



University of Management & Technology
School of Science
Department of Chemistry

CH-608 NANOCHEMISTRY

Lecture Schedule	Once a week (06:30 – 09:15 pm)	Semester	Every Spring Semester
Pre-requisite	Graduate Standing (General Chemistry)	Credit Hours	3
Instructor(s)	Dr Sammia Shahid	Contact	sammia.shahid@umt.edu.pk Extension. 3614
Office	2 nd Floor, Center Block, C3-25	Office/Counseling Hours	As per faculty semester timetable
Program Learning Objectives	<p>The aim of graduate education is to create individuals with the capacity to learn independently and the ability to define and solve new problems. Chemists with graduate degrees can advance the fundamental understanding of their discipline and communicate what they have learned to others.</p> <p>Program Learning Objectives:</p> <ul style="list-style-type: none">➤ to demonstrate an advanced understanding of selected topics in chemistry,➤ to demonstrate information literacy skills for acquiring knowledge of chemistry, both as a student and as a life-long learner,➤ to demonstrate an understanding of experimentation, observation, and data analysis, and their application to defined questions in chemistry,➤ to demonstrate a familiarity with available instrumentation for conducting specific scientific research,➤ to communicate effectively, verbally and written, for the purposes of conveying chemical information to both professional scientists and to the public.		
Course Learning Objectives	<p>The course's main objective is to familiarize the students with the basic concept of nanochemistry, changes in chemical and physical properties due to size reduction, and the terminology related to science, nanomaterials, and nanotechnology. The students will study nanoparticle preparation methods, the most recent tools of nanomaterials characterization, and the applications and fictionalization of nanomaterials. Learning objectives for this course will focus on developing a fundamental understanding of the following topics as they relate to nanomaterials.</p>		

	<ul style="list-style-type: none"> ➤ Motivation/Vision: Feynman’s vision, why use/explore new nanomaterials? ➤ Synthesis and Fabrication: Top-down vs. bottom-up techniques, nucleation theory, surface energy and stabilization ➤ Characterization: Composition, structure, porosity, crystallinity, single vs. ensemble measurements ➤ Examples: General classification (zero – two dimensional and assembled nanostructures), materials composition/function (metals, metal oxides, semiconductors, carbon, biological) ➤ Size-Dependent Chemical and Physical Properties: Electrical, optical, catalytic, magnetic, thermodynamic, why purification is needed Applications: Electrical, optical, catalytic, magnetic, thermodynamic, purification, sensing, biology, medicine, solar cells, etc. (literature) ➤ Implications: Environment, health, and safety as well as impacts on policy, society, and education
Course Description	<p>The course deals with the basic concepts of nanochemistry including a general introduction and history of nanotechnology, classification of nanostructures, methods of preparation, and importance in industries. Take some nanostructures as examples. Spectroscopic and microscopic tools used in nanomaterials characterizations and applications of materials at nanometer length scales with an emphasis on recent technological breakthroughs in the field. Introduction to scientific writing is also an integral part of the course.</p>
Expected Learning Outcomes	<p>After a successful completion of the course, students should be able to have:</p> <p>Knowledge: Recognize the basic concept of nanochemistry. Develop an awareness of methods of nanoparticle preparation. Understanding of some applications of nanomaterials in industry. Gain knowledge of characterization tools of nanomaterials.</p> <p>Skills: Predict the type of hybridization in a chemical compound. Compare nanomaterials and other materials. Estimate the principles of nanomaterials preparation and characterization. Basic interpersonal skills, relating to the ability to interact with other people and to engage in teamwork. interpret the characterization results of nanomaterials. Skills in data presentation. Perform a literature survey on a chosen topic in scientific literature. Write a scientific report with appropriate references and citations. Present results of research in the form of an oral presentation.</p> <p>Competence: Develop the student's ability in self-reliance and responsibility. Communicate results and participate in discussions with his classmates. Use computer and internet to perform reports on applications of nanomaterials</p>
Recommended Text Books	<p>1) <i>Nanochemistry: A Chemical approach to Nanomaterials</i>, Geoffrey A. Ozin, Andre C. Arsenault, and Ludovico Cademartiri, Latest Ed, The Royal Society of Chemistry Publishing.</p>

