 13 [10% of Assignment Mark] CALCULATE (in groups of three): 1. Worksheet on molecular absorption spectroscopy	A2, C1	It, En
11	Unit 10 - Atomic Spectroscopy	<ul style="list-style-type: none"> Atomic spectroscopy The different types of atomizers The instrumentation used in atomic emission spectrometry Sources of interferences in the plasma and flame atomic emission spectroscopy Atomic absorption spectrum and the instrument used 	<p>Students should be able to:</p> <ol style="list-style-type: none"> Define atomic spectroscopy Summarize the origins of optical spectra Outline the mass spectra Discuss the production of atoms and ions using sample introduction system atomizers, plasmasources atomizer, flame atomizer, electrothermal atomizers Discuss atomic emission spectrometry Explain atomic absorption spectrometry Illustrate the use atomic fluorescence spectrometry Discuss atomic mass spectrometry <p>Activities: READ:</p> <ol style="list-style-type: none"> Fundamentals of Analytical Chemistry (8th Edition) – Chapter 28: Atomic Spectroscopy, pages 839 – 873 <p>VIEW:</p> <ol style="list-style-type: none"> Atomic Spectra - Atomic Emission Spectroscopy – Bryan Sanctuary http://www.youtube.com/watch?v=AfvVQsLdUAW AAS Instructional Video – Wagtech International Limited http://www.youtube.com/watch?v=cnuECrdGV2k <p>DISCUSS:</p> <ol style="list-style-type: none"> The production of atoms and ions using sample introduction system atomizers, plasmasources atomizer, flame atomizer, electrothermal atomizers Atomic emission spectrometry, atomic absorption 	<p>K3</p> <p>K3</p> <p>K3</p> <p>K3</p> <p>K3</p> <p>K3</p> <p>A1, A2</p> <p>K3</p> <p>K3</p> <p>K3</p> <p>K3</p> <p>A1, A2</p> <p>K3</p> <p>K3</p>	<p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>Im</p> <p>Im, It</p> <p>Im</p> <p>Im</p> <p>Im, It</p> <p>Im</p> <p>Im</p>

			<p>spectrometry, atomic fluorescence spectrometry, atomic mass spectrometry</p> <p>ASSIGNMENT 14 [10% of Assignment Mark] CALCULATE (in groups of three):</p> <ol style="list-style-type: none"> Worksheet on molecular absorption spectroscopy 	A2, C1	Im, En
12	MIDTERM ASSESSMENT 1: UNITS 5 – 9 (15%) - See Appendix 1 for Table of Specifications				
Week	Unit	Content	Specific Objectives and Activities	Competency	Level
13	Unit 11 - Errors and Statistical treatment of data	<ul style="list-style-type: none"> Different types of errors Methods of estimating accuracy and precision Sources of error 	<p>Students should be able to:</p> <ol style="list-style-type: none"> Give examples of errors in chemical analysis Define the following terms: errors, ppm, replication, mean, medium precision, accuracy, absolute error and relative errors Use and the formulas for the following: mean, medium, precision, accuracy involving absolute error and relative error Identify the types of errors in experimental data Define the following terms: random/interdetermine errors, systematic errors, gross errors Identify systematic errors involving instrumental and method error Identify the effect of systematic errors on analytical result <p>Activities: READ:</p> <ol style="list-style-type: none"> Fundamentals of Analytical Chemistry (8th Edition) – Chapter 5: Errors in Chemical Analyses, pages 90 – 104 & Chapter 6: Random Errors in Chemical Analysis, pages 105 - 141 <p>VIEW:</p> <ol style="list-style-type: none"> Chem Basics - Uncertainty and errors of a measurement College & AP Chemistry Tutorial 20 - igetCHEM http://www.youtube.com/watch?v=qzfs1Z4Aec0 Chemistry – Precision & Accuracy – MindBites.com 	<p>K2</p> <p>K2</p> <p>A2</p> <p>A5</p> <p>K2</p> <p>A5</p> <p>A2, A4</p> <p>K2</p> <p>A4, A5</p> <p>A4, A5</p>	<p>Im</p> <p>Im</p> <p>It</p> <p>Ad</p> <p>Im</p> <p>Ad</p> <p>It, Ad</p> <p>Im</p> <p>Ad, Ad</p> <p>Ad, Ad</p>

