

# Syllabus

MSc Chemical Engineering (M-CHE)

MME Track (version November 2016)

2016 / 2017

\*Please note that even though the information in this syllabus is gathered with the utmost care, you cannot derive any rights from this syllabus. At the moment of composing this syllabus not all course descriptions were available. **Please check Osiris regular for the most up-to-date information.**

Molecular & Materials Engineering (M1)				
	Block 1A	Block 1B	Block 2A	Block 2B
Core modules	<b>AMM Molecular and Biomolecular CT</b> (5 EC, Huskens)	<b>AMM Organic Materials Science</b> (5 EC, Vancso)	<b>AMM Inorganic Materials Science</b> (5 EC, Rijnders)	<b>AMM Project Inorg. Materials &amp; Mol. CT</b> (5 EC, Lai/Koster)
	<b>AMM Characterization</b> (5 EC, Schön)		<b>AMM Project Organic Materials</b> (5 EC, Hempenius)	<b>Tech. Venturing &amp; Soc. Embedding</b> (5 EC, Bliet/Konrad)
Electives (scheduled)	<b>Colloids and Interfaces</b> (5 EC, Lammertink)	<b>Advanced Molecular Separations</b> (5 EC, de Vos/Schuur)	<b>Physical Organic Chemistry</b> (5 EC, Jonkheijm)	<b>Biochemistry</b> (5 EC, Poot)
	<b>Controlled Drug and Gene Delivery</b> (5 EC, Bansal)	<b>Batteries, Fuel Cells &amp; Electrolysers</b> (5 EC, Bouwmeester)	<b>Biomedical Materials Engineering</b> (5 EC, Grijpma/Poot)	<b>Polymers &amp; Materials Science Practice</b> (3 EC, Hempenius)
	<b>Labcourse Chemistry for Biomed. Appls.</b> (5 EC, Grijpma)	<b>Advanced Ceramics</b> (5 EC, Winnubst)	<b>Elastomeric Technology</b> (5 EC, Blume)	
		<b>Advanced Catalysis</b> (5 EC, Lefferts/Mul)		<b>Photocatalysis Engineering</b> (5 EC, Mul)
		<b>Nanomedicine</b> (5 EC, Prakash)		
		<b>Lab on a chip</b> (5 EC, Eijkel)		
		<b>Biomedical Materials Engineering</b> (5 EC, Grijpma/Poot)		
Electives (not scheduled)	<b>Theory of Phase Equilibria</b> (5 EC, van der Hoef)			
	<b>Lab Course Advanced Materials</b> (5 EC, ten Elshof)			
	<b>Chemistry of Inorganic Materials and Nanostructures</b> (5 EC, ten Elshof)			
	<b>Imperfections</b> (5 EC, Koster)			
	<b>Polymer Physics</b> (5 EC, Vancso)			
	<b>Organic Chemistry of Polymers</b> (5 EC, Dijkstra)			

	<b>Bioinspired Molecular Engineering (5 EC, Jonkheijm)</b>			
	<b>Contract Research (5 EC, Betlem)</b>			
	<b>Capita selecta ... (5 EC)</b>			
	<b>Molecular &amp; Materials Engineering (M2)</b>			
	Block 1A	Block 1B	Block 2A	Block 2B
Core modules	<b>Internship</b> (20 EC, Folkers)			
	<b>Final project MSc</b> (45 EC)			

## Block structure

The MSc Chemical Engineering program is a 2-year program (120 EC). As all other BSc and MSc programs at the University of Twente the year starts in September and ends at the beginning of July. Each year is divided into 4 blocks, which are referred to as 1A, 1B, 2A and 2B.

Block		Weeks	Dates
Block 1A	Instruction weeks	36 - 43	Sep 5 - Oct 28
	Exam weeks	44, 45	Oct 31 - Nov 11
Block 1B	Instruction weeks	46 - 51, 1, 2	Nov 14 - Dec 23, Jan 9 - Jan 20
	Exam weeks	3, 4	Jan 23 - Feb 3
Block 2A	Instruction weeks	5 - 7, 9 - 14	Feb 6 - Feb 17, Feb 27- April 7
	Exam weeks	15, 16	April 10 - April 21
Block 2B	Instruction weeks	17 - 25	April 24 - June 23
	Exam weeks	26	June 26 – June 30

## Core modules

193700020		<b>AMM – Molecular and Biomolecular Chemistry and Technology</b>
5 ec	1A	
Lecturer(s)	Prof.dr. J.J.L.M. Cornelissen, prof.dr.ir. J. Huskens	
Objective	Molecular recognition is an essential phenomenon in living systems as well as in artificial ones. It describes the specific interaction between molecules, ranging from discrete complexes to large architectures. The course will discuss supramolecular systems going from basic molecular recognition (involving single, monovalent interactions), to systems with cooperativity and/or multivalency, and finally to large polyvalent systems. For all subclasses, molecular and biomolecular examples will be discussed as well as materials applications.	
Content description	<ol style="list-style-type: none"> <li>1. Noncovalent interactions, development of supramolecular chemistry (incl. the Excel modeling of thermodynamic equilibria)</li> <li>2. Synthetic host-guest chemistry I: cation-binding hosts</li> <li>3. Synthetic host-guest chemistry II: binding of guests in solution</li> <li>4. Molecular recognition in biological systems, enzyme catalysis</li> <li>5. Sensor concepts and sensor devices</li> <li>6. Cooperativity: molecular and biomolecular (e.g. hemoglobin) examples</li> <li>7. Multivalency: effective molarity concept, cyclization, cell membrane recognition</li> <li>8. Polyvalent systems I: macromolecular assembly + supramolecular polymers</li> <li>9. Polyvalent systems II: coordination polymers, MOFs</li> <li>10. Polyvalent systems III: proteins and protein folding</li> <li>11. Polyvalent systems IV: virus assembly</li> <li>12. Polyvalent systems V: DNA + artificial DNA constructs</li> <li>13. Polyvalent systems VI: layer-by-layer assembly</li> <li>14. Polyvalent systems VII: supramolecular materials</li> </ol>	
Prior knowledge	Required: Organic chemistry & Thermodynamics	
Course material	<ul style="list-style-type: none"> <li>- Supplementary handouts (review articles, presentation files)</li> <li>- "Supramolecular Chemistry", J.W. Steed &amp; J.L. Atwood, 2009, 2nd edition, Wiley (<b>required</b>)</li> <li>- "Organic Chemistry", Paula Y. Bruice, 2007, 5th edition, Pearson International Edition/Prentice Hall (or older/newer edition) (chapters and paragraphs on structure of carbohydrates, proteins, and nucleic acids (<b>recommended</b>))</li> </ul>	