	2) <i>Nanostructures & Nanomaterials-Synthesis Properties & Applications</i> , Guozhong & Cao, Latest Ed, Imperial College Press, Latest Edition.	
Recommended Reference Books	1) <i>Core Concepts in Supramolecular Chemistry and Nanochemistry</i> , Jonathan W. Steed, David R. Turner, Karl J. Wallace, Latest Ed, John Wiley & Sons, Ltd, 2) <i>Nanoscale Materials in Chemistry</i> , Kenneth J. Klabunde, John Wiley & Sons, Ltd. Latest edition.	
Assessment Criteria	<ul style="list-style-type: none"> • Quizzes: 10% • Assignments: 05% • Presentations: 05% 	<ul style="list-style-type: none"> • Case Study/Project: 05 % • Midterm: 25% • Final Exam: 50%
Course Delivery	<p>To meet course objectives, the delivery of CH 608 will be accomplished through a combination of in-class collaborative work groups, dialogic discussions, individually written reflections and mini-lectures designed to help meet the needs of all learners and learning preferences. These include:</p> <ul style="list-style-type: none"> ➤ Presentations (i.e., mini-lectures, often assisted by Power Point and other visuals); ➤ Discussions (i.e., active involvement of students in learning by asking questions that provoke critical thinking and verbal interaction); ➤ Cooperative learning (i.e., small group structure emphasizing learning from and with others); ➤ Collaborative learning (i.e., heterogeneous groups in an interdisciplinary context); ➤ Student sharing and mini-presentations; ➤ Web-based journaling; ➤ Learning Management System- Moodle-web-based course management and portal system. 	
Classroom Behavior	<p>Regularity and punctuality will be very strictly observed. You have an allowance of only three absences (<u>Out of 16 sessions</u>). This includes the leaves that are approved from your Batch Advisor. In case you are absent in four classes, you will get an 'F' in the course. Regarding punctuality, you will be marked present only if you arrive in the class within five minutes of the scheduled time. Any absents during the presentation sessions will result in deduction of 1 point each from the presentation marks. If your group is making a presentation and you are not there, you get a zero. If you miss a Quiz you get zero in that Quiz. You will lose 5 points if you deliver your assignment / report after the given date. The chapters and other material included in the Mid-term and final Exam will be discussed one week prior to its commencement respectively.</p>	
Participant Responsibilities	<p><i>Class Participation:</i> Positive, healthy and constructive class participation will be monitored for each class. Particular emphasis will be given during the presentation sessions. The manner in which the question is asked or answered will also be noted.</p> <p><i>Honesty Policy:</i> A student found in cheating (<u>plagiarism</u>) on any exam/ assignment/ project, his/her case will be referred to Unfair Means Committee (UFM) that may result in no credit (i.e. no grade) for that exam/ assignment/ project. A deduction from the sessional marks and financial penalties are other possibilities as decided by the committee.</p>	

Plagiarism: It is defined in dictionaries as "the wrongful appropriation, close imitation, or purloining (stealing) and publication, of another author's language, thoughts, ideas, or expressions, and the representation of them as one's own original work. **HEC Plagiarism policy** will be followed.