			http://www.youtube.com/watch?v=-7rzmMUEaW8 DISCUSS: <ol style="list-style-type: none"> 1. The use and the formulas for the following: mean, medium, precision, accuracy involving absolute error and relative error 2. The types of errors in experimental data 3. Systematic errors involving instrumental and method error and their effect of systematic errors on analytical result CALCULATE (in groups of three): <ol style="list-style-type: none"> 1. Worksheet on statistical treatment of data CONSTRUCT (in groups of three to present to class): <ol style="list-style-type: none"> 1. A concept map of the errors in chemical analyses and their effects and detection 	 K2 K2 A2, A4, A5 A2, C1 K2, C2	 Im Im It, Ad, Ad It, En Im, It
14	PROJECT PRESENTATIONS – See Appendix II for Rubric				
15	TUTORIAL				
16	FINAL EXAMINATION: UNITS 1 – 11 (40%) - See Appendix 1 for Table of Specifications				

For this course, the following grading scheme will be used:

Grading system used in AAS for Chemistry			
Mark Range	Definitions	Grade	GPA
90 - 100	Excellent	A	4.0
85 - 89	Very good	B+	3.5
80 - 84	Good	B	3.0
75 - 79	Satisfactory	C+	2.5
70 - 74	Average	C	2.0
65 - 69	Below average	D+	1.5
60 - 64	Minimum passing grade	D	1.0
0 - 59	Fail	F	0.0

The mark allocation for this course will be broken down as follows:

Mark Allocation system used for Analytical Chemistry	
2 In-course exams at 15% each See Appendix I for Table of Specifications	30 %
Project See Appendix II for Rubric	10%
Assignments See Appendix III for Rubric	10 %
Laboratory performance and Reporting An 80% attendance of Labs is expected for all Science courses. Labs will be assessed based on Manipulation skills, Analytical Skills, Observation skills, Reporting and Calculations. Students are expected to adhere to safety precautions outlined in the Laboratory manual, with special attention to appropriate lab wear (Lab coats and covered shoes.) Students are further expected to be cognizant of the mark penalty for late submission of lab reports and exercises, where two (2) marks per day will be deducted for late assignments. Students are required to submit an explanatory letter and a medical certificate should illness prevent timely completion of an assignment. See Appendices IV - VI for Rubrics	10 %
Final Examination See Appendix I for Table of Specifications	40 %

Please note: Any late assignments that are not delivered directly to the lecturer must be deposited with the Programme Assistant and signed for in the register. Assignments that are not submitted in the format designated by the lecturer will not be graded.

STATEMENT ON ACADEMIC DISHONESTY

“Academic dishonesty is unacceptable and will not be tolerated. Cheating, forgery, plagiarism and collusion in dishonest acts undermine the College’s educational mission and the student’s personal and intellectual growth. COSTATT students are expected to bear individual responsibility for their work and to uphold the ideal of academic Integrity. Any Student who attempts to compromise the academic process will be sanctioned.”

- COSTAATT Academic, Integrity and Honesty Policies and Procedures Handbook.

A QUICK NOTE ON CITATION

Plagiarism is the representation of someone else’s ideas or words as one’s own. It is a serious academic offence that includes:

- Presenting another person’s paper or ideas as original, submitting borrowed, purchased, ghost-written papers and documents downloaded from internet sites.
- Extensive paraphrasing
- Flagrant failure to properly cite sources. This includes uncited ideas, quotations and/or words.

