Principles and Applications of Nuclear Chemistry

1.GENERAL

SCHOOL	NATURAL SCIENCES		
ACADEMIC UNIT	CHEMISTRY		
LEVEL OF STUDIES	UNDERGRADUATE		
COURSE CODE	**XA 742**	**SEMESTER**	**7th**
COURSE TITLE	PRINCIPLES AND APPLICATIONS OF NUCLEAR CHEMISTRY		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures	3	5
Seminars	1	
Laboratory work	1	
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Field of Science (Nuclear Chemistry), skills development
PREREQUISITE COURSES:	Typically, there are not prerequisite courses
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek. Teaching may be however performed in English in case foreign students attend the course.
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES
COURSE WEBSITE (URL)	

2.LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

By the end of this course the student will be able to:

1. Know the basic concepts related to radioactivity and its applications in Chemistry
2. Know the operation principles of radiation detection systems for γ-rays and β-particles and to handle them successfully
3. Manipulate radioactive substances safely and carry out measurements by using Geiger-Müller counter and scintillation detector.
4. Understand how basic determinations related to radioanalytical techniques are carried out.
5. Understand the basic processes that occur inside a nuclear reactor
6. Know the ways ionizing radiation interacts with matter (selected chemical and biological systems)
7. Know the process of monitoring and the units used to measure exposure to radiation and radiation dose

8. Know how matter have to be shielded and protected from ionizing radiation

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology	*Project planning and management*
Adapting to new situations	*Respect for difference and multiculturalism*
Decision-making	*Respect for the natural environment*
Working independently	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Team work	*Criticism and self-criticism*
Working in an international environment	*Production of free, creative and inductive thinking*
Working in an interdisciplinary environment	……
Production of new research ideas	*Others…*
	…….

By the end of this course the student will, furthermore, have developed the following skills (general abilities):

1. Ability to demonstrate knowledge and understanding of essential concepts and principles related to radiochemistry and its applications.
2. Ability to apply such knowledge to the solution of chemical problems using radionuclides.
3. Ability to apply such specific knowledge in as many other fields.
4. Ability to get more specific knowledge for professional development.

Generally, by the end of this course the student will, furthermore, have develop the following general abilities (from the list above):

Searching, analysis and synthesis of facts and information, as well as using the necessary technologies

Adaptation to new situations

Decision making

Autonomous (Independent) work

Exercise of criticism and self-criticism

Promotion of free, creative and inductive thinking

Respect to natural environment

Work design and management

3.SYLLABUS

1. Introduction to Radiochemistry

Discovery of radioactivity, forces in matter and subatomic particles, nuclides and natural decay series.

2. Nuclear properties

Description of nucleus, mass and energy relationships

3. Types of radioactive decay.

α-, β- and γ-decay

4. Rates of nuclear decay.

Rates of radioactive decay, units of radioactivity

5. Nuclear reactions

Types, energetics, cross sections of nuclear reactions, fission, fusion.

6. Activation analysis.

Overview and Principles of Nuclear Activation Analysis – Principles of Charged Particle Activation Analysis – Advantages and Disadvantages of Nuclear Activation Methods – Sources of Activating Particles or Radiations – Qualitative and quantitative determination of elements applying Neutron Activation Analysis – Interferences in Activation Analysis – Primary Interference Reactions – Gamma Ray Spectral Interferences –

Overview of all Neutron Activation Procedures (TNAA, ENAA, FNAA, INAA, RNAA) – Application of all aforementioned types of Activation Analysis in different research areas and in real life.

7. Principles of Nuclear Reactors

Multiplication factor – Demonstration of the four factor formula – The Nuclear Fuel (Abundances of Isotopes of Natural Uranium, Enrichment) – Moderators and Coolants in different types of Reactors – Control Materials and Reactor's control via Delayed Neutrons – Types of Reactors (Light and Heavy Water Reactor, Homogeneous and Heterogeneous Reactor, Breeder Reactor)

8. Interactions of radiation with matter

Ionizing and non-ionizing radiation (α- & β- particles, γ-rays, accelerated charged particles beams and neutrons) – Ionizing Radiation Sources (natural or artificial radionuclides-sources, accelerators, nuclear reactors) – Modes of ionizing radiation interaction with matter (interaction of charged particles, neutrons and electromagnetic radiation with matter) - Linear Energy Transfer (LET) – Physical effects of radiation on matter

9. Health Physics

Radiation quantities and units – Primary and secondary dosimeters – Radiolysis of gases, water, aqueous solutions, solids, organic compounds and polymeric substances – Chemicals with radioprotective action – Biological Effects of Radiation – Sources of Radiation exposure (natural and artificial) - Radiation Protection and control – Anti-radioactive drugs

4.TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Lectures and laboratory work face to face.
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	Use of Information and Communication Technologies (ICTs) (e.g. PowerPoint, video etc) in teaching. The lectures content of the course for each chapter, all problems, in the form of a series of ppt files, and announces are uploaded on the internet, from where the students can freely download them.
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	

Activity	*Semester workload*
Lectures (3 contact hours per week × 13 weeks)	39
Tutorials (1 contact hours per week × 13 weeks)	13
Laboratory work (1 contact hour per week × 13 weeks)	13
Hours for private study of the student and optional problems solving given in each lecture, preparation for the Laboratory (study of techniques and theory) and writing reports, for the Laboratory exercises	44
Final written examination at the end of semester (3 contact hours × 1 time)	3
Three optional tests during the semester (1 contact hour × 3 times)	3
Course total	**125**

STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem*	1. At the end of the semester there is a final written examination with multiple choice questions and short answer questions (70% of the final mark). Laboratory exercises (30% of the total mark, taken into account only when the student secures the minimum mark of 5 in the final written examination). Minimum passing grade: 5 2. Optional delivery of solved problems (at least 2) each week, given in each lecture. Addition of 1 grade to the final exam grade (if it's

solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	higher than 5) of the students who have delivered all the solved problems and the percentage of the unit to the others, according to the number of solved problems each person has delivered. Addition of 1/10 of tests grade to the final exam grade (if it's higher than 5)

5.ATTACHED BIBLIOGRAPHY

- Suggested bibliography:

1. G. Choppin, J.-O. Liljenzin, J. Rydberg, C. Ekberg "Radiochemistry and Nuclear Chemistry", 4th Edition, Academic Press, USA 2013.
2. W.D. Loveland, D. J. Morrissey, G. T. Seaborg, "Modern Nuclear Chemistry", 2nd Edition, John Wiley & Sons, Inc., USA 2006.
3. A. Mozumder, "Fundamentals of Radiation Chemistry", Academic Press, USA 1999.
4. K.H. Lieser, "Nuclear Chemistry and Radiochemistry: Fundamentals and Applications", 2nd Rev. Edition, Wiley -VCH, Verlag GmbH, 2001.
5. W.D. Ehmann, D. E. Vance, "Radiochemistry and Nuclear Methods of Analysis", 1st Edition, Wiley-Interscience, 1991.
6. G.R. Choppin, J. Rydberg, "Nuclear Chemistry, Theory and Applications", Pergamon Press, New York, 1980.