Fall 2019

CHEM 748-101: Nanomaterials

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NJIT New Jersey Institute of Technology

THE COLLEGE OF SCIENCE AND LIBERAL ARTS

THE DEPARTMENT OF CHEMISTRY AND ENVIRONMENTAL SCIENCE

Chemistry:
Fall 2019 Course Syllabus

NJIT Academic Integrity Code: All Students should be aware that the Department of Chemistry & Environmental Science (CES) takes the University Code on Academic Integrity at NJIT very seriously and enforces it strictly. This means that there must not be any forms of plagiarism, i.e., copying of homework, class projects, or lab assignments, or any form of cheating in quizzes and exams. Under the University Code on Academic Integrity, students are obligated to report any such activities to the Instructor.

COURSE INFORMATION

Course Description: This **3 credit** course [3 hrs/week of class] on Nanomaterials is designed to introduce advanced undergraduates and graduate students in chemistry, materials science, physics, electrical engineering and bio-engineering to the emerging area of nanotechnology that has the potential to revolutionize techniques by which materials and products will be created in the future with new and superior properties and functionalities. Nanotechnology refers to the world as it works on the nanometer scale from **below a nanometer to a few hundred nanometers**. The synthesis and control of nanomaterials will involve so-called **"bottom up"** strategies of self-assembly starting with the smallest possible entities, such as atoms and molecules, much in the same way as synthesis is conducted in biological systems. Some **"top down"** mechanical methods will also be discussed. The goal of the course will be to prepare and train students in this evolving technology which lies at the interfaces of chemistry, physics and biology. The course will start with fundamental concepts and then proceed to nanoscale phenomena and properties. This will be followed by discussions on the synthesis and self-assembly of nanomaterials and methods for their characterization. Emerging and potential applications of nanomaterials will be considered in the final segment of the course.

Number of Credits: 3

Prerequisites: Senior undergraduate level quantum mechanics, calculus, chemistry and physics

Course-Section and Instructor

Course-Section	Instructor
Chem 748-101	Zafar Iqbal

Office Hours: Monday- Friday 3-5 pm; iqbal@njit.edu

Recommended Textbook:

Title	The Physics and Chemistry of NanoSolids
Author	F.J. Owens and Charles P. Poole Jr

Edition	First, 2008
Publisher	John Wiley and Sons Inc, Hoboken, New Jersey
ISBN #	978-0-470-06740-6

University-wide Withdrawal Date: The last day to withdraw with a **W** is November 11, 2019 . It will be strictly enforced.

Learning Outcomes: Understanding the chemistry and physics of nanomaterials, how nanomaterials are synthesized including both bottom up and top down methods, how best to characterize nanomaterials, and finally to get an overview of conventional and potential applications in emerging areas of nanotechnology related to electronics, energy and biology.

POLICIES

All CES students must familiarize themselves with, and adhere to, all official university-wide student policies. CES takes these policies very seriously and enforces them strictly.

Grading Policy: The final grade in this course will be determined as follows:

Homeworks	20%
Quizzes and term paper	20%
Midterm Exam I	15%
Midterm Exam II	15%
Final Exam	30%

Your final letter grade in this course will be based on the following grade ranges:

A	80% and above	**C**	40-49.5
B+	70-79.5	**D**	30-39.5
B	60-69.5	**F**	Below 30
C+	50-59.5		

Attendance Policy: Attendance at classes will be recorded and is **mandatory**. Each class is a learning experience that cannot be replicated through simply "getting the notes."

Homework Policy: Homework is an expectation of the course. The homework problems set by the instructor are to be handed in for grading and will be used in the determination of the final letter grade as described above.

Exams: There will be two midterm exams held in class during the semester and one comprehensive final exam covering the entire course. The mid-term exam dates are tentative and are subject to change:

Midterm Exam I	October 18, 2019
Midterm Exam II	November 1, 2019
Final Exam Period	December 14 - 20, 2019

The final exam will test your knowledge of all the course material taught in the entire course.