Course Schedule/ Calendar of Activities

Weeks	Topics	Activities	Assignments & Tasks	Readings	Learning Outcomes/Objectives
01	Nanochemistry Basics <ul style="list-style-type: none"> ❖ What is Nanochemistry? ❖ The Roots of Nanochemistry in Materials Chemistry ❖ Synthesis of materials and nanomaterials ❖ Supramolecular Vision ❖ Synthetic Creations with Natural Form ❖ Extending the Prospects of Nanomaterials Journal Paper Intro and Types/ Impact Factor/HJRS	Introduction Video Clip Presentation Discussion	Formative: Formative: PMI	Chapter 1 (Guozhong)	<ul style="list-style-type: none"> ❖ Explain what a nanometer is and list a number of examples of objects on that scale ❖ Has a good sense of the size of various micro- and nano-objects? ❖ Describe the history of the development of nanochemistry. ❖ Explain the relation between nanotechnology, Nanoscience and nanochemistry ❖ Define what is Impact factor of Journal how it is calculated ❖ Differentiate between research and review paper
02	Nanochemistry: Overview and Applications <ul style="list-style-type: none"> ❖ Overview of Properties of Nanomaterials ❖ Characterization tools of Nanomaterials ❖ Applications of Nanomaterials ❖ Disruptive applications Journal Paper Intro and Types/ Impact Factor/HJRS-Continued	Presentation Discussion Video Clip	Summative: Assignment # 1	Chapter 1 (Guozhong)	<ul style="list-style-type: none"> ❖ Explain various properties of nanomaterials ❖ Understand why nanosized is important ❖ Explain surface to volume ratio and its effect on properties ❖ Name various characterization tools and their use ❖ Discuss the various applications that can be expected from nanochemistry ❖ Understand HJRS system of Journal classification
03	Physical Chemistry of Solid Surfaces (Part A) <ul style="list-style-type: none"> ❖ Crystal Structures 	Lecture Presentation Group	Summative: Quiz # 1	Chapter 2 (Guozhong)	<ul style="list-style-type: none"> ❖ Understanding of the physico-chemical properties of nanomaterials in comparison to bulk materials, atoms and molecules.

	<ul style="list-style-type: none"> ❖ Surface energy ❖ Calculation methods ❖ How to reduce Surface Energy 	Discussion	Formative: Headlines		<ul style="list-style-type: none"> ❖ Basic knowledge on physical and chemical procedures for the fabrication and synthesis of nanomaterials ❖ Understand accurate description of Surface energy ❖ Describe and understand basics of Crystalline Structure of solids ❖ Describe and understand Phase Transformations in nucleation
04	Physical Chemistry of Solid Surfaces (Part B) <ul style="list-style-type: none"> ❖ Chemical potential as function of surface curvature ❖ Electrostatic Stabilization ❖ Steric Stabilization 	Lecture Presentation Group Discussion	Summative: Quiz # 2	Chapter 2 (Guozhong)	<ul style="list-style-type: none"> ❖ Describe chemical potential and its role in nanosynthesis ❖ Knowledge of basic surface functionalization and coating procedures for nanomaterials ❖ Demonstrate a basic knowledge of key issues related to materials with nanoscale dimensions, and describe a number of application areas
05	Zero Dimensional Nanostructures: Nanoparticles (Part A) <ul style="list-style-type: none"> ❖ Nanoparticles through bottom up approach ❖ Nanoparticles through top down approach ❖ Nanoparticles through homogeneous nucleation 	Lecture Presentation Group Discussion Case Study Topics will be discussed	Summative: Quiz # 3 Student Presentations** Formative: Exit Slip	Chapter 3 (Guozhong)	<ul style="list-style-type: none"> ❖ Explain different classes of Nanomaterials ❖ Tell the difference between bottom-up and top-down techniques. ❖ Set up a basic process outline for the fabrication of certain nanostructures. ❖ choose appropriate synthesis technique to synthesize quantum nanostructures of desired size, shape and surface properties ❖ Name applications of nanoparticles.
06	Zero Dimensional Nanostructures: Nanoparticles (Part B) <ul style="list-style-type: none"> ❖ Nanoparticles through heterogeneous nucleation ❖ Kinetically confined synthesis of Nanoparticles ❖ Epitaxial Core-Shell Nanoparticles 	Lecture Presentation Group Discussion	Summative: Assignment # 2 Student Presentations Formative: Think-Pair-Share	Chapter 3 (Guozhong)	<ul style="list-style-type: none"> ❖ Knowledge of related terminology, numbering and classification systems ❖ Describe bottom-up and top-down strategies for making nanostructured materials. ❖ List solution based techniques used for the fabrication of nanomaterials. ❖ Describe co-precipitation technique and compare it with other solution based techniques. ❖ Describe sol-gel technique and compare it with other solution based techniques. ❖ Describe microemulsion synthesis technique and compare it with other solution based techniques. ❖ Explain the underlying principle of morphology and size control in solution-based fabrication techniques.