Students are expected to implement the methods taught in COMM117, COMM118 and LIBS130 and should be cognizant of the fact that credit will not be given for work found to be plagiarized. Repeated incidents of plagiarism will result in a failing grade and/or academic sanction.

COSTAATT requires students to adhere to the APA (American Psychology Association) citation standards that require in text citation and a reference list. Details of these requirements are as follows:

- In text citation (Quotes/Paraphrasing)
 - Direct quotation
 - Use quotation marks and include page numbers (when quoting books, journals and periodicals) or paragraph number (para. when quoting online sources).
 - A quotation of 40 or more words should be formatted as a freestanding, indented block of text without quotation marks.
 - Indirect quotation/paraphrasing
 - Citations from a secondary source

- References list
 - At the end of an assignment, the full bibliographic information for each source cited in text should be provided. *Do not use footnotes*
 - References must be listed in alphabetical order by author and should use the hanging indent format.
- Books / Reports / DVDs
 - Each reference should include four elements:
 - Author/Editor/Producer
 - Date
 - Title
 - Publication Information
- Periodicals -Serials or periodicals are resources published on a regular basis, such as journals, magazines and newspapers. The elements to be included are:
 - Author(s)
 - Date
 - Title of article
 - Title of Periodical
 - Volume, Issue and Page numbers
- Webpages (unpublished and informally published work) Reference to web page should include the following elements :
 - Author
 - Date
 - Title
 - Retrieval statement (URL)

THE TEACHING TEAM FOR THIS COURSE:

In addition to the lecturer, several people are responsible for the smooth and efficient running of this course. From time to time, a student will interact with one of the following people:

- **The Programme Assistant**

Students may leave messages for their lecturer with the Programme Assistant, including late lab submissions. The Programme Assistant also sets up appointments should a student wish to see the Department Chair.

- **Lab Lecturer**

In some courses, team teaching is performed where one lecturer is in charge of the theory component of the course and another, highly qualified lecturer teaches the laboratory component. This lecturer is additionally responsible for collecting and grading lab reports.

- **Lab Technicians:**

The Lab Technicians are highly capable individuals who are responsible for setting up labs, assisting with handling samples and equipment during labs and responsible for lab safety procedures and protocols. In case of an emergency, the Lab Technician and Lab Lecturer are responsible for your safety in the lab.

ESSENTIAL SUPPLIES

- Text books – students should walk with their text books to class and to labs.
- Lab manual – to be provided at the start of the lab component of each course.
- Appropriate Lab wear – slippers, flip-flops and open toed footwear are strictly prohibited in the Labs. Students are also expected to wear protective clothing in labs, for example a lab coat. For the safety of all concerned, the Lab Technician has the responsibility to deny a student access to the lab if they are improperly attired.

TEXTBOOKS:

Recommended Texts:

Analytical Chemistry: An Introduction (7th Edition)

Douglas A. Skoog

Donald M. West

F. James Holler

Stanley R. Crouch

REFERENCE TEXT:

Fundamentals of Analytical Chemistry (8th Edition)

Douglas A. Skoog

Donald M. West

F. James Holler

Stanley R. Crouch

AUDIO-VISUAL RESOURCES:

Multimedia Projector, Laptop with Microsoft Office Word, PowerPoint, Excel, Multimedia Player DVD drive, USB ports and Speakers.

COURSE COORDINATOR:

Ms. Romona Olton

Senior Lecturer

Department of Natural and Life Sciences

COSTAATT

Romona.olton@my.costaatt.edu.tt

DEPARTMENT CHAIR:

Ms. Delamae Wilson

Chair: Natural & Life Sciences Department

COSTAATT

Email: DWilson@costaatt.edu.tt

Appendix I-

Tables of Specifications for CHEM210 Midterms and Final Examination

Table of Specifications for CHEM210 Midterms I & II - 15% Each

Sections	Marks	Item Type	Competency	% Weighting	Comments
A	30	MCQ, T/F, Diagram labeling, Matching, Short Answer	Knowledge	30%	At least two different item types should be used in this section. No more than 20 marks should be allocated to MCQs in this section.
B	50	MCQ, T/F, Diagram labeling, Matching, Short Answer	Analytical Ability	50%	At least two different item types should be used in this section. No more than 10 marks should be allocated to MCQs in this section.
C	20	Essay Question	Analytical Ability	10%	A rubric is provided in the course outline to guide marking in this section (see Appendix VII).
			Effective Communication	10%	

