"APPROVED"
Dean of the Faculty of Advanced Technologies and Chemistry

Prof. Stanisław CUDZIŁO

Warsaw, ..............................

SYLLABUS OF THE SUBJECT

Subject: The Chemistry of High-Energy Materials

Code of the subject:
Basic Organizational Unit: (managing the direction of studies): Institute of Chemistry
Direction of the studies: materials science
Specialization: high energy materials
Category of the studies: third degree studies
Form of the studies: full time studies
Official language: English
Validity of the syllabus for recruitment in the academic year: 2012/2013

1. REALIZATION OF THE SUBJECT

Lecturer’s name: Prof. Stanisław Cudziło; Dr Mateusz Szala; Dr Wojciech Kiciński

Basic organizational unit of the lecturer’s employment: Institute of Chemistry, Faculty of Advanced Technologies and Chemistry

2. TIME ACCOUNT

<table>
<thead>
<tr>
<th>semester</th>
<th>Form of teaching, lecture’s number / qualification (X - examination, + - credit, # - project)</th>
<th>ECTS points</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>total lectures recitations laboratories projects seminars</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>46      16x                                         16+           14+</td>
<td>5</td>
</tr>
<tr>
<td>total</td>
<td>46      16                                           16           14</td>
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3. INTRODUCTORY SUBJECTS AND PRELIMINARY REQUIREMENTS

- Organic Chemistry. Prerequisites: structure, functional groups, reaction mechanisms
- General and Inorganic Chemistry. Prerequisites: atomic structure and bonding
- Physical Chemistry. Prerequisites: reaction kinetics and thermodynamics

4. AIMS OF THE SUBJECT:

After successful completion of this course, students should be able to:
- understand the mechanism of explosion by chemical explosives,
- know and understand the methods and mechanism of nitration,
- know the structure, compositions and properties of current and novel energetic compounds and materials,
- prepare and test of explosive compounds at a laboratory scale.

5. TEACHING METHODS

- lecturing based on modern technical means enabling efficient transfer of information
- thermochemical calculations of explosive parameters
- experiments on synthesis of explosive compounds and formulation of explosive mixtures
- permanent checking and estimation of the students’ knowledge in the form of discussion, seminars, homework assignments etc
- self-study

6. SUBJECT CONTENTS

<table>
<thead>
<tr>
<th>No</th>
<th>Subject matter</th>
<th>Number of lecture hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>lect.</td>
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<tr>
<td>1.</td>
<td>The nature of explosions: physical, nuclear and chemical explosions. <strong>Types of explosive transformations</strong>: burning, deflagration, detonation. <strong>Thermochemistry of explosives</strong>: oxygen balance, decomposition reactions, heat and temperature of explosion, explosive power.</td>
<td>2</td>
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<tr>
<td>2.</td>
<td><strong>Basic properties and test methods for explosives</strong>: sensitivity, stability and performance of explosives.</td>
<td>2</td>
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<td>3.</td>
<td><strong>Classification and general characterization of explosives</strong>: the history, present and future development of explosives.</td>
<td>2</td>
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<td>4.</td>
<td><strong>Nitration – reagents, methods and mechanisms</strong>: aromatic and aliphatic C-nitration, N-nitration, O-nitration, technological aspects of nitration process.</td>
<td>2</td>
</tr>
<tