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 133: PHYSICAL 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 133
Course Title:	Physical Chemistry
Number of Credits:	3
Semester:	2
Track:	-
Co-requisites:	-
Prerequisite:	CHEM 132 (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:

This course builds on the topics covered in CHEM 131 & CHEM 132 and covers topics including: chemical thermodynamics, chemical kinetics, chemical equilibrium, ionic equilibria, energy and forces, and electrochemistry. It allows students to develop the ability to interpret and analyze data on these aspects of physical chemistry.

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

General Objectives for Physical 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.** Interpret the principles and concepts of thermodynamics
- **K2.** Interpret the factors which affect rates of reactions
- **K3.** Explain the basic concepts of chemical equilibrium
- **K4.** Explain the difference between strong and weak electrolytes
- **K5.** Explain the autoionization of water
- **K6.** Describe the difference between solvolysis and hydrolysis
- **K7.** Describe the common ion effect

K8. Explain the chemistry of buffer solutions
K9. Describe what acid-base indicators are and how they function
K10. Outline how to write solubility product constant expressions
K11. Outline some methods of dissolving precipitates
K12. Explain the basic concepts of energy and forces
K13. Outline the chemistry of corrosion
K14. Outline the chemistry of primary and secondary voltaic cells

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 Physical 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. Apply the first and second laws of thermodynamics to new situations
A2. Demonstrate an understanding of the factors which affect reaction rates
A3. Demonstrate correct usage of the equilibrium constant, Kc
A4. Recognize some common, slightly soluble compounds
A5. Demonstrate an understanding of the distribution of energy in molecules

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

Students should be able to:

A6. Apply the first and second laws of thermodynamics to solve mathematical problems
A7. Apply the laws and theories of kinetics to solve mathematical problems
A8. Apply the equilibrium constant, Kc, to solve mathematical problems
A9. Demonstrate an understanding of how polyprotic acids ionize in steps and how to calculate concentrations of all species in solutions of polyprotic acids
A10. Apply knowledge of buffer chemistry to carry out calculations related to buffer solutions and their action
A11. Apply knowledge of Ksp values to solve mathematical problems
A12. Apply the concepts of fractional precipitation to solve mathematical problems
A13. Evaluate the effect of concentrations (or partial pressures) on electrode potentials

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. Perform pH/Acid-Base titrimetry
T2. Perform out quantitative analyses using the UV spectrophotometer
T3. Standardize a pH meter and then use it to determine the pH of various solutions

COLLABORATION

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

Students should be able to:

C1. Work in a group to solve calculation types problems

Immersion Level: **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: **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. Describe an innovative approach to the topic of their research project

WEEKLY CLASS SCHEDULE AND TEACHING OBJECTIVES

Key:

Competency	Levels
K= Knowledge	En = Entry
E= Effective Communication	Im =Immersion
A = Analytical Ability	It = Intermediate
T= Technological Expertise	
C= Collaboration	
Cr= Creativity	

Week	Unit	Content	Specific Objectives and Activities	Competency	Level
1	**Unit 1 - Chemical Thermodynamics**	• The First Law of Thermodynamics • Bond energies • Changes in Internal Energy, ΔE • Relationship between ΔH and ΔE • The two aspects of spontaneity • Dispersal of energy and matter • Entropy, S and entropy change, ΔS • The Second law of Thermodynamics • Free Energy Change, ΔG, and spontaneity • The temperature dependence of spontaneity	Students should be able to: 1. Use the First Law of Thermodynamics to relate heat, work and energy changes 2. Use bond energies to estimate heats of reaction for gas phase reactions; use ΔH values for gas phase reactions to find bond energies 3. Discuss changes in Internal Energy, ΔE, and its relationship to heat and work 4. Discuss the relationship between ΔH and ΔE at constant temperature and pressure 5. Distinguish between product-favoured (spontaneous) processes and reactant-favoured (nonspontaneous) processes 6. Outline the relationship of entropy to the dispersal of energy and matter (disorder) in a system 7. Use tabulated values of absolute entropies to calculate the entropy changes, ΔS 8. Explain how the spontaneity of a process is related to entropy changes – the Second Law of Thermodynamics 9. Calculate changes in Gibbs free energy, ΔG, by two methods: (a) from values of ΔH and ΔS and (b) from tabulated values of standard molar free energies of	 K1 A6 K1 K1 A1 K1 A6 K1 A6	 Im It Im Im Im Im It Im It