					<ul style="list-style-type: none"> ❖ Describe self-assembly route, explain the underlying principle for the fabrication of nanostructured materials. ❖ Give examples of nanostructured materials fabricated via self-assembly route. ❖ Describe mesocrystals and their formation using self-assembly principles.
07	One Dimensional Nanostructures: Nanowires (Part A) <ul style="list-style-type: none"> ❖ Spontaneous Growth ❖ Evaporation (or dissolution)-condensation ❖ Vapour (or solution)-liquid-solid (VLS or SLS) Growth ❖ Stress-induced recrystallization 	Lecture Presentation Group Discussion	Summative: Quiz # 4 Student Presentations Formative: One Minute Paper	Chapter 4 (Guozhong)	<ul style="list-style-type: none"> ❖ Suggest possible strategies for fabrication of one dimensional nanomaterial with given complexity. ❖ Design a strategy/strategies for the fabrication of one dimensional nanomaterials with defined composition, morphology and size constraints. ❖ Perform literature survey on physical and chemical fabrication routes.
08	One Dimensional Nanostructures: Nanowires (Part B) <ul style="list-style-type: none"> ❖ Temperature based Synthesis ❖ Electrospinning ❖ Lithography 	Lecture Presentation Group Discussion Video Clip	Summative: Student Presentations Formative: D.E.A.R	Chapter 4 (Guozhong)	<ul style="list-style-type: none"> ❖ Fabricate nanorods/nanotubes by template based methods ❖ Understand process of electrospinning
09	Mid Term Exam				
10	Two Dimensional Nanostructures: Thin films (Part A) <ul style="list-style-type: none"> ❖ Fundamentals of Film Growth ❖ Film growth methods ❖ Vapour-phase deposition ❖ Evaporation ❖ Sputtering ❖ Physical Vapour Deposition ❖ Chemical Vapour Deposition 	Lecture Presentation Group Discussion	Summative: Assignment # 3 Student Presentations	Chapter 05 (Guozhong)	<ul style="list-style-type: none"> ❖ Determine processes for nanomaterials nano thin films and coatings. ❖ classifies different materials and thin films depending on their application ❖ determine the new process techniques in these areas. ❖ determine the characterization techniques for nanomaterials and nano thin films ❖ can classify different techniques depending on application area
11	Two Dimensional Nanostructures: Thin films (Part B) <ul style="list-style-type: none"> ❖ Molecular beam epitaxy (MBE) ❖ Atomic Layer deposition 	Lecture Presentation Group Discussion Video clip	Summative: Quiz # 5 Student Presentations	Chapter 05 (Guozhong)	<ul style="list-style-type: none"> ❖ understand the fundamental atomistic mechanisms and processes that control film formation and microstructural evolution. ❖ understand the effect of the process conditions on film growth microstructural evolution. ❖ know the principle, the advantages and the