<b>193700010</b>		<b>AMM - Characterization</b>
<b>5 ec</b>	<b>1A</b>	
Lecturer(s)	Prof.dr.ir. J. Huskens, prof.dr.ing. A.J.H.M. Rijnders, dr. P.M. Schön, prof.dr. G.J. Vancso	
Objective	To explain and identify the physical and instrumental principles of techniques used for the molecular and continuum (macroscopic) scale characterization of organic and inorganic materials and their application to specific questions. By the end of this course the students are able to estimate specific materials and molecular properties from given examples and problems.	
Content description	<p>Materials Characterization refers to the use of techniques to probe into the internal structure and properties of molecules and materials. This course includes various modern, state of the art analytical techniques to characterize structure and properties of advanced materials and molecules. It emphasizes the general applicability to organic and inorganic materials. The central goal is to provide a fundamental understanding of various aspects of molecular and continuum (macroscopic) scale characterization of organic and inorganic materials, which are divided into various problems:</p> <ol style="list-style-type: none"> <li>1. Molecular characterization</li> <li>2. Ensemble characterization <ul style="list-style-type: none"> <li>- in solution</li> <li>- in solid state</li> </ul> </li> <li>3. Surface / Interface characterization</li> <li>4. Heterogeneous systems: dispersions, particles</li> </ol>	
Prior knowledge	Basic knowledge in Physical Chemistry, Organic and Inorganic Chemistry and Materials Science.	
Course material	Handouts; review articles; Powerpoint presentations of the lectures. Yang Leng, Materials Characterization John Wiley & Sons, 2008 (recommended, as supporting material, covers only partly the course topics)	

<b>193700030</b>		<b>AMM – Organic Materials Science</b>
<b>5 ec</b>	<b>1B</b>	
Lecturer(s)	Prof.dr. G.J. Vancso	
Content description	Organic materials feature enormous variations in their physical properties as a result of the tremendous wealth of the different possible existing molecular structures of carbon based compounds. The consequence of this plethora of properties is that function and use of organic materials can be tailored by controlling molecular structure virtually at will by using modern synthetic approaches, allowing one to realize many advanced applications, which belonged to the realm of phantasy just a few decades ago. In this lecture molecular structure-property relations will be discussed for the different types of (advanced) synthetic and natural (macromolecular) organic materials, including man-made polymers, liquid crystals, carbon allotropes (nanotubes, fullerenes and graphenes), dendrimers, nucleic acids, proteins and polysaccharides.	

	<p>Materials selection diagrams will be used to compare organic, inorganic, metallic and other materials, focusing on mechanical properties. Similarities and differences on the basis of molecular/atomic structures among the different classes of materials will be elucidated. Approaches will be treated which allow materials engineers to quantitatively estimate physical properties based on the molecular structure (by the so-called group contribution techniques). Effects of processing on structure (texture) and hence on properties will be demonstrated. A description and comparison of the major classes of the most frequently used industrial polymers for different function will complement this course. This is an advanced level graduate course, thus basic knowledge of organic chemistry, materials science and polymer science taught in the bachelor curriculum is a prerequisite and will be assumed.</p> <ul style="list-style-type: none"> <li>- Introduction (course overview, keywords of knowledge required, exam expectations, recommended literature) (lecture notes)</li> <li>- Overview of structures of the major classes of organic materials (polymers, liquid crystals, carbon allotropes (nanotubes, fullerenes and graphenes), dendrimers, nucleic acids, proteins and polysaccharides (lecture notes)</li> <li>- Materials selection diagrams, organic, metallic and ceramic materials contrasts and similarities (M.F. Ashby, Materials Selection in Mechanical Design)</li> <li>- Carbon allotropes as molecular building blocks (fullerenes, carbon nanotubes and graphenes)</li> <li>- Dendrimers and hyperbranched structures</li> <li>- Elastomers, rubber and hydrogels</li> <li>- Liquid crystals as functional materials</li> <li>- Relationships between polymer structure and properties Part I: main chain effects (H.R. Allcock et al., Contemporary Polymer Chemistry, 3rd Ed. Chapter 22)</li> <li>- Relationships between polymer structure and properties Part II: side chain effects (H.R. Allcock et al., Contemporary Polymer Chemistry, 3rd Ed. Chapter 22)</li> <li>- Group contribution techniques for estimating properties based on molecular structure (D.W. van Krevelen, Properties of Polymers); Calculation examples</li> <li>- Industrial polymers (H. Ulrich, Introduction to Industrial Polymers)</li> <li>- Influence of processing, texture and anisotropy Part I. (I.M. Ward, Editor, Structure and Properties of oriented Polymers)</li> <li>- Influence of processing, texture and anisotropy Part II. (I.M. Ward, Editor, Structure and Properties of oriented Polymers)</li> <li>- Electroactive organic materials</li> <li>- Photonic organic materials (solar cells, light emitting organics, photochromism, photonic band gap materials)</li> <li>- Natural organic engineering materials</li> </ul>
Prior knowledge	Chemie & Technologie van Organische Materialen (CTOM, 19135539)
Course material	"Soft condensed matter", Richard A.L. Jones, ISBN 978-0-19-850590-7