			formation and know when to use each type of calculation 10. Discuss the temperature dependence of spontaneity **Activities:** READ: 1. General Chemistry (9th Edition) – Chapter 15: Chemical Thermodynamics, pages 565 - 605 VIEW: 1. Introduction to Thermodynamics – Steorn Physics Primer http://www.youtube.com/watch?v=sCjVMMe_w0g&feature=related 2. Using Bond Energies to Calculate Heats (Enthalpy) of Reactions – YouChem Tutorials http://www.youtube.com/watch?v=1FCf2UhPS40 3. Calculate the standard entropy change for a reaction - IB Chemistry HL http://www.youtube.com/watch?v=IwRy4iYVQLI DISCUSS: 1. **The two aspects of spontaneity.** What are the two factors which affect the spontaneity of any physical or chemical change? 2. **The dispersal of energy and matter.** How does the dispersal of energy in a system affect the distribution of energy in that system? What factors affect the dispersal of energy in a system? What factors influence the dispersal of matter in a system? 3. **Entropy, S and entropy change, ΔS.** What factors influence entropy changes? **ASSIGNMENT 1 [10% of Assignment Mark]** CALCULATE (in groups of three): 1. Bond Energies 2. Changes in Internal Energy, ΔE 3. Entropy, S and entropy change, ΔS 4. Free Energy Change, ΔG, and use it to predict the spontaneity of a reaction	K1 K1 K1, A1 A6 A6 K1 K1 A6 A6, C1 A6, C1 A6, C1 A6, C1	Im Im Im, Im It It Im Im It It, En It, En It, En It, En

			5. The temperature at which a process is at equilibrium	A6, C1	It, En
Week	**Unit**	**Content**	**Specific Objectives and Activities**	**Competency**	**Level**
2	**Unit 2 – Chemical Kinetics**	• Transition State Theory • Reaction Mechanisms and the rate-law expression • Temperature: The Arrhenius Equation • Catalysts	Students should be able to: 1. Describe the main aspects of transition state theory and the role of activation energy in determining the rate of a reaction 2. Explain how the mechanism of a reaction is related to its rate-law expression 3. Devise the rate-law expression that would result from a proposed reaction mechanism 4. Identify reactants, products, intermediates, and catalysts in a multistep reaction mechanism 5. Explain how temperature affects rates of reactions 6. Use the Arrhenius equation to relate the activation energy for a reaction to changes in its rate constant with changing temperature 7. Explain how a catalyst changes the rate of a reaction 8. Describe homogenous and heterogeneous catalysis **Activities:** READ: 1. General Chemistry (9th Edition) – Chapter 16: Chemical Kinetics, pages 606 - 659 VIEW: 1. Transition State Theory – A Traffic Metaphor – YouChem Tutorials http://www.youtube.com/watch?v=2ae8aBoEwS8 2. Chemical Kinetics - Reaction mechanisms - College & AP Chemistry Tutorial 13	K2 K2 A7 A2 K2 A7 K2 K2 K2 K2 K2	Im Im It Im Im It Im Im Im Im Im

			http://www.youtube.com/watch?v=NXaVqplPDlo 3. Arrhenius Equation and Activation Energy – Linda Susan Hanson http://www.youtube.com/watch?v=crJ0JJiiGfw DISCUSS: 1. **Transition State Theory.** What are the main aspects of transition state theory? What is the role of activation energy in determining the rate of a reaction? 2. **Reaction Mechanisms and the Rate Law Expression.** How is the mechanism related to the rate-law expression? How is the rate-law expression predicted from the proposed reaction mechanism? 3. **Temperature: The Arrhenius Equation.** How does temperature affect the rates of reactions? How is the Arrhenius equation used to relate activation energy to changes in the rate constant with changing temperature? 4. **Catalysts.** How do catalysts change the rate of a reaction? What is the difference between homogenous and heterogeneous catalysts? **<u>ASSIGNMENT 2 [10% of Assignment Mark]</u>** CALCULATE (in groups of three): 1. The specific rate constant, k, using the Arrhenius Equation 2. The activation energy for a reaction using the Arrhenius Equation **<u>PRACTICAL EXERCISE</u>** 1. Laboratory Experiment 1: Reaction Rate Lab – Sulphur Clock **<u>GROUP PROJECTS</u>** Assignement of Group Projects. Due date: Week 14. See Appendix II for Mark Scheme	A7 K2 A2, A7 A2, A7 K2 A7, C1 A7, C1 A7, E1, T1, C2 A1-12 (dependent on topic), C3, Cr1	It Im Im, It Im, It Im It, En It, En It, It, It, Im It, It It

Week	Unit	Content	Specific Objectives and Activities	Competency	Level
3 & 4	**Unit 3 – Chemical Equilibrium**	• Partial pressures and the equilibrium constant • Relationship between K_p and K_c • Heterogeneous equilibria • Relationship between ΔG^o_{rxn} and the equilibrium constant • Evaluation of equilibrium constants at Different Temperatures • The variation of Gibbs free energy with pressure for an ideal gas • The variation of Gibbs free energy with temperature for an ideal gas • Application of free energy in determining the position of phase equilibria • Derivation of the Clapeyron and the Clausius-Clapeyron equation for two phase systems	Students should be able to: 1. Use the equilibrium constant expressed in terms of partial pressures (K_p) and relate K_p to K_c 2. Describe heterogeneous equilibria and write their equilibrium constants 3. Use the relationship between thermodynamics and equilibrium 4. Estimate equilibrium constants at different temperatures 5. Relate the variation of Gibbs free energy to pressure for an ideal gas 6. Relate the variation of Gibbs free energy to temperature for an ideal gas 7. Use the free energy to determine the position of phase equilibria 8. Summarize the Clapeyron and the Clausius-Clapeyron equation for two phase systems 9. Use Raoult's Law to define ideal solutions **Activities:** READ: 1. General Chemistry (9th Edition) – Chapter 17: Chemical Equilibrium, pages 685 - 702 VIEW: 1. Heterogeneous Equilibria – The Khan Academy http://www.youtube.com/watch?v=TsXlTWgyItw 2. Gibbs Free Energy: Temperature and Pressure Dependence – University of Colorado Boulder http://www.youtube.com/watch?v=0IGQKS_3Vpw 3. Phase Equilibria – Professor Chuck Wight, The University	 A3 K3 A3 A8 A8 A8 A8 A8 K3 K3 A3 A8	 Im Im Im It It It It Im Im Im It

		• Ideal solutions and Raoult's Law	of Utah http://www.youtube.com/watch?v=jNWTnQfQ1wE DISCUSS: 1. **Partial pressures and the equilibrium constant.** How is Kp different from Kc? What is the relationship between Kp and Kc? 2. **Heterogeneous Equilibria.** What is heterogensous equilibria? How are Kp and Kc expressions written for heterogeneous equilibria? 3. **Relationship between ΔG^o_{rxn} and the equilibrium constant.** What is the relationship between ΔG^o_{rxn} and the equilibrium constant? 4. **Variation of Gibbs free energy.** How does Gibbs free energy vary with temperature for an ideal gas? How does Gibbs free energy vary with pressure for an ideal gas? **ASSIGNMENT 3 [10% of Assignment Mark]** CALCULATE (in groups of three): 1. Equilibrium constant in terms of partial pressures in atomospheres, Kp 2. Concentrations using Kc and Kp 3. Kc and Kp for heterogenous equilibria 4. K versus ΔG^orxn **5.** Kp at different temperatures **ASSIGNMENT 4 [10% of Assignment Mark]** WRITE(individually): 1. Use given information to derive the Clapeyron and the Clausius-Clapeyron equation for two phase systems 2. Use Raoult's Law to define ideal solutions	 A3 K3 A8 A8 A8, C1 A8, C1 A8, C1 A8, C1 A8, C1 A8, E1 A8, E1	 Im Im It It It, En It, En It, En It, En It, En It, It It, It
Week	**Unit**	**Content**	**Specific Objectives and Activities**	**Competency**	**Level**
5 & 6	**Unit 4 – Ionic Equilibria I: Acids & Bases**	• A Review of Strong Electrolytes • The Autoionization of water • The pH and pOH	Students should be able to: 1. Identify strong electrolytes and calculate concentrations of their ions 2. Explain the autoionization of water	 K4, A9 K5	 Im, It Im