	<p>(ALD)</p> <ul style="list-style-type: none"> ❖ Self Assembly ❖ Atomic Layer Deposition ❖ Sol-Gel Films 				<p>disadvantages of different thin film deposition methods.</p> <ul style="list-style-type: none"> ❖ have insights in possibilities and the importance of different thin films and coatings for a variety industrial applications
12	<p>Special Nanomaterials</p> <ul style="list-style-type: none"> ❖ Carbon and Fullerenes ❖ Nanotubes ❖ SWNT ❖ MWNT ❖ Micro and Mesoporous Materials 	<p>Lecture Presentation Group Discussion</p>	<p>Formative: 3-2-1</p> <p>Summative: Quiz # 6 Student Presentations**</p>	<p>Chapter 06 (Guozhong)</p>	<ul style="list-style-type: none"> ❖ Describe Nano diamond particles and diamond like carbon films. ❖ Analyze the properties of carbon nanotubes ❖ Illustrate the synthesis of carbon nanotubes. ❖ Explain the applications of carbon Nano tubes ❖ Have the knowledge of structures, mechanism of formation of carbon nano structures including fullerene, CNT, carbon nano-particles and their applications in solar cells, medicine and superconductors. ❖ Acquired the skills of formation of carbon nano structures.
13	<p>Characterization and Properties of Nanomaterials (Part A)</p> <ul style="list-style-type: none"> ❖ Structural Characterization ❖ Chemical Characterization ❖ Physical Properties of Nanomaterials ❖ Scanning Electron Microscope 	<p>Lecture Presentation Group Discussion Video clip</p>	<p>Formative: Exit Slips</p> <p>Summative: Quiz # 7 Student Presentations</p>	<p>Chapter 8 (Guozhong)</p>	<ul style="list-style-type: none"> ❖ Describe the fundamentals of the covered techniques. ❖ Identify a suitable technique for a proposed problem. ❖ The student will demonstrate an understanding of approaches to nanomaterials characterization ❖ Principles of operation and use of an scanning electron microscope.
14	<p>Characterization and Properties of Nanomaterials (Part B)</p> <ul style="list-style-type: none"> ❖ Transmission Electron Microscope ❖ Atomic Force Microscope ❖ XRD ❖ Other Characterization Techniques 	<p>Lecture Presentation Group Discussion Video clip</p>	<p>Summative: Quiz # 8 Student Presentations Submission Date of Case Study/Review Article</p>	<p>Chapter 8 (Guozhong)</p>	<ul style="list-style-type: none"> ❖ Principles of operation and use of an atomic force microscope. ❖ Tell the differences between the electron microscopy techniques. ❖ Tell the differences between the scanning probe techniques. ❖ Principles and operation of XRD ❖ List the limitations of the discussed techniques.
15	<p>Nanostructures Fabricated by Physical Techniques</p> <ul style="list-style-type: none"> ❖ Lithography 	<p>Lecture Presentation Group Discussion</p>	<p>Summative: Quiz # 9 Student Presentations</p>	<p>Chapter 7 (Guozhong)</p>	<ul style="list-style-type: none"> ❖ Students learn the main manufacturing methods of Microelectronics and Nanoelectronics. ❖ They understand the methods of Optical Lithography, Electron Beam lithography and

	<ul style="list-style-type: none"> ❖ Nanomanipulation and Nanolithography ❖ Soft Lithography ❖ Assembly of Nanoparticles and Nanowires ❖ Other Methods for Microfabrication 	Video clip			<p>Nano-imprint Lithography.</p> <ul style="list-style-type: none"> ❖ They learn the successive steps in building important electronic devices such as transistors and solar cells. ❖ Lithography and microscopy resolution limits
16	<p>Applications of Nanomaterials</p> <ul style="list-style-type: none"> ❖ Molecular electronics and Nanoelectronics ❖ Nanobots ❖ Biological Applications ❖ Catalysis by Gold Nanoparticles ❖ Quantum Devices ❖ Carbon Nanotube Emitters ❖ Photonic Crystals <p>Sessional Marks Display</p>	Lecture Presentation Group Discussion	Formative: 3-2-1 Summative: Student Presentations	Chapter 9 (Guozhong)	<ul style="list-style-type: none"> ❖ appreciate enhanced sensitivity of nanomaterial based sensors and their novel applications in industry ❖ Translate technology to a medical application. ❖ Identify the restrictions of such devices. ❖ Identify the sectors where bio-inspired nanostructured surfaces are needed. ❖ Translate technology to a agriculture, energy enhancing, water purification and other application. ❖ Students will be able to investigate, critique, evaluate research paper, ❖ Students will be able to demonstrate, implement, create, apply group project, and research paper ❖ Use computer and internet to preform reports on applications of nanomaterials
17	Student Presentation				Presentations from assigned research papers
18	Final Exam				