Table of Specifications for CHEM210 Final Examination - 40%

Section	Marks	Item Type	Competency	% Weighting	Comments
A	30	MCQ, T/F, Diagram labeling, Matching, Short Answer	Knowledge	30	At least two different item types should be used in this section. No more than 20 marks should be allocated to MCQs in this section.
B	40	MCQ, T/F, Diagram labeling, Matching, Short Answer	Analysis	40	At least two different item types should be used in this section. No more than 10 marks should be allocated to MCQs in this section.
C	20	Essay	Analysis	10	A rubric is provided in the course outline to guide marking in this section (see Appendix VII).
			Effective Communication	10	
D	10	Diagram labeling, short answer, matching	Technical Expertise	10	This question must test, at the appropriate level, topics related to those covered in the laboratory aspect of the course.

Appendix II

Rubric for grading CHEM 210 Group Project

ORAL PRESENTATION					
Criteria	Weighting	Excellent	Good	Fair	Weak
Introduction	4	(4) Introduction is new, original and intelligent at a level appropriate to the audience.	(3) Gets audience attention immediately by starting with a statement/ relevant humour	(2) Makes the audience curious to hear about the topic	(1) Is underdeveloped and irrelevant
Clear and Logical Format of Presentation	4	(4) Demonstrates clear and logical sequencing that is comprehensive and detailed.	(3) Generally comprehensive and detailed. Small gaps in sequencing and detail.	(2) Examination of topic not very clear. Gaps in sequencing and no detail on contents.	(1) Shows confusion and disorder in sequencing of content. No structures and detail.
Information and Communication Technology Skills	4	(4) Student uses audio, video, pictures, clip art and other files to collaborate for the creation of an electronic product that effectively informs multiple audiences both inside and outside the college environment.	(3) Some of the audio, video, pictures, clip art and other files used were inappropriate and/or were not necessary.	(2) Most of the audio, video, pictures, clip art and other files used were inappropriate and/or were not necessary.	(1) No audio, video, pictures, clip art or other files were used.
Communication	4	(4) Fluent speech, engaging in clear dialogue and proficient use of English and correct grammar.	(3) Clarity maintained, only minor errors in English and grammar. Generally clear.	(2) Reasonable use of English. Some errors in fluency.	(1) Lacking in fluency. Major errors in English and grammar. Poor use of language.
Response to Questions	3	(3) Clear, articulate. Logical/demonstrates critical thinking. Response relevant to questions asked.	(2) Attempts to answer questions. Responses not completely relevant.	-	(1) No attempts to answer questions asked.
Timing	3	(3) Finished within 75 – 100% of the allocated time.	(2) Finished within a 50% deviation of the allocated time.	-	(1) Poor planning. Showed no consideration for time keeping.

WRITTEN REPORT

The written report should be typewritten using Times New Roman x12 font; double spaced; and printed on standard A4 or 8.5x 11 paper. The pages should be numbered and included in the table of contents. Reports that have been heavily plagiarized will not be marked.