		scales • Ionization constants for weak monoprotic acids and bases • Polyprotic acids • Solvolysis • Salts of Strong Bases and Strong Acids • Salts of strong bases and weak acids • Salts of weak bases and strong acids • Salts of weak bases and weak acids	3. Describe and explain the pH and pOH scales 4. Use ionization constants for weak monoprotic acids and bases 5. Discuss the concepts of solvolysis and hydrolysis 6. Outline how polyprotic acids ionize in steps and how to calculate concentrations of all species in solutions of polyprotic acids 7. Outline acid-base equilibrium concepts with respect to salts of strong bases and strong acids 8. Outline acid-base equilibrium concepts with respect to salts of strong bases and weak acids 9. Outline acid-base equilibrium concepts with respect to salts of weak bases and strong acids 10. Outline acid-base equilibrium concepts with respect to salts of weak bases and weak acids 11. Outline acid-base equilibrium concepts with respect to salts of small, highly charged cations **Activities:** READ: 1. General Chemistry (9th Edition) – Chapter 18: Ionic Equilibria I: Acids and Bases, pages 703 - 742 VIEW: 1. Chemistry 12.3a pH and pOH – IsaacsTEACH http://www.youtube.com/watch?v=pFK16GsU1e4 2. Ionization Constant Lecture – Kurtzmanj Channel http://www.youtube.com/watch?v=5Wht_Hl2zfM DISCUSS: 1. **Strong electrolytes.** What are strong electrolytes? How are they identified?	K5 A9 K6 A9 A9 A9 A9 A9 A9 K4, K5 K5 A9 K4	Im It Im It It It It It It Im, Im Im It Im

			2. **The autoionization of water.** What is the expression for the autoionization of water?	K5	Im
			3. **Ionization constants for weak monoprotic acids and bases.** How is the ionization constant of a weak acid, Ka, calculated?	A9	It
			4. **Polyprotic acids.** What are polyprotic acids? How do they ionize?	A9	It
			5. **Solvolysis.** What is solvolysis?	K6	Im
			CALCULATE (in groups of three):		
			1. Ion concentrations	A9, C1	It, En
			2. pH, H_3O^+ from pH, pH and pOH of an acidic solution, $[H_3O^+]$, pH, $[OH^-]$ and pOH from concentration	A9, C1	It, En
			3. Ka and pKa from equilibrium concentrations, Ka from percent ionization, Ka from pH, Concentration from Ka, Percent ionization, pKa values	A9, C1	It, En
			4. pH of a weak base solution	A9, C1	It, En
			5. Molarity using pH, Concentration of species using molarity	A9, C1	It, En
			6. Kb for the anion of a weak acid	A9, C1	It, En
			7. Percent hydrolysis	A9, C1	It, En
			8. pH of a soluble salt of a strong acid and a weak base	A9, C1	It, En
			ASSIGNMENT 5 [10% of Assignment Mark] WRITE(individually):		
			1. Write an essay to explain the following points: • the solutions of salts of strong bases and strong acids are always neutral • the solutions of salts of strong bases and weak acids are always basic • the solutions of salts of weak bases and strong acids are always acidic In the essay, also discuss the pH of the solutions of weak bases and weak acids.	A9, E1	It, It
			2. Write an essay discussing the hydrolysis of salts that contain small, highly charged cations.	A9, E1	It, It
7	**MIDTERM ASSESSMENT 1: UNITS 1 – 3 (15%) - See Appendix 1 for Table of Specifications**				