<b>193700040</b>		<b>AMM – Inorganic Materials Science</b>
<b>5 ec</b>	<b>2A</b>	
Lecturer(s)	Dr.ir. G. Koster, prof.dr.ing. A.J.H.M. Rijnders	
Objective	The aim is to provide knowledge of fundamental aspects of the structure/composition in relation to the properties and performance of advanced inorganic materials.	
Content description	These are novel materials or modified materials with new or enhanced properties to cope with the increased demands in technological applications. These are, amongst others, electronic applications (dielectrics and ferroelectrics), optical applications (transparent conducting oxides) and materials for energy production and storage (ionic conductors, and mixed electronic/ionic conductors). The course consists of three parts: Landau theory (e.g., ferroelectrics), defect chemistry (oxides) and group theory of crystal symmetry (e.g., ferroelectrics). These topics will be discussed using recent articles.	
Prior knowledge	Required: Chemistry and Technology of Inorganic Materials	
Course material	"Understanding solids: the science of materials", R. Tilley, Wiley 2007 (required)	

<b>193700050</b>		<b>AMM – Project Organic Materials</b>
<b>5 ec</b>	<b>2A</b>	
Lecturer(s)	Dr. M.A. Hempenius	
Objective	This Lab course aims to broaden the knowledge and skills of students in the areas of polymer synthesis, polymer characterization, and processing. The course illustrates structure-property relations in polymeric materials, i.e. how polymer chain characteristics and composition influence macroscopic properties.	
Content description	The following topics are included: 1. Well-defined polymers by Anionic Polymerization. 2. Thin polymer films as separation media. 3. Polymer characterization in solution. 4. Designer surfaces by polymer grafting. 5. Smart materials. 6. Micro / nanofabrication with polymers.	
Course material	Manuals describing the various experiments (will be provided)	

<b>193700070</b>		<b>AMM – Project Inorganic Materials &amp; Molecular S&amp;T</b>
<b>5 ec</b>	<b>2B</b>	
Lecturer(s)	Dr. S.C.S. Lai, dr.ir. G. Koster	
Objective	The course is aimed at exposure to a variety of synthesis and characterization techniques by means of two practical projects. The possible projects are embedded in six research groups with different research themes	
Prior knowledge	AMM or AMS courses (required)	
Assessment	Two reports	

<b>193799009</b>	<b>Internship</b>
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<b>20 ec</b>	-	
Contact person	<u>Ing. A. Folkers</u>	
Aims	<ul style="list-style-type: none"> <li>- To perform an assignment applying the principles and methods of Chemical Engineering in a practical situation,</li> <li>- to gain insights into the functioning of a professional organization,</li> <li>- to obtain specific competencies necessary for working in a professional institute or company,</li> <li>- to gain insights about the field of Chemical Engineering.</li> </ul>	
Content description	<p>The internship is an integral part of the Master of Science of Chemical Engineering programme. (Master's students with a preceding HBO-bachelor diploma have an adapted programme without an internship period. If these students wish, they may ask for an internship period as well as an additional course).</p> <p>The internship has to be scheduled in the first or the second year of the master, has to cover at least 13 weeks (20EC) and should be conducted preferably at a company but can also be conducted at a research institute or an university. Students may start the assignment after completing their bachelor Degree. The TNW master programmes offer several opportunities for adding an international dimension to the knowledge and the practical experience of a student. Therefore the internship may be carried out in the Netherlands or abroad. We believe a stay abroad is a valuable component of the study; therefore stimulating measures like the Twente Mobility Fund (TMF-fund) and the Erasmus-scholarship are available.</p> <p>The internship is coordinated by the internship coordinator. Orientation for internship has to start half a year prior to national internship and a year prior to international internship. This time is required for actual arrangements of the internship, such as getting an accommodation, visa and all formalities. Application for the internship has to be submitted to the Student Mobility System <a href="http://webapps.utwente.nl/srs/en/srsservlet">http://webapps.utwente.nl/srs/en/srsservlet</a> All relevant information, internship posts and all required forms for the internship can be found on the <b>Blackboard</b> organization 'Internships TNW'. International students should also contact Rik Akse during the arrangement of the internship. (<a href="mailto:h.a.akse@utwente.nl">h.a.akse@utwente.nl</a> )</p>	
More information	Blackboard Organizations: Internship TNW <a href="http://www.tnw.utwente.nl/che/education/internship">http://www.tnw.utwente.nl/che/education/internship</a>	

<b>201300054 / 55</b>		<b>Master Thesis</b>
<b>25 / 20 ec</b>	-	
Contact person	dr.ir. B.H.L. Betlem	
Description	The individual master assignment is the completion of the master's programme. The main objective of the assignment is that the student learns and proves that (s)he is able to define, perform, complete and reflect a research project at a large degree of independence. The four learning objectives of the 'reporting and general aspects' are defined below. The assignment is performed in one of the	

	Chemical Engineering research chairs of the faculty of Science and Technology of the UT under the supervision of a mentor and the responsibility of a Master's Assignment Committee. Conditionally, the assignment can be done (partially) at another external UT-group or an external institute or organisation.
Content description	The student has to perform a substantial research or design project that meets scientific criteria. The level of profundity and complexity is defined by the chairman of the Master's Assignment Committee. The student completes the assignment with a written report (the MSc.-thesis) and an oral public presentation.
Assessment	The MSc.-assignment will be assessed with two marks. The first mark covers the quality of the research performance, whereas the second mark covers the other three mentioned objectives, concerning the reporting and general aspects of the research. For each mark a different course code has been assigned.
Codes	201300054 (25 ec): Master Thesis Scientific and Research Aspects (SRA) 201300055 (20 ec): Master Thesis Reporting and General Aspects (RGA)

## Elective modules

		<b>Advanced Catalysis</b>
5 ec	1B	
Lecturer(s)		Lefferts/Mul
		<b>More detailed information about this course will follow later, please check Osiris regular for the most up-to-date information.</b>