Content	12	(12) All parts are included. No errors exist in the information.	(9) All parts are included. Minor errors exist in the information.	(6) One part is missing. Minor errors exist in the information.	(3) More than one part is missing. Minor errors exist in the information.
Organizational Skills	4	(4) Demonstrates clear and logical sequencing that is comprehensive and detailed.	(3) Generally comprehensive and detailed. Small gaps in sequencing and detail.	(2) Examination of topic not very clear. Gaps in sequencing and no detail on contents.	(1) Shows confusion and disorder in sequencing of content. No structures and detail.
Accuracy of Expression	4	(4) Makes virtually no grammatical, spelling or punctuation errors. Establishes credibility with the audience	(3) Makes few grammatical, spelling or punctuation errors.	(2) Makes a moderate number of grammatical, spelling or punctuation errors.	(1) Makes repeated grammatical, spelling or punctuation errors.
Aesthetics	4	(4) Diagrams, tables and figures so clear and understandable as to enhance report impact	(3) Diagrams, tables and figures are readable and understandable; style is acceptable	(2) Diagrams, tables and figures are sloppy and unclear	(1) No diagrams, tables or figures are included
GROUP SKILLS					
Group Skills	4	(4) Group members were able to work on the project and resolve group issues amongst themselves.	(3) Lecturer had to intervene one (1) time to help group members to resolve group issues.	(2) Lecturer had to intervene two (2) times to help group members to resolve group issues.	(1) Lecturer had to intervene more than twice to help group members to resolve group issues.
TOTAL / 50					
TOTAL / 100					

Name of Presenter(s) _____

Other Comments

Appendix III-

Rubric for grading CHEM 210 Class Assignments

ASSIGNMENT NUMBER	COMPETENCY	PERFORMANCE RANKING		
		EXCELLENT (8-10)	AVERAGE (5-7)	POOR (0-4)
1, 3 & 10	KNOWLEDGE (70%)	Students display a high level of knowledge as evidenced by accurate answers to most questions.	Students display a moderate level of knowledge as evidenced by accurate answers to some questions.	Students display a low level of knowledge as evidenced by accurate answers to few questions.
	EFFECTIVE COMMUNICATION (20%)	Students demonstrate clear and logical sequencing that is comprehensive and detailed. Makes virtually no grammatical, spelling or punctuation errors.	Students' report is generally comprehensive and detailed. Small gaps in sequencing and detail. Makes few grammatical, spelling or punctuation errors.	Students' examination of topic not very clear. Gaps in sequencing and no detail on contents. Makes a moderate number of grammatical, spelling or punctuation errors.
	COLLABORATION (10%)	The student is an active part of the class group and participates fully in class discussions and activities as directed by the lecturer.	The student is a fairly active part of the class group and participates in class discussions and activities as directed by the lecturer.	The student is not an active part of the class group and does not participate in class discussions and activities as directed by the lecturer.
2, 4, 5, 8, 9, 11, 13 & 14	ANALYTICAL ABILITY (70%)	Students display a high level of analytical ability as evidenced by accurate answers to most questions.	Students display a moderate level of analytical ability as evidenced by accurate answers to some questions.	Students display a low level of analytical ability as evidenced by accurate answers to few questions.
	COLLABORATION (30%)	The student is an active part of the class group and participates fully in class discussions and activities as directed by the lecturer.	The student is a fairly active part of the class group and participates in class discussions and activities as directed by the lecturer.	The student is not an active part of the class group and does not participate in class discussions and activities as directed by the lecturer.
6, 7 & 12	ANALYTICAL ABILITY (50%)	Student displays a high level of analytical ability as evidenced by accurate answers to most questions.	Student displays a moderate level of analytical ability as evidenced by accurate answers to some questions.	Student displays a low level of analytical ability as evidenced by accurate answers to few questions.
	EFFECTIVE COMMUNICATION (10%)	Student demonstrates clear and logical sequencing that is comprehensive and detailed. Makes virtually no grammatical, spelling or punctuation errors.	Student's report is generally comprehensive and detailed. Small gaps in sequencing and detail. Makes few grammatical, spelling or punctuation errors.	Student's examination of topic not very clear. Gaps in sequencing and no detail on contents. Makes a moderate number of grammatical, spelling or punctuation errors.
	CREATIVITY (40%)	Student displays a high level of creativity as evidenced by accurate approach to question.	Student displays a moderate level of creativity as evidenced by a semi-accurate answers to question.	Student displays a low level of creativity as evidenced by inaccurate approach to question.