Week	Unit	Content	Specific Objectives and Activities	Competency	Level
8	**Unit 5 – Ionic Equilibria II: Buffers & Titration Curves**	• The common ion effect and buffer solutions • Buffering action • Preparation of buffer solutions • Acid-Base indicators • Strong Acid/Strong Base Titration curves • Weak Acid/Strong Base Titration curves • Weak Acid/Weak Base Titration curves • Summary of Acid-Base Calculations	Students should be able to: 1. Explain the common ion effect and give illustrations of its operation 2. Describe buffer solutions and outline their chemistry 3. Outline how to prepare a buffer solution of a specified pH 4. Carry out calculations related to buffer solutions and their action 5. Explain what acid-base indicators are and how they function 6. Identify what species are present at various stages of titration curves for (a) strong acids and strong bases, (b) weak acids and strong basses, and (c) weak acids and weak bases 7. Carry out calculations based on titration curves for (a) strong acids and strong bases and (b) weak acids and strong bases **Activities:** READ: 1. General Chemistry (9th Edition) – Chapter 19: Ionic Equilibria II: Buffers and Titration Curves, pages 743 - 770 VIEW: 1. Buffer Solutions – Professor Chuck Wight, The University of Utah http://www.youtube.com/watch?v=O_QlZe4fv4g 2. Preparation of a Buffer Solution – S. Venkatachalam http://www.youtube.com/watch?v=HgpwCyGSVos DISCUSS: 1. **The common ion effect and buffer solutions.** What is the	 K7 K8 A10 A10 K9 K9 A10 K7, K8, K9 K8 A10 K7, K8	 Im Im It It Im Im It Im, Im, Im Im It Im

			common ion effect? What are buffer solutions? 2. **Buffering action.** How does a buffer work? 3. **Preparation of buffer solutions.** What are the different methods of preparing buffer solutions? 4. **Acid-base indicators.** Why are acid-base indicators important? How do they work? 5. **Titration curves.** What is a titration curve? Why is the end point and the equivalence point important? How are titration curves interpreted? What are the different types of titration curves? **ASSIGNMENT 6 [10% of Assignment Mark]** CALCULATE (in groups of three): 1. Concentrations of species in weak acid/salt of weak acid buffer solutions, concentrations of species in weak acid/salt of weak acid buffer solutions (via the Henderson-Hasselbalch Equation), concentration of species in weak base/salt of weak base buffer solutions 2. Buffering action, pH of a buffer solution 3. Buffer preparation by addition of a salt, Buffer preparation by partial neutralization WRITE: 1. Write short notes on the different types of titration curves. Include labeled diagrams of the different types of titration curves. **PRACTICAL EXERCISE** 1. Laboratory Experiment 2: pH / Acid-Base Indicators / Buffers	 K8 A10 K9 A10 A10, C1 A10, C1 A10, C1 E1, A10 A10, E1, T2, C2	 Im It Im It It, En It, En It, En It, It It, It, It, Im
Week	**Unit**	**Content**	**Specific Objectives and Activities**	**Competency**	**Level**
9	**Unit 6 – Ionic Equilibria III: The Solubility Product Principle**	• Solubility Product Constants • Determination of Solubility Product Constants • Uses of Solubility	Students should be able to: 1. Write solubility product constant expressions 2. Explain how K_{sp} values are determined 3. Use K_{sp} values in chemical calculations	 A4 K10 A11	 Im Im It

		Product constants • Fractional Precipitation • Simultaneous equilibria involving slightly soluble compounds • Dissolving precipitates	4. Identify common, slightly soluble compounds 5. Outline fractional precipitation and how it can be used to separate ions 6. Outline how simultaneous equilibria can be used to control solubility 7. Describe some methods of dissolving precipitates **Activities:** READ: 1. General Chemistry (9th Edition) – Chapter 20: Ionic Equilibria III: The Solubility Product Principle, pages 771 - 793 VIEW: 1. Chemistry Tutorial 9.3c: Solubility Product Constant, Ksp – Mark Rosengarten http://www.youtube.com/watch?v=n1vVyWQMEPw 2. Chemistry: Fractional Precipitation – Mindbites.com http://www.youtube.com/watch?v=gHn7uZtpgJc&feature=related DISCUSS: 1. **Solubility product constants.** What are solubility product constants? How are solubility product constants expressed? Why are solubility product constants useful? 2. **Fractional precipitation.** What is fractional precipitation? Why is fractional precipitation useful? 3. **Simultaneous equilibira involving slightly soluble compounds.** When does simultaneous equilibria occur? 4. **Dissolving precipitates.** When will precipitates dissolve? **ASSIGNMENT 7 [10% of Assignment Mark]** CALCULATE (in groups of three): 1. Molar solubility and product constants, Molar solubility and solubility product constant, Molar solubilities from Ksp values, Molar solubilities and the common ion effect 2. Prediction of precipitate formation, Initiation of	A4 A12 A12 K11 K10, K11 A4, A11 A12 K10 A12 A12 K11 A11, C1 A12, C1	Im It It Im Im, Im Im, It It Im It It Im It, En It, En

			precipitation 3. Concentration of common ion, Concentration required to initiate precipitation 4. Fractional precipitation 5. Simultaneous equilibria WRITE: 1. Summarize the conditions under which precipitates will dissolve. **PRACTICAL EXERCISE** 1. Laboratory Experiment 3: Solubility Product	A12, C1 A12, C1 A12, C1 K11, E1 A4, A11, A12, E1, T3, C2	It, En It, En It, En Im, It It, It, It It, It, Im
Week	**Unit**	**Content**	**Specific Objectives and Activities**	**Competency**	**Level**
10 & 11	**Unit 7 – Energy and Forces**	• The Law of Conservation of energy • Newton's Laws of motion • Fundamental interactions • Types of molecular energy • Ideal gas law • The Equirpartition principle • Rotational and vibrational energy of a diatomic gas • Heat capacities of ideal gases	Students should be able to: 1. State the Law of Conservation of Energy 2. Use scalars and vectors to describe Newton's Laws of Motion 3. Outline the fundamental interactions including gravitational, electric, weak and strong interactions 4. Describe the types of molecular energy - translational, rotational and vibrational 5. State the ideal gas law 6. Apply the ideal gas law to derive the Equipartition principle 7. Outline classical expressions for the rotational and vibrational energy of a diatomic gas 8. Describe the heat capacities of ideal gases 9. Outline the classical treatment of the variation of heat capacity with temperature and the failure of the classical	 K12 K12 K12 K12 K12 A5 A5 K12 K12	 Im Im Im Im Im Im Im Im Im