<b>193737010</b>		<b>Advanced Ceramics</b>
5 ec	1B	
Lecturer(s)		Prof.dr. A.J.A. Winnubst
Objective		The aim of the course is to obtain insights in processes, which play a role in the fabrication of inorganic (or ceramic) materials and ceramic coatings. If one has sufficient insight in the several process steps in ceramic fabrication it is possible to make a reproducible material with regard to microstructure and properties.
Content description		<p>Several steps in the fabrication process of ceramic materials are discussed and the importance to understand the effects of processing variables on the evolution of microstructural parameters is emphasized. Basic processes are treated like powder preparation, powder treatments (milling and mixing), forming into a green shape and sintering. Basic phenomena are e.g.: particle size, interaction between particles, nucleation/crystallization, solid state reactions and transport phenomena in solid state systems.</p> <p>The objective in materials process engineering is to find relations between (desired) materials properties and relevant microstructural parameters on one side and to understand which process parameter changes a certain microstructural parameter on the other hand.</p> <p>The basic processes and phenomena, as indicated above, will be treated in lecture notes and tutorials. An important aspect of the course is the in-depth treatment by the student of a specific part of a ceramic fabrication process. This project will be presented by means of a literature essay and a lecture. It is also possible to perform a small practical assignment, treating a specific part of the course. The content of this practical course is determined in consultation with the student.</p>
Course material		Lecture notes

<b>201300049</b>		<b>Advanced Molecular Separations</b>
5 ec	1B	
Lecturer(s)		Dr.ir. W.M. de Vos, dr.ir. B. Schuur
Objective		<p>At the end of the course the students should:</p> <ul style="list-style-type: none"> <li>- Be able to list relevant industrial (advanced) separations, including those applied in the energy, bulk chemical, fine chemical, and pharmaceutical</li> </ul>

	<p>industries. Understand their working principles, molecular basis of separation and role within larger processes.</p> <ul style="list-style-type: none"> <li>- Be able to make a motivated decision for a separation technology based on the molecular properties of the molecules to be separated.</li> <li>- Be able to analyze a separation technology related case, assess the technical feasibility of different separation technologies, and develop a separation process.</li> <li>- For fluid separations and membrane based separations, be able to calculate mass transfer and thermodynamic properties within a separation process. Be able to design a functional extractant, adsorbant or membrane for a given molecular separation.</li> </ul>
Content description	<p>In Advanced Molecular Separations, separation technology is discussed starting from molecular properties up to full scale processes. The focus is on choosing a separation technology for given molecular properties, and the subsequent molecular design of more advanced separation technologies.</p> <p>For two separation technologies, fluid separations and membrane technology, the molecular design and separation process are treated in much greater detail, including a discussion on useful models to describe thermodynamics and mass transfer. The course will include two tests, one on fluid separations and one on barrier separations, but will also include two assignments on selecting the right separation technology for a given separation case</p>
Course material	Reader and Henley, Seader and Roper: "Separation Process Principles, International Student Version, Third edition". ISBN: 9780470646113 <b>(required)</b>

<b>201200119</b>		<b>Batteries, Fuel Cells &amp; Electrolysers</b>
<b>5 ec</b>	<b>1B</b>	
Lecturer(s)	Prof.dr. H.J.M. Bouwmeester, dr. B.A. Boukamp	
Content description	<p>Introduction, basic principles and theory of:</p> <ul style="list-style-type: none"> <li>- Thermodynamics of electrochemical cells, losses and efficiency</li> <li>- Electrolyte membranes, membrane electrode assemblies</li> <li>- Electrode kinetics</li> <li>- Different types of batteries and fuel cells; SOFC, SAFC, PEMFC, DMFC, BioFC, AFC, primary and secondary batteries, etc.</li> <li>- Miniaturization and other recent trends</li> <li>- Societal relevance and acceptance</li> </ul>	
Course materials	Lecture notes "Fuel cell handbook", US Department of Energy, 2004	

<b>193740050</b>		<b>Biochemistry</b>
<b>5 ec</b>	<b>2B</b>	
Lecturer(s)	Dr. A.A. Poot	
Objective	To obtain basic knowledge of cellular processes.	
Content description	During this course basic knowledge is provided concerning compounds and processes in living cells. Topics include cell structure, biomembranes, amino acids, proteins and enzymes, the role of ATP, glycolysis and oxidative	

	metabolism, genetic information, gene regulation, recombinant DNA technology, tissues and cancer.
Prior knowledge	Desired: Chemistry and biology (high school-level)
Instruction mode	Self-study
Course material	“Essential Cell Biology”, Alberts et al., Garland Publishers, New York, 4e edition 2013, paperback ISBN 978-0-8153-4455-1 (recommended)

<b>201400143</b>		<b>Bioinspired Molecular Engineering</b>
<b>5 ec</b>	-	
Lecturer(s)	Dr. P. Jonkheijm	
Objective	Surface science for bio-applications. Surface modification strategies; stimuli-responsive surfaces; bioactive surfaces; micro- and nanopatterning of surfaces; cell repellent and adhesive surfaces; cell-material interfaces	
Content description	<p>It is generally accepted that synthetic and semi-synthetic materials are an asset for, among others, medical doctors trying to improve the quality of life of their patients. This can for example be achieved by replacing damaged organs or tissues with artificial hips, knees, heart valves, blood vessels and so forth. To successfully do this, however, the clinicians do need a solid understanding of how the artificial materials interact with the body of the patient and which biological feedback loops may be triggered or altered by, for example, implantation.</p> <p>Biomimetic materials chemistry is essentially founded on the recognition that in many aspects Nature is superior to human technology. It is much more clever if you wish. Because the first contact between tissue and material is always at the surface, the surface of a material needs very special attention from scientists and engineers as well as from clinicians. We will cover physical and chemical strategies for generating a specifically organized surface. Various surface architectures (supramolecular, polymer, hydrogels, etc) and properties (stimuli-responsive, gradient, biofouling, sensors, topography, patterning, etc) will be discussed. Model substrates for protein chips, cell adhesion, cell sheet production, cell mechanics, and electrode-tissue interaction will be discussed.</p>	

<b>201400283</b>		<b>Biomedical Materials Engineering</b>
<b>5 ec</b>	<b>1B</b>	
Lecturer(s)	Dr. A.A. Poot, prof.dr. D.W. Grijpma	
Objective	To understand the basic principles of polymer processing, biomaterial surface modification and tissue-biomaterial interactions in regenerative medicine. To learn how to draw up and defend a research proposal.	
Content description	This course deals with the basic principles of tissue-biomaterial interactions, surface modification of biomaterials and polymer processing for regenerative medicine. Moreover, groups of 3-4 students draw up a research proposal that has to be defended during a plenary session.	