Appendix IV-
Format guide for CHEM210 Laboratory Reports

OLD FORMAT	NEW FORMAT	INFORMATION IN THIS SECTION	CORE COMPETENCY BEING DEVELOPED
Aim	Introduction	<i>Gives the purpose of the lab and its theoretical background.</i>	EFFECTIVE COMMUNICATION
Theory			KNOWLEDGE
Apparatus	Materials and Methods	<i>Details what materials and equipment were/should be* used to carry out the experiment, and the way in which they were/will be* used. Also clarifies how potential sources of error can be avoided by the choice of suitable methods and materials.</i>	KNOWLEDGE*
Method			EFFECTIVE COMMUNICATION
Precautions			TECHNICAL EXPERTISE
Drawing	Results	<i>Provides raw (i.e., uninterpreted) data collected and (perhaps) expresses the data in table form, as percentages/ratios, charts, tables, graphs, drawings. Data may also be used to perform calculations.</i>	TECHNICAL EXPERTISE
Results			
Treatment of results			EFFECTIVE COMMUNICATION
Discussion and Conclusion	Discussion	<i>Considers how the data you obtained is linked to the purpose of the lab and explores the applications of the experiment and the conclusions that can be made. Judges any unavoidable limitations of your experimental design and assesses their effect on the results.</i>	ANALYTICAL ABILITY
Sources of error			

Appendix V-
Rubric for marking CHEM210 Laboratory Reports

SECTION	COMPETENCY	PERFORMANCE RATING			
		Excellent 4	Average 3	Fair 2	Poor 1
Introduction	Knowledge	The theoretical discussion is complete, factual and relevant.	The theoretical discussion is incomplete or not factual or irrelevant.	The theoretical discussion is either incomplete or not factual, and irrelevant.	The theoretical discussion is incomplete, not factual and irrelevant.
	Effective Communication 1	The aim and/or hypothesis is clearly stated in a testable form.	The aim and/or hypothesis is slightly unclear.	The aim and/or hypothesis is quite vague.	The aim and/or hypothesis is not stated.
	Effective communication 2 (Lab Format)	Lab neatly written with all required sections included in the correct order including date, title and all post lab questions.	Lab tidily/ untidily written with most/all required sections included in the correct order including date, title and all/most post lab questions.	Lab tidily/ untidily written with few/most required sections included in the correct order including date, title and most post lab questions.	Lab untidily written with few required sections included in the correct order. Few post lab questions answered.
Materials and Methods	Knowledge (Plan & Design only)	The student chooses an appropriate method, and includes a complete, factual and relevant theoretical discussion.	The student chooses an inappropriate method, or includes an incomplete or non- factual or irrelevant theoretical discussion.	The student chooses an inappropriate method, and includes either an incomplete or non-factual, and irrelevant theoretical discussion.	The student chooses an inappropriate method, and includes an incomplete, non-factual and irrelevant theoretical discussion.

	Effective Communication	Method is correct, logical, complete and written in appropriate tense. Materials list is complete.	Method is incorrect, or illogical, or incomplete or written in inappropriate tense, or materials list is incomplete.	Method has two - three deficiencies and/or materials list is incomplete.	Method is incorrect and illogical and incomplete and written in inappropriate tense and materials list is incomplete.
	Technical expertise	Method and type of materials chosen so as to eliminate all potential sources of error.	Method and type of materials chosen so as to eliminate most potential sources of error.	Method and type of materials chosen so as to eliminate few potential sources of error.	No effort made to choose method and materials chosen so as to eliminate potential sources of error.
Results	Effective Communication	All results are included in appropriate/ suitable format.	All/Most results are included in inappropriate/ appropriate format.	Most results are included in inappropriate format.	Few results are recorded in inappropriate format.
	Technical Expertise 1	Guidelines for each different mode of data presentation used strictly adhered to. All results correct.	Guidelines for each/most different mode of data presentation used generally/strictly adhered to. All/most results correct.	Guidelines for most different mode of data presentation used generally adhered to and most results correct.	No effort made to adhere to guidelines for each different mode of data presentation used or most results incorrect.
	Technical Expertise 2	All lab equipment used and techniques performed correctly. All general and safety rules strictly adhered to.	Most lab equipment used and techniques performed correctly. All general and safety rules strictly adhered to.	Most lab equipment used and techniques performed correctly. Most general and safety rules strictly adhered to.	Few lab equipment used and techniques performed correctly. Few general and safety rules strictly adhered to.