		• Classical treatment of the variation of heat capacity with temperature • Quantum theory predictions of energy for atoms and diatomics • Maxwell-Boltzmann distribution law • The quantum-mechanical treatment of heat capacity and its temperature variation • Phenomena which show an exponential dependence on temperature • Potential energy curves	prediction 10. Describe the quantized nature of molecular energy levels 11. Discuss the quantum theory predictions of translational, rotational and vibrational energy levels for atoms and diatomics 12. Outline the Maxwell-Boltzmann distribution law for an assembly of molecules at equilibrium at constant temperature 13. Outline the quantum mechanical treatment of heat capacity and its temperature variation 14. Give examples of phenomena which show an exponential dependence on temperature 15. Relate potential energy curves to the variation of the electronic energy of a diatomic with internuclear distance and the relation to dissociation energy **Activities:** READ: 1. General Chemistry (9th Edition) – Chapter 12: Gases and the Kinetic-Molecular Theory, pages 400 - 447 VIEW: 1. VideoBrief: Newton's Laws of Motion illustrated with 3D animations and motion graphics Bryan Ierardi, Science Vision http://www.youtube.com/watch?v=iH48Lc7wq0U 2. 6.2.5 Sketch/Explain Qualitatively the Maxwell-Boltzmann Energy Distribution Curve IB Chemistry SL – Rich Thornley http://www.youtube.com/watch?v=YnHIfqUZi48 3. Thermodynamics and Chemical Dynamics: Lec 5. The Equipartition Theorum – Professor Reginald M. Penner, University of California, Irvine http://www.youtube.com/watch?v=ymk3YvH2m9c DISCUSS:	K12 K12 A5 A5 K12 A5 K12 K12 A5 A5	Im Im Im Im Im Im Im Im Im Im

			1. **The law of conservation of energy.** What is the law of conservation of energy? 2. **Types of molecular energy.** What are the three types of molecular energy? What is quantized nature of molecular energy levels? What are the quantum theory predictions of translational, rotational and vibrational energy levels for atoms and diatomics? 3. **Heat capacity.** What is heat capacity? What is the classical treatment of the variation of heat capacity with temperature? How does the classical prediction fail? 4. **The equipartition principle.** How is the ideal gas law applied to derive the equipartition principle? **<u>ASSIGNMENT 8 [10% of Assignment Mark]</u>** CREATE presentations on the following (individually to present to class): 1. An outline of the Maxwell-Boltzmann distribution law for an assembly of molecules at equilibrium at constant temperature 2. A summary relating potential energy curves to the variation of the electronic energy of a diatomic with internuclear distance and the relation to dissociation energy	K12 K12 K12 A5 A5, E1 A5, E1	Im Im Im Im Im, It It, It
12	**MIDTERM ASSESSMENT 2: UNITS 4 – 6 (15%) - See Appendix I for Table of Specifications**				
Week	**Unit**	**Content**	**Specific Objectives and Activities**	**Competency**	**Level**
13	**Unit 8 - Electrochemistry**	• Corrosion • Corrosion protection • The Nernst equation • Using electrochemical cells to determine concentrations • The relationship of E^{o}_{cell} to ΔG^{o} and K • Dry cells • The lead storage battery • The nickel-cadmium (Nicad) cell	Students should be able to: 1. Describe some corrosion processes and some methods for preventing corrosion 2. Use the Nernst equation to relate electrode potentials and cell potentials to different concentrations and partial pressures 3. Relate the standard cell potential (E^{o}_{cell}) to the standard Gibbs free energy change (ΔG^{o}) and the equilibrium constant (K) 4. Distinguish the compositions and reactions of some useful	 K13 A13 A13 K14	 Im It It Im

		• The hydrogen-oxygen fuel cell	primary and secondary cells (batteries) 5. Outline the electrochemical processes involved in discharging and recharging a lead storage (automobile) battery 6. Outline the electrochemical processes involved in the nickel-cadmium (Nicad) cell 7. Outline the electrochemical processes involved in the hydrogen oxygen fuel cell **Activities:** READ: 1. General Chemistry (9th Edition) – Chapter 21: Electrochemistry, pages 794 - 841 VIEW: 1. Chemistry: Corrosion & Prevention of Corrosion – Mindbites.com http://www.youtube.com/watch?v=CnFuMWpmJzg DISCUSS: 1. **Corrosion.** What is corrosion? How can metals be protected from corrosion? 2. **Effect of concentration (or partial pressures) on electrode potentials.** What is the Nernst equation? When is the Nernst equation used? **ASSIGNMENT 9 [10% of Assignment Mark]** CALCULATE(in groups of three): 1. The potential, E, for a half-cell reaction using the Nernst equation, The overall cell potential using the Nernst equation, Q, $[H^+]$ and pH using the Nernst equation 2. ΔG^o from cell potentials, K from cell potentials **ASSIGNMENT 10 [10% of Assignment Mark]** WRITE (individually): Write short summary notes on primary and secondary voltaic cells	K14 K14 K14 K13, K14 K13 K13 A13 A13, C1 A13, C1 K14, E1	Im Im Im Im, Im Im Im It It, En It, En Im, It