** Student Presentation will be from assigned research Papers

1. Research Paper Rubric

Name: _____ Date: _____ Score: _____

Category	Exceeds Standard	Meets Standard	Nearly Meets Standard	Does Not Meet Standard	No Evidence	Score
Title Page	Title Your Name, Teacher's Name, Affiliation, Date, Neatly finished-no errors	Evidence of four	Evidence of 3	Evidence of 2 or less	Absent	
Statement	Clearly and concisely states the paper's purpose in a single sentence, which is engaging, and thought provoking.	Clearly states the paper's purpose in a single sentence.	States the paper's purpose in a single sentence.	Incomplete and/or unfocused.	Absent, no evidence	
Introduction	The introduction is engaging, states the main topic and previews the structure of the paper.	The introduction states the main topic and previews the structure of the paper.	The introduction states the main topic but does not adequately preview the structure of the paper.	There is no clear introduction or main topic and the structure of the paper is missing.	Absent, no evidence	
Body	Each paragraph has thoughtful supporting detail sentences that develop the main idea.	Each paragraph has sufficient supporting detail sentences that develop the main idea.	Each paragraph lacks supporting detail sentences.	Each paragraph fails to develop the main idea.	Not applicable	
Organization- Structural Development of the Idea	Writer demonstrates logical and subtle sequencing of ideas through well-developed paragraphs; transitions are used to enhance organization.	Paragraph development present but not perfected.	Logical organization; organization of ideas not fully developed.	No evidence of structure or organization.	Not applicable	
Conclusion	The conclusion is engaging and restates the thesis.	The conclusion restates the thesis.	The conclusion does not adequately restate the thesis.	Incomplete and/or unfocused.	Absent	
Mechanics	No errors in punctuation, capitalization and spelling.	Almost no errors in punctuation, capitalization and spelling.	Many errors in punctuation, capitalization and spelling.	Numerous and distracting errors in punctuation, capitalization and spelling.	Not applicable	
Usage	No errors sentence structure and word usage.	Almost no errors in sentence structure and word usage.	Many errors in sentence structure and word usage.	Numerous and distracting errors in sentence structure and word usage.	Not applicable	
Citation	All cited works, both text and visual, are done in the correct format with no errors.	Some cited works, both text and visual, are done in the correct format. Inconsistencies evident.	Few cited works, both text and visual, are done in the correct format.	Absent	Not applicable	
Bibliography	Done in the correct format with no errors. Includes more than 5 major references (e.g. science journal articles, books, but no more than two internet sites. Periodicals available on-line are not considered internet sites)	Done in the correct format with few errors. . Includes 5 major references (e.g. science journal articles, books, but no more than two internet sites. Periodicals available on-line are not considered internet).	Done in the correct format with some errors. Includes 4 major references (e.g. science journal articles, books, but no more than two internet sites. Periodicals available on-line are not considered internet).	Done in the correct format with many errors. Includes 3 major references (e.g. science journal articles, books, but no more than two internet sites. Periodicals available on-line are not considered internet sites.)	Absent or the only sites are internet sites.	

2. Oral Presentation:

Name: _____ Date: _____ Score: _____

Select the box which most describes student performance. Alternatively you can "split the indicators" by using the check boxes before each indicator to evaluate each item individually.