<b>XXXXXXXXXX</b>		<b>Capita Selecta (MME track)</b>
<b>5 ec</b>	-	
Description	All research groups offer 5 EC Capita Selecta (C.S.) modules, that you can take as an elective in your MSc program. For detailed information on these, please contact the group leader for more information on the format and content. Underneath is the list of available C.S. courses (with contact persons)	
Available courses	<p>C.S. Biomaterials Science and Technology (201300052) Prof.dr. J.D. de Bruijn, prof.dr. D.W. Grijpma, dr. A.A. Poot, dr. D. Stamatialis</p> <p>C.S. Biomedical Chemistry (193742000) Dr.ir. J.M.J. Paulusse, prof.dr. J.F.J. Engbersen</p> <p>C.S. Biomolecular Nanotechnology (193700080) Prof.dr. J.J.L.M. Cornelissen</p> <p>C.S. Inorganic Materials Science (193770000) Prof.dr.ir. J.E. ten Elshof, prof.dr.ing. A.J.H.M. Rijnders</p> <p>C.S. MTP: Macromolecular Nanofabrication (193730070) Dr. M.A. Hempenius, dr. P.M. Schön, prof.dr. G.J. Vancso</p> <p>C.S. Molecular Nanofabrication (193775000) Prof.dr.ir. J. Huskens</p> <p>C.S. Catalytic Processes and Materials (193765000) Prof.dr.ir. L. Lefferts, prof.dr. K. Seshan</p> <p>C.S. Inorganic Membranes (193737000) Dr.ir. N.E. Benes, prof.dr. H.J.M. Bouwmeester, prof.dr.ir. A. Nijmeijer, prof.dr. A.J.A. Winnubst</p> <p>C.S. Membrane Technology (193735000) Dr.ir. A.J.B. Kemperman, dr.ir. W.M. de Vos</p> <p>C.S. Mesoscale Chemical Systems (193780000) Prof.dr. J.G.E. Gardeniers</p> <p>C.S. Soft Matter, Fluidics and Interfaces (201000218) Prof.dr.ir. R.G.H. Lammertink</p>	
<b>193770090</b>		<b>Chemistry of Inorganic Materials and Nanostructures</b>
<b>5 ec</b>	-	
Lecturer(s)	Prof.dr.ir. J.E. ten Elshof	
Objective	Chemistry of advanced functional inorganic materials	
Content description	The design and synthesis of advanced functional materials by chemical processing methods requires a thorough understanding of the basic reaction	

	mechanisms and physical phenomena that play a role in the sequence of steps that lead from starting molecular precursors via nanoparticles to the final functional solid. This course provides an introduction into the chemistry of inorganic materials, the most common chemical synthesis methods, and their deposition into low-dimensional nanostructures, thin films and micropatterns. Topics that are discussed in the course include inorganic molecules; structural solid state chemistry; physical chemistry of inorganic surfaces; nucleation and growth of nanoparticles; morphogenesis of particles with fractal-like structure; synthesis of inorganic materials; soft chemistry; thin films; low-dimensional nanostructures; soft lithography; sintering.
Prior knowledge	Required: Inorganic Chemistry (191330012) Desired: Colloids and Interfaces (193735060)
Assessment	Oral examination
Course material	Handouts Recommended books: "The Inorganic Chemistry of Materials", P.J. van der Put, Plenum Press, New York, 1998 (recommended). "Nanostructures & Nanomaterials", G. Cao, Imperial College Press, London, 2004 (recommended) "Basic Solid State Chemistry", A.R. West, 2nd edition, Wiley, Chichester, 1999 (recommended). "Sol-Gel", J.D. Wright, N.A.J.M. Sommerdijk, CRC Press, Boca Raton, 2000 (recommended).

<b>193735060</b>		<b>Colloids and Interfaces</b>
<b>5 ec</b>	<b>1A</b>	
Lecturer(s)	Prof.dr.ir. R.G.H. Lammertink	
Objective	<p>Learning objectives of this course include:</p> <ul style="list-style-type: none"> <li>• Gain insight in important interfacial aspects including interfacial energy and surface potential.</li> <li>• Be able to explain and describe different interfacial phenomena, such as: wetting, colloidal stability.</li> <li>• Become familiar with experimental techniques for measurement of various colloidal and interfacial properties (ex. zeta potential, streaming potential, contact angle, etc.) and interpretation.</li> <li>• Understand the applicability and limitations of various colloid-related theoretical frameworks, such as DLVO.</li> <li>• Critically evaluate scientific literature on interfacial phenomena.</li> </ul>	
Content description	<p>Description of colloids, surfaces and interfaces. All kinds of interfaces between different phases are treated. Thermodynamic descriptions of these interfaces are deduced. Several techniques for characterizing interfaces are discussed. During contact hours, the contents of will be presented and discussed, and exercises will be made and discussed. For each topic, a case assignment will be offered. Topics include:</p> <ul style="list-style-type: none"> <li>• Lifshitz-van der Waals Interactions</li> <li>• Polar/Acid-Base Interactions</li> </ul>	

	<ul style="list-style-type: none"> <li>• Wetting and Contact Angles</li> <li>• Electrostatics</li> <li>• Electrokinetic Phenomena</li> <li>• Electrostatic and Polymeric Stabilization of Colloids</li> <li>• Colloidal Phenomena (Marangoni-Effect, Ouzo effect, etc.)</li> </ul>
Course material	Handouts and other literature will be provided during the course

<b>193799700</b>		<b>Contract research (for study trip)</b>
<b>5.0 ec</b>	-	
Contact person	Dr.ir. B.H.L. Betlem	
Objective	The objective is to conduct a some research commissioned by an internal or external client. The project must be performed to the satisfaction of both the client and the supervisor. Both of them will evaluate the project and report.	
Content description	This Contract Research Assignment is conducted by groups of 2 students and is for the financial support of the international study tour. Projects are coming from internal and external customers. The assignment is coached by a staff member selected on the basis of the subject of the assignment. He/she coaches and helps the students but also grades the final result which is almost always a report for the customer.	

<b>193740010</b>		<b>Controlled Drug and Gene Delivery</b>
<b>5 ec</b>	<b>1A</b>	
Lecturer(s)	J.M. Metselaar	
Content description	<p>Controlled drug delivery technology represents one of the emerging and challenging frontier areas in the development of modern medication and pharmaceuticals. Controlled drug delivery systems aim to achieve more effective therapies which eliminates the potential for both under- and over-dosing originating from uncontrolled drug release and avoid the need for frequent dosing and target the drugs better to a specified area, minimizing drug side effects. Targeted drug delivery can be accomplished by the introduction of ligands (carbohydrates, hormones, and peptides) or antibodies to the drug delivery system in such a way that it binds preferentially to malignant cells that are uniquely expressing certain receptors at the cell surface. In gene therapy, a genetic disorder or chronic disease is treated by delivering DNA or RNA to the targeted cells, inducing or suppressing a specific genetic function like new immune activity, or the development of enzymes that destroy viral or cancerous genetic material within cells. The ideal drug or gene delivery system should be nontoxic, biocompatible, safe from accidental release, simple to administer, easy to fabricate and sterilise, and should have efficient drug or gene targeting specificity. Delivery systems based on polymeric backbones can fulfill the majority of these requirements and have come to the centre stage of biomaterials research in recent years. This course gives a review of the recent advances and directions of future developments in controlled release technology. Topics included are: fundamental principles of controlled drug and gene delivery and their pharmaceutical applications in various delivery routes (oral, pulmonary, nasal, ocular, brain, etc.); delivery from biodegradable</p>	

	polymeric systems (nanoparticles, hydrogels, microspheres, dendrimers, etc.), microstents and nanodevices; delivery in tissue engineering.
Course material	Handouts

<b>191156500</b>		<b>Elastomeric Technology</b>
<b>5 ec</b>	<b>2A+2B</b>	
Lecturer(s)	Prof.dr. A. Blume, dr. W.K. Dierkes	
Objective	Define performance criteria for rubber (as part of the broader polymer technology) articles and translate these into the design and production of compounds and articles with the specific visco-elastic or rubber-elastic material behaviour of elastomers.	
Content description	<p>Elastomer or Rubber Technology represents a sub-group of the wider field of polymer technology. It covers about 15% of the total polymer turnover. Polymer-technology originated from rubber-technology, but rubbers have kept their own identity because of their unique combination of resilience and form stability after extremely large deformations, commonly designated as "rubber-elasticity".</p> <p>Elastomeric articles always are there to perform a function, wherein the rubber-elastic properties are the key factor: e.g. a car-tire translates all car-drivers interventions into the car-road contact: accelerating, breaking, cornering, etc. In this functional performance, the design of the article, the composition of the elastomeric material - commonly prepared for the purpose and called "compounding" - and the manufacturing technique all come together and jointly determine the end-result.</p> <p>In this introductory course the structural characteristics and properties of elastomers are covered, as well as the basic principles of compounding, processing and vulcanization, all illustrated with representative examples of rubber applications.</p> <p>The course includes a 5 days laboratory training into rubber compounding, vulcanization and characterization of mechanical properties, mainly to illustrate and visualize the main processing and performance tests in use in the rubber world, as they are different from thermoplastic polymers.</p>	
Prior knowledge	Some basic knowledge of polymers	
Course material	<p>"Rubber Compounding", B. Rodgers (ed.), Marcel Dekker Inc., New York, Basel (2004)</p> <p>Lecture notes: "Elastomeric Technology" 115650, nr. 799</p>	

<b>193770070</b>		<b>Imperfections</b>
<b>5 ec</b>	<b>-</b>	
Lecturer(s)	Dr.ir. G. Koster	
Content description	<p>Study of a topic in solid state chemistry concerning a deviation from perfect crystallinity. For example, at a crystal surface, atoms are not similarly coordinated as the bulk atoms, point defects, color centers, quasi crystals etc. What are the consequences for the properties? Can defects be synthesized in a controlled manner and thereby the properties of a material. The course will be</p>	

	given in the form of informal lectures and discussion sessions. The students will give some lectures. The final grade is determined by homework and the lectures. Students are requested to contact the professor prior to the start of the course.
Prior knowledge	AMS courses
Course material	Defects in Solids, Richard J. D. Tilley, ISBN: 9780470077948, Copyright © 2008 John Wiley & Sons, Inc. <b>(required)</b> Inorganic Chemistry, Shriver and Atkins, 4th edition <b>(recommended)</b>

<b>193770030</b>		<b>Lab Course Advanced Materials</b>
<b>5 ec</b>	-	
Lecturer(s)	Prof.dr.ir. J.E. ten Elshof, dr.ir. G. Koster, prof.dr.ing. A.J.H.M. Rijnders	
Objective	Train practical skills in synthesis and characterization of modern functional inorganic materials.	
Content description	Functional inorganic materials (especially complex metal oxides) are used in almost every modern device. Inorganic materials exhibit properties that are mostly difficult or impossible to achieve with other materials, so their presence is often crucial for the functionality of a device. Nanoelectronics, superconductors, magnetic and many electrical materials are just some examples. The way in which inorganic components are made is usually decisive for the final crystallographic structure, microstructure and functional properties of the material. This lab course is intended as a hands-on introduction to the field of advanced functional inorganic materials, their synthesis and characterization. Students get an individual assignment depending on his/her interests. The assignment may focus on the deposition of thin films or nanostructures by advanced physical or chemical deposition methods, the characterization of crystallographic structure by X-ray diffraction, the characterization of microstructure by atomic force microscopy or electron microscopy, or a combination of these.	
Note	This is a practical course.	

<b>201400290</b>		<b>Labcourse Chemistry for Biomedical Applications</b>
<b>5 ec</b>	<b>1A</b>	
Lecturer(s)	Prof.dr. D.W. Grijpma, dr.ir. J.M.J. Paulusse	
Objective	In this laboratory course the students will acquire experimental skills related to polymer synthesis and characterization, as well as the processing of polymers into medical devices. The students will be able to analyse, discuss and present their results in a written report.	
Content description	In medical implants and -devices, polymer-based biomaterials play an essential role. This laboratory course covers a broad range of experiments in which the student prepares his/her own medical implant or device, and assesses its functionality. Research topics that are treated during this course include: <ul style="list-style-type: none"> <li>- Biodegradable polymer-based materials in implant devices and drug delivery</li> </ul>	

	<ul style="list-style-type: none"> <li>- Ring-opening polymerization and network formation by photo-polymerization</li> <li>- Advanced (composite) biomaterials and microstructures</li> <li>- Well-defined polymers and nanoparticles</li> </ul>
Note	Students can register for this course via dr. ir. J. Paulusse (j.m.j.paulusse@utwente.nl)
Course material	Handouts, course guide

<b>191211120</b>		<b>Lab on a Chip</b>
<b>5 ec</b>	<b>1B</b>	
Lecturer(s)	prof. dr. J.C.T. Eijkel	
Objective	To obtain understanding of the working principles, the basic elements and most relevant applications of Lab on a Chip.	
Content description	<p>The Lab on a Chip course will take the student to the world of miniaturised systems used in various fields of chemistry and life sciences. A "Lab-on-a-Chip" consists of electrical, fluidic, and optical functions integrated in a microsystem, and has applications in (bio)chemical and medical fields. The core of the lab-on-a-chip system is a microfluidic channel structure, through which fluid sample plugs with less than a nanoliter volume are propelled by hydraulic, electrokinetic or surface forces. The fluidic structures are machined in materials like fused silica, borofloat glass, or polymers. The course will discuss all aspects of such microsystems. After a thorough introduction on miniaturisation, the microfluidic and nanofluidic theoretical principles are treated, followed by aspects of microfabrication and a visit to the cleanroom. The effect of miniaturisation on sample preparation, separation and detection forms the next chapter of the course. Surface modification and kinetics plays a vital role in increasing selectivity and efficiency of the device. Finally, all theory comes together in the practical examples presented as selected topics: applications of miniaturized diagnostic devices in clinical measurements and in life sciences, experiments on the micrometer to the nanometer scale, manipulation and analysis of (living) cells and biomolecules and tissue engineering. At the end of the course, the students write a short thesis on a chosen subject. The course is aimed at MSc students of Biomedical Engineering, Electrical Engineering, Chemical Engineering, Mechanical Engineering or Applied Physics.</p>	
Prior knowledge	General physics at bachelor level ( <b>required</b> ); Biomedical Signal Acquisition (191210720), Micro Electro Mechanical Systems (191211050), Technology (191210730) ( <b>desirable</b> )	
Course material	Fundamentals of biomems and medical microdevices, Steven S. Saliterman, ISBN 081945977-1 (pdf copy will be available and one book per student is available to borrow from the research group, deposit required)	

<b>201200220</b>		<b>Nanomedicine</b>
<b>5 ec</b>	<b>1B</b>	
Lecturer(s)	J. Prakash, S. le Gac, dr. R. Gill, dr. T.G.G.M. Lammers, J.M. Metselaar	
Objective	The following are the learning objectives of the course. After the course, students	

	<p>a) are able to distinguish between active and passive targeting and explain their applicability for different diseases</p> <p>b) can explain the concept of active targeting, biological barriers for nanoparticles and cell-specific targeting and gene delivery</p> <p>c) are able to apply the knowledge of targeting technologies for in vivo diagnosis/imaging, image-guided drug delivery</p> <p>d) understand the concepts of microfluidics in nanomedicine such as point-of-care devices, molecular and single cell analysis and drug screening, in vitro diagnostics</p> <p>e) are able to explain design of a study, methods and interpret results of the given paper as well as critically analyze research papers on the topic a), b), c) and d).</p> <p>f) are able to write and present a research proposal and can fulfill the following criteria thereof:</p> <ul style="list-style-type: none"> <li>• identify and define a research problem, and take a scientific approach to solve the problem.</li> <li>• are able to design experimental plan</li> <li>• describe the application of the expected results.</li> <li>• are able to estimate budget</li> <li>• are able to work in a team</li> </ul>
Content description	<p>Nanomedicine is one of the most dynamic fields, which hold high potential to make a huge impact on the medical science. Nanomedicine is in general defined as medical applications of nanotechnology. In recent years, nanotechnologies have been applied for drug delivery, imaging/diagnostics, biosensing, in vitro diagnostics, and tissue engineering. One of the largest areas for nanomedicine is the drug delivery/targeting. Conventional medicine, which are either administered orally or with injections, are not always successful for achieving the desired therapeutic effects but rather show high side effects. Therefore, novel drug delivery systems are highly crucial to develop, using which the drugs can be specially delivered at the targeted site or even to the specific cell types. Using these novel approaches, high therapeutic effects and low/no side effects can be achieved. A large part of the course will be devoted to the drug delivery. Besides drug delivery, nanomedicine includes applications of nanomaterials for imaging and diagnostics as well as theranostics (therapeutics + diagnostics), which will be covered up during this course. Applications to drug delivery and imaging are mostly related to applications of nanotechnologies in vivo. However, nanomedicine also covers up in vitro applications such as diagnostics using biosensing techniques and microfluidics. Students will also write a research proposal during this course on an assigned topic of nanomedicine, which allows them to further develop their knowledge on this subject. Altogether this course provides a broader and in depth understanding of this emerging field of nanomedicine.</p>

<b>193740040</b>		<b>Organic chemistry of polymers</b>
5 ec	-	
Lecturer(s)		Prof.dr. P.J. Dijkstra

Content description	A study towards the main polymerization processes; step-, chain-, and ring-opening polymerization. Structure-properties relationships of natural and synthetic polymers
Prior knowledge	Required: General and (bio)organic chemistry
Instructional mode	Self-study
Course material	"Organic chemistry", Paula Y. Bruice, ISBN 978-0321663139

<b>193775020</b>		<b>Physical Organic Chemistry</b>
<b>5 ec</b>	<b>2A</b>	
Lecturer(s)	Dr. P. Jonkheijm, prof. dr. ir. J. Huskens	
Objective	Making correlations between stable organic structures and reactive intermediates enables students to develop reaction mechanisms using concepts of structure and bonding. The students will learn the ability to anticipate and design organic chemistry experiments and decipher their mechanism using concepts of kinetics and dynamics. Several examples from organometallic chemistry, bio-organic chemistry and enzymology are used to highlight the utility of the techniques in different fields. The students will advance their analysis of electronic structure theory by getting acquainted with notions of quantum mechanics. The students will apply these notions to the analysis of pericyclic reactions, photochemistry and electronic organic materials.	
Prior knowledge	Required: Structure and reactivity (191300041); Organic chemistry (191320013)	
Course material	"Modern physical organic chemistry", Eric V. Anslyn/ Dennis A. Dougherty, University Science Books, Sausalito, California, 2006 (required)	
Note	This course is offered in combination with C.S. Molecular Nanofabrication (193775000, prof. dr. ir. J. Huskens)	

<b>201000308</b>		<b>Photocatalysis Engineering</b>
<b>5 ec</b>	<b>2B</b>	
Lecturer(s)	Prof. dr. G. Mul, prof. dr. R. Lammertink	
Objective	Gaining fundamental and practical knowledge of the factors which determine the performance of photocatalytically active materials and reactors, as well as understanding design criteria for solar to fuel devices.	
Content description	Introduction to use of semiconductors in photocatalytic reactions, including Z-scheme configurations, and effects of (supported) catalyst properties (surface area, crystallinity, colloidal behaviour, and interfaces) on performance. Engineering guidelines of photocatalytic processes: we will discuss the effect of various reaction parameters, including light intensity, temperature, slurry density, and photoreactor design on achievable rates and efficiency. Methods to characterize photocatalytic performance, including some photocatalysis experiments in the PCS or SFI laboratories. Kinetics will be discussed on the basis of practical examples in microreactors, including several matlab tutorials on	

	modelling of mass and light transfer. Design criteria of solar to fuel devices, including assignment to design your own!
Prior knowledge	BSc in Chemistry, Chemical Engineering, Advanced Technology, or Physics
Course material	"Photocatalytic Reaction Engineering", Hugo de Lasa, Benito Serrano, Miguel Salaices, <a href="http://link.springer.com/book/10.1007%2F0-387-27591-6">http://link.springer.com/book/10.1007%2F0-387-27591-6</a> ), Matlab cases, and papers from the current literature
More info	Please contact Martina Overdulte (m.m.j.overdulte@utwente.nl) and register as "bijvakker" when not a student of the University of Twente. Otherwise through Blackboard.

<b>193730060</b>		<b>Polymer physics</b>
<b>5 ec</b>	-	
Lecturer(s)	Prof.dr. G.J. Vancso	
Content description	A coherent introduction at the graduate student level is offered into the properties and behavior of soft matter. The treatment follows the book "Soft condensed matter" of R.A.L. Jones. The content of the book will be discussed in small groups, allowing students to read/prepare and ask questions chapter by chapter. Focus is on a general overview of soft matter, phase transitions, colloidal dispersions, polymer gelation, molecular order, supramolecular self assembly in polymers, and soft matter in nature.	
Course materials	"Soft condensed matter", Richard A.L. Jones, ISBN 978-0-19-850590-7	

<b>193730040</b>		<b>Polymers &amp; Materials Science Practice</b>
<b>3 ec</b>	<b>2B</b>	
Lecturer(s)	Dr. M.A. Hempenius	
Objective	This laboratory course is an elective course where students can deepen their knowledge and skills in selected areas in polymer chemistry (synthesis, molecular characterization) and materials science.	
Content description	The topic of this Lab Course is "Controlled Polymerizations", we will perform a living/controlled ATRP polymerization of methyl methacrylate using a tetrafunctional initiator and aim to form a well-defined four arm star polymer. Then, a second block will be attached to create a core-shell star block copolymer. These materials are of interest in the biomedical field for imaging, drug loading, etc. During polymer synthesis, a glove box and vacuum lines will be used. Techniques that we use for characterization of these polymer architectures include <sup>1</sup> H NMR spectroscopy, Gel Permeation Chromatography (GPC), and Differential Scanning Calorimetry (DSC)	
Assessment	Reports	

<b>193720050</b>		<b>Theory of Phase Equilibria</b>
<b>5 ec</b>	-	
Lecturer(s)	Dr.ir. M.A. van der Hoef	
Content description	The first part of this course consists of a recapitulation of elementary thermodynamics from a more formal viewpoint by using state functions, rather	

than from processes, as is common in most undergraduate courses. This formalism will then be applied to a description of phase-equilibria between two or more phases of single component systems. This is followed by a description of phase equilibria in two- and three-component systems, where the solutions are considered to be ideal.

Finally, non-ideality is introduced via excess functions and activity models. The most important application is found in the calculation of the P-x,y diagram of a binary system, starting from well-known excess state functions such as the Peng-Robinson and the RKS equation of state. This calculation will require some code development. This course is highly suitable for self study, where assistance from the lecturer can be obtained on an individual basis, preferably by appointment. In any case it is requested to get into touch with the lecturer before commencing. In the case of self-study, the course can be done the whole year round. If there is sufficient interest, a limited set of lectures will be given, in principle in the block 2B.