14	**PROJECT PRESENTATIONS – See Appendix II for Rubric**
15	**TUTORIAL**
16	**FINAL EXAMINATION: UNITS 1 – 8 (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 AAS in Chemistry	
2 In-course exams at 15% each	30 %
See Appendix I for Table of Specifications	
Group Project	10%
See Appendix II for Rubric	
Assignments	10 %
See Appendix III for Rubric	
Laboratory performance and Reporting	10 %
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	
Final Examination	40 %
See Appendix I for Table of Specifications	

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. Anu 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 LIBS130and 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:

General Chemistry (9th Edition)
Kenneth W. Whitten
Raymond E. Davis
M. Larry Peck
George G. Stanley
ISBN-13:978-0-495-39163-0
ISBN-10:0-495-39163-8

Chemistry:Principles & Practice (2nd Edition)
Reger, Goode & Mercer
ISBN- **13:** 9780030059186
ISBN: 0030059186

AUDIO-VISUAL RESOURCES:

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

BIBLIOGRAPHY IN PREPARING SYLLABUS:

Brown, T.; LeMay, H; Bursten, B, 2006. *Chemistry, The Central Science.* Pearson Education Inc.
Whitten, Kenneth W. ; Davis, Raymond E. ; Peck, Larry ; Stanley, George G. 2010. *General Chemistry, 9th Edition.* Brooks/Cole Cengage Learning

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 CHEM133 Midterms and Final Examination

Table of Specifications for CHEM133 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 CHEM133 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 133 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 133 Class Assignments

Rubric for CHEM133 Class Assignments - 10%

ASSIGNMENT NUMBER	COMPETENCY	PERFORMANCE RANKING		
		EXCELLENT (8-10)	AVERAGE (5-7)	POOR (0-4)
1, 2, 3, 6, 7 & 9	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 abilitly 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.
4, 5 & 8	ANALYTICAL ABILITY (70%)	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 abilitly as evidenced by accurate answers to few questions.
	EFFECTIVE COMMUNICATION (30%)	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.
10	KNOWLEDGE (70%)	Student displays a high level of knowledge as evidenced by accurate answers to most questions.	Student displays a moderate level of knowledge as evidenced by accurate answers to some questions.	Student displays a low level of knowledge as evidenced by accurate answers to few questions.
	EFFECTIVE COMMUNICATION (30%)	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.

Appendix IV-
Format guide for CHEM133 Laboratory Reports

OLD FORMAT	NEW FORMAT	INFORMATION IN THIS SECTION	CORE COMPETENCY BEING DEVELOPED
Aim	**Introduction**	*Gives the purpose of the lab and its theoretical background.*	EFFECTIVE COMMUNICATION
Theory			KNOWLEDGE
Apparatus	**Materials and Methods**	*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.*	KNOWLEDGE*
Method			EFFECTIVE COMMUNICATION
Precautions			TECHNICAL EXPERTISE
Drawing	**Results**	*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.*	TECHNICAL EXPERTISE
Results			
Treatment of results			EFFECTIVE COMMUNICATION
Discussion and Conclusion	**Discussion**	*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.*	ANALYTICAL ABILITY
Sources of error			

Appendix V-
Rubric for marking CHEM133 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	The laboratory report: 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.	The laboratory report: Fulfills any three requirements of this section completely and one only partially/ not at all.	The laboratory report: Fulfills any two requirements of this section completely and two only partially/ not at all.	The laboratory report: Fulfills any one requirement of this section completely and three only partially/ not at all.
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%)** *Sentence Structure, Grammar, Mechanics, & Spelling*	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%)** *Interpretation of question and use of scientific jargon*	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.