	Exceeds Standard	Meets Standard	Nearly Meets Standards	Does Not Meet Standard	Score
Language Use and Delivery The student communicates ideas effectively	<ul style="list-style-type: none"> ☞ Effectively uses eye contact. ☞ Speaks clearly, effectively and confidently using suitable volume and pace. ☞ Fully engages the audience. ☞ Dresses appropriately, ☞ Selects rich and varied words for context and uses correct grammar. 	<ul style="list-style-type: none"> ☞ Maintains eye contact. ☞ Speaks clearly and uses suitable volume and pace. ☞ Takes steps to engage the audience. ☞ Dresses appropriately. ☞ Selects words appropriate for context and uses correct grammar. 	<ul style="list-style-type: none"> ☞ Some eye contact, but not maintained. ☞ Speaks clearly and unclearly in different portions. ☞ Occasionally engages audience. ☞ Dresses inappropriately. ☞ Selects words inappropriate for context; uses incorrect grammar. 	<ul style="list-style-type: none"> ☞ Uses eye contact ineffectively. ☞ Fails to speak clearly and audibly and uses unsuitable pace. ☞ Does not engage audience. ☞ Dresses inappropriately. ☞ Selects words inappropriate for context; uses incorrect grammar. 	
Organization and Preparation The student exhibits logical organization.	<ul style="list-style-type: none"> ☞ Introduces the topic clearly and creatively. ☞ Maintains clear focus on the topic.. ☞ Effectively includes smooth transitions to connect key points. ☞ Ends with logical, effective and relevant conclusion. 	<ul style="list-style-type: none"> ☞ Introduces the topic clearly. ☞ Maintains focus on the topic. ☞ Include transitions to connect key points. ☞ Ends with coherent conclusion based on evidence. 	<ul style="list-style-type: none"> ☞ Introduces the topic. ☞ Somewhat maintains focus on the topic. ☞ Includes some transitions to connect key points. ☞ Ends with a conclusion based on evidence. 	<ul style="list-style-type: none"> ☞ Does not clearly introduce the topic. ☞ Does not establish or maintain focus on the topic. ☞ Uses ineffective transitions that rarely connect points. ☞ Ends without a conclusion. 	
Content The student explains the process and findings of the project and the resulting learning.	<ul style="list-style-type: none"> ☞ Clearly defines the topic or thesis and its significance. ☞ Supports the thesis and key findings with an analysis of relevant and accurate evidence ☞ Provides evidence of extensive and valid research with multiple and varied sources ☞ Provides evidence of complex problem solving and learning stretch. ☞ Combines and evaluates existing ideas to form new insights. 	<ul style="list-style-type: none"> ☞ Clearly defines the topic or thesis. ☞ Supports the thesis and key findings with evidence. ☞ Presents evidence of valid research with multiple sources. ☞ Provides evidence of problem solving and learning stretch. ☞ Combines existing ideas to form new insights. 	<ul style="list-style-type: none"> ☞ Defines the topic or thesis. ☞ Supports the thesis with evidence. ☞ Presents evidence of research with sources. ☞ Provides some evidence of problem solving and learning stretch. ☞ Combines existing ideas. 	<ul style="list-style-type: none"> ☞ Does not clearly define the topic or thesis. ☞ Does not support the thesis with evidence. ☞ Presents little or no evidence of valid research. ☞ Shows little evidence of problem solving and learning stretch. ☞ Shows little evidence of the combination of ideas. 	
Questions and Answers	Demonstrates extensive knowledge of the topic by responding confidently, precisely and appropriately to all audience questions and feedback.	Demonstrates knowledge of the topic by responding accurately and appropriately to questions and feedback.	Demonstrates some knowledge of the topic by responding accurately and appropriately to questions and feedback.	Demonstrates incomplete knowledge of the topic by responding inaccurately and inappropriately to questions and feedback.	

3. Backboard of Presentation

Name: _____ Date: _____ Score: _____

	Exceeds Standard	Meets Standard	Nearly Meets Standard	Does Not Meet Standard	No Evidence	Score
Clarity of Topic	Includes a clear title which gives specific information about main topic.	Includes a title which gives information about the main topic.	Includes a title that gives some information about the main topic.	Missing a title or statement of the main topic.	Not present	
Details of Research	Includes all details from research and have clear labels, phrases, or sentence descriptions.	Includes most details from research and have clear labels or phrases.	Includes some details from research and have labels or phrases.	Includes only a few details from research using labels or phrases.	No details from research.	
Effectiveness	Viewer has a thorough understanding of topic researched. Backboard includes specific examples and/or illustrations in an organized manner.	Viewer has an understanding of the topic researched. Backboard includes examples and /or illustrations.	Viewer has some understanding of the topic researched. Backboard includes some examples and/or illustrations.	Viewer has difficulty understanding topic researched. Backboard includes few examples and/or illustrations.	Backboard does not communicate topic researched.	
Quality	Includes illustrations and labels. Content is edited for spelling and punctuation and has no errors.	Includes illustrations and labels. Content is edited for spelling and punctuation and has less than 3 errors.	Includes illustrations and labels. Content is not edited for spelling and punctuation and has more than 3 errors.	Does not include illustrations and labels and/or contains more than 3 errors in spelling and punctuation.	Work is haphazard and careless. Has none of the required elements.	