	Laboratory skills (marked during the lab session)				
Discussion	Analytical Ability	<p>The laboratory report:</p> <p>1. Evaluates the results obtained in the context of the aim/ hypothesis. 2. Advances possible explanations of the results with reference to the theoretical discussion in the Introduction. 3. Deduces which procedures may have introduced errors into the results and assesses their effects. 4. Draws appropriate, relevant conclusions from the results.</p>	<p>The laboratory report:</p> <p>Fulfills any three requirements of this section completely and one only partially/ not at all.</p>	<p>The laboratory report:</p> <p>Fulfills any two requirements of this section completely and two only partially/ not at all.</p>	<p>The laboratory report:</p> <p>Fulfills any one requirement of this section completely and three only partially/ not at all.</p>
Post lab questions	Analytical Ability	All questions answered correctly.	Most questions answered correctly.	Few questions answered correctly.	No questions answered correctly.

Appendix VI -
Form to be returned to students after grading of Laboratory Reports

LAB ASSESSMENT SHEET

Students please submit **one sheet per lab with Sections i-iv filled out.**

i. Student name:						
ii. Course:						
iii. Lab Title:						
iv. Date:						
v. FOR LECTURER'S USE ONLY- DO NOT WRITE IN THIS SECTION						
Section	Competency	SCORE				COMMENTS
Introduction	Knowledge	4	3	2	1	
	Eff. Comm. 1	4	3	2	1	
	Eff. Comm. 2	4	3	2	1	
	TOTAL					
Materials and Methods	Knowledge	4	3	2	1	
	Eff. Comm.	4	3	2	1	
	Tech. Expertise	4	3	2	1	
	TOTAL					
Results	Eff. Comm.	4	3	2	1	
	Tech. Exp. 1	4	3	2	1	
	Tech. Exp. 2	4	3	2	1	
	TOTAL					
Discussion	Anal. Ability	4	3	2	1	
	TOTAL					
Post Lab questions	Anal. Ability	4	3	2	1	
	TOTAL					
TOTAL LAB MARK (%):						
Lecturer Signature:						

Appendix VII

Rubric for Grading of the Midterm & Final Examination Essay (20%)

COMPETENCY	PERFORMANCE RANKING		
	EXCELLENT (8-10)	AVERAGE (5-7)	POOR (0-4)
EFFECTIVE COMMUNICATION (10%) <i>Sentence</i> <i>Structure,</i> <i>Grammar,</i> <i>Mechanics, &</i> <i>Spelling</i>	The essay contains the following elements: 1. Sentences which are all well constructed, with variation in structure and length. 2. No grammatical and/or spelling errors 3. Legible handwriting 4. Correct use of paragraphs 5. Correct use of relevant jargon	The essay contains three - four of the required elements.	The essay contains less than three of the required elements.
ANALYTICAL ABILITY (10%) <i>Interpretation of question</i> <i>and use of scientific jargon</i>	The essay contains the following elements: 1. The question is accurately interpreted. 2. Main ideas are appropriately emphasized, and are well supported by detailed and accurate information and appropriate jargon. 3. The introduction is inviting, states the main topic, and provides an overview of the paper. 4. Information is relevant and presented in a logical order. 5. The conclusion is strong and supported by the main points of the essay.	The essay contains three - four of the required elements.	The essay contains less than three of the required elements.