Makeup Exam Policy: There will normally be **NO MAKE-UP QUIZZES OR EXAMS** during the semester. In the event that a student has a legitimate reason for missing a quiz or exam, the student should contact the Dean

of Students office and present written verifiable proof of the reason for missing the exam, e.g., a doctor's note, police report, court notice, etc. clearly stating the date AND time of the mitigating problem. The student must also notify the CES Department Office/Instructor that the exam will be missed so that appropriate steps can be taken to make up the grade.

Cellular Phones: All cellular phones and other electronic devices must be switched off during all class times. Such devices must be stowed in bags during exams or quizzes.

ADDITIONAL RESOURCES

Chemistry Tutoring Center: Located in the Central King Building, Lower Level, Rm. G12. Hours of operation are Monday – Friday 10:00 am - 6:00 pm. For further information please click here.

Accommodation of Disabilities: Office of Accessibility Resources and Services (***formerly known as Disability Support Services***) offers long term and temporary accommodations for undergraduate, graduate and visiting students at NJIT.

If you are in need of accommodations due to a disability please contact Chantonette Lyles, Associate Director at the Office of Accessibility Resources and Services at 973-596-5417 or via email at lyles@njit.edu. The office is located in Fenster Hall Room 260. A Letter of Accommodation Eligibility from the Office of Accessibility Resources Services office authorizing your accommodations will be required.

For further information regarding self-identification, the submission of medical documentation and additional support services provided please visit the Accessibility Resources and Services (OARS) website at:

- http://www5.njit.edu/studentsuccess/disability-support-services/

Important Dates (See: Fall 2019 Academic Calendar, Registrar)

Date	Day	Event
September 3	T	First Day of Classes
September 13	F	Last Day to Add/Drop Classes
November 11	M	Last Day to Withdraw
November 26	T	Thursday Classes Meet
November 27	W	Friday Classes Meet
November 28 – December 1	R - Su	Thanksgiving Break - University Closed
December 11	W	Last Day of Classes
December 12-13	R - F	Reading Days
December 14 - 20	Sa - F	Final Exam Period

Course Outline

Lecture	Section	Topic	Assignment
1		I. Introduction 1. Definitions and course organization 2. Historical development of nanomaterials 3. Classification of nanomaterials	Homework 1

2,3		II. Size & Scale 1.Units 2.Scaling Atoms, Molecules, Clusters and Supramolecules 3. Structure and Bonding in Nanomaterials Chemical Bonds (types and strength) Inter-molecular Forces Molecular and Crystalline Structures Hierarchical Structures Self-assembly and thermodynamics	Homeworks 2, 3
4,5		III. Properties and Size dependence of properties 1.Chemical 2.Optical 3.Electrical 4.Magnetic 5.Mechanical 6.Theoretical Aspects-e.g. density functional theory	Homeworks 4,5
6,7		IV. Nanomaterial Synthesis 1.Chemical routes 2.Electrochemical methods 3. Vapor growth 4. Thin films methods: chemical vapor deposition, physical vapor deposition (sputtering, laser ablation), Langmuir-Blodgett growth 5.Mechanical methods: ball milling, mechanical attrition 6. Sol-gel methods 7. Synthesis of special nanomaterials: *carbon nanotubes, fullerenes, nanowires, porous silicon* 8. Bio-inspired synthesis 9. Nanocomposite fabrication 10.Nanolithography	Homeworks 6,7

8,9		V. Nanomaterial characterization techniques 1. Scanning and Transmission Electron Microscopy 2. Scanning Probe Microscopies: Atomic Force, scanning tunneling microscopy 3.Diffraction and scattering techniques 4.Vibrational spectroscopy 5.Surface techniques	Homework 8,9
10		VI. Applications 1.Nano-electronics	Homework 10, term paper
		2.Nanoscale chemical- and bio-sensing 3.Biological/bio-medical applications 4.Photovoltaic, fuel cells, batteries and energy applications 5.High strength nanocomposites 6.Nanoenergetic materials	
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