CHEM 6342
Nanotechnology – Fundamentals and Applications

Class location:	TBD
Lectures, time and location:	TBD
Lab times and location:	TBD
Instructor:	Dieter Cremer, 325 FOSC, ext 8-1300, dcremer@smu.edu http://smu.edu/catco/
Office Hours:	By appointment
Units:	3
Grading:	ABC Letter Grade
Class number	TBD

1. Rationale:

Nanotechnology (NT) is a rather young discipline, which came up in the nineties. Nevertheless, NT has gained so much importance within the last years that universities at all rankings have introduced or are going to introduce NT teaching programs. Predictions say that NT will change our lives and society more than computer technology and electricity have done together.

The course will provide an overview over NT. It will show that the nano regime is so different from other regimes because both classical and quantum effects can be active thus leading to unique properties of nano devices. NT is a highly interdisciplinary science, which will be reflected in the course by making reference to chemistry, physics, biology, pharmacy, and engineering. Applications of NT, as they are already in use today or as they are planned for the future, will be discussed.

2. Course Recommendations:

The course is designed to reach all graduate students who had have an education in chemistry, physics, engineering or biology. It does not require special knowledge in mathematics or theoretical physics. The course contents will be presented in self-sustained modules, which make it possible to follow the course without special knowledge. The course will prepare for the interdisciplinary work in NT.

3. Texts:

There are many books on NT, however none of these is suitable for a course at the undergraduate level. An updated reading list will be handed out 3 weeks before the course. However, it is not mandatory to buy any of the books listed. Instead, a compendium summarizing the course on 300 pages will be handed out over the period of the course.

4. Course Aims and Objectives:

The course will be presented in such a way that students from different areas (physics, engineering, chemistry, biology, etc.) will be able to follow it. The **general goal** of the course is to provide an introduction to and an overview over nanotechnology (NT). Apart from this, the course pursues a number of specific goals:

First, it will characterize NT as a multitude of different bottom-up and top-down-approaches. The present and future goals of NT have to become clear and its nature as a typical crossover discipline.

Second, it will provide a basic understanding of the physical laws and effects that are active in the nano-world. The relationship between these laws and the extraordinary properties of nano-devices will be outlined.

Third, it will provide an insight into the chemical materials and fabrication lines nowadays used in nanotechnology.

Fourth, it will emphasize the design concepts and strategies used today and in the near future to build molecular machines.

Fifth, it will demonstrate how the applications of NT will influence science of tomorrow and will change many sides of our life. The impact of NT on our society will be discussed.

Specific Learning Objectives:

By the end of this course, students:

- will be able to characterize major top-down and bottom-up strategies;
- will be able to understand the physical laws active in the nano-range and as they differ from those in the micro-range;
- will know the basics of the electronic structure of atoms, molecules, and nano-particles. Also, the student will know what forces act between atoms and/or molecules when nano-particles are generated;
- will be able to understand the physics of a quantum dot, a quantum wire, and a quantum well;
- will know the major chemical materials used in NT;
- will be aware of major fabrication strategies of nano-particles;
- will be able to understand the role and functioning of smart materials;
- will be able to understand the fundamental theory of electron and energy transfer
- will be able to understand the functioning of molecular switches;
- will be able to understand the problems and principles of solar energy conversion;
- will be able to understand the basic principles of molecular machines;
- will be able give an overview over the mechanical like motions of molecules created by special design concepts;
- will be able to understand the properties of carbon-nanotubes and their role for engineering nano-electronic devices.

General Education Learning outcomes:

Science and Technology

1) Students will be able of demonstrating basic facility with the methods and approaches of scientific inquiry and problem solving.

2) Students will be able of explaining how the concepts and findings of science in general, or of particular sciences, shape our world.

5. Course Outline:
The course contains the following topics:

1. General Concepts in Nanotechnology
1.1 What is nanotechnology?
1.2 History of nanotechnology
1.3 Classification of different areas of nanotechnology
1.3.1 Top-down Approach
1.3.2 Bottom-up Approach
1.4 The interdisciplinary nature of nanotechnology
1.5 What does nanotechnology offer for our future?
1.6 Nanotechnology and the Converging Technologies

2. Nanotechnology and the Nanosciences
2.1 Why does one use the term Nanotechnology rather than Nano-sciences?
2.2 Nano-Physics and Nano-Chemistry
2.2.1 Physics: Quantum Mechanics
2.2.2 Quantum Mechanics: The Physics of Smallness
2.2.3. Physics and Chemistry: Electronic Structure of Atoms
2.2.4 Types of Bonding
2.2.5 Molecular Interactions - van der Waals Interactions
2.2.6 Molecular Interactions - Hydrogen bonding
2.2.7 Molecular Interactions - Casimir effect
2.2.8 Molecular Interactions - Hydrophilic and Hydrophobic Effects
2.2.9 Molecular Interactions - π-Stacking
2.3. Nano-Chemistry
2.3.1 Colloidal Chemistry
2.3.2 Electrochemistry and Electrochemical Nanotechnology
2.4 Nanobiology
2.5 Nano-Pharmacy
2.6 Nanomedicine

3. Nanostructures
3.1 Aerogels
3.1.1 General Description of Aerogels
3.1.2 History of Aerogels
3.1.3 Intermezzo: Phase Diagrams and Critical Temperature
3.1.4 Formation of Aerogels
3.1.5 Properties of Aerogels
3.1.6 Applications of Aerogels

3.2 Fullerenes: Buckyballs
3.2.1 General Description of Spherical Fullerenes
3.2.2 Discovery of the first Fullerenes
3.2.2 The Structure of Buckminsterfullerene (Fullerene)
3.2.2.1 Intermezzo: Platonic Bodies

3.7.1 Q-dot structure
3.7.2 History of Q-Dots
3.7.3 Q-dot Properties
3.7.4 Quantum Confinement
3.7.5 Synthesis of Quantum Dots
3.7.6 Optical Properties of Quantum Dots
3.7.7 Electrical Transport Properties of Quantum Dots
3.7.8 Q-dot Bioconjugates
3.7.9 Toxicity of Quantum Dots

3.8 Magnetic molecules
3.8.1 Intermezzo: Ferromagnetism and Antiferromagnetism
3.8.2 Examples of Magnetic Molecules
3.8.3 Magnetic Relaxation and Magnetization Tunneling
3.8.4 Properties of Magnetic Molecules
3.8.5 Application Possibilities of Magnetic Molecules

3.9 Quantum Corrals
3.9.1 Properties
3.9.2 Kondo Effect
3.9.3 Quantum mirage

3.10 Nanoclays
3.10.1 Structure
3.10.2 Properties
3.10.3 Generation
3.10.4 Application

3.11 Self-Assembled Monolayers
3.11.1 Structure
3.11.2 Preparation of SAMs
3.11.3 Types of SAMs
3.11.4 Properties of SAMs
3.11.5 Application of SAMs

3.12. Carbon Nanofoam and Graphene
3.12.1 Carbon Nanofoam
3.12.2 Graphene
3.12.3 Generation of graphene sheets
3.12.4 Production of graphene transistor elements

Teaching Methodology: Lectures combined with exercises, assigned readings, class discussions, and student presentations. A computer lab complementing lectures and exercises is under development.

6. Student Responsibilities:

Since the course content is not summarized in any of the available books, it is mandatory for each student to attend lecture hours and exercises. Although attendance will not necessarily lead to a better grade, attendance is a prerequisite for being accepted for the student presentations, the quizzes, and the final exam. Any problems, which might come up in this connection should be discussed without delay with the course instructor.

7. Final Examination: Day and time TBD.

8. Grading Procedures:
Grades are based on the degree of learning and competence demonstrated in the quizzes, the exercises, student presentations, and the final exam. Final grades will be calculated according to the following scheme:

Quizzes	30 %
Student presentation	10%
Exercises	20%
Final exam	40%

Grading Table	A	100.0	-	90.0 %
	B	89	-	80.0 %
	C	79	-	70.0 %
	D	69	-	60.0 %
	F	59% and below		

Any problem with the final grading must be discussed with the course instructor within 8 days from the day of the return of the final exam

9. Statement of Honor Code:
All SMU Dedman College students are bound by the honor code. The applicable section of the code reads: "All academic work undertaken at the University shall be subject to the guidelines of the Honor Code. Any giving or receiving of aid on academic work submitted for evaluation, without the express consent of the instructor, or the toleration of such action shall constitute a breach of the Honor Code." A violation of the Code can result in an F for the course and an Honor Code Violation recorded on a student's transcript. Academic dishonesty includes plagiarism, cheating, academic sabotage, facilitating academic dishonesty and fabrication. Plagiarism is prohibited in all papers, projects, take-home exams or any other assignments in which the student submits another’s work as being his or her own. Cheating is defined as intentionally using or attempting to use unauthorized materials, information or study aids in any academic exercise. Academic sabotage is defined as intentionally taking any action, which negatively affects the academic work of another student. Facilitating academic dishonesty is defined as intentionally or knowingly helping or attempting to help another to violate any provision of the Honor Code. Fabrication is defined as intentional and unauthorized falsification or invention of any information or citation in an academic exercise.

10. Disability Accommodations:
Students needing academic accommodations for a disability must first contact Ms. Rebecca Marin, Director, Services for Students with Disabilities (214-768-4557) to verify the disability and establish eligibility for accommodations. They should then schedule an appointment with the professor to make appropriate arrangements.

11. Religious Observance:
Religiously observant students wishing to be absent on holidays that require missing class should notify their professors in writing at the beginning of the semester, and should discuss with them, in advance, acceptable ways of making up any work missed because of the absence.

12. Excused Absences for University Extracurricular Activities:
Students participating in an officially sanctioned, scheduled University extracurricular activity should be given the opportunity to make up class assignments or other graded assignments missed as a result of their participation. It is the responsibility of the student to make arrangements with the instructor prior to any missed scheduled examination or other missed assignment for making up the work.

13. Assessment:
In accordance with University regulations copies of student work may be retained to asses how the learning objectives of the course are being met.

14. Course Schedule:
Will be discussed in the first meeting worked out to accommodate best to the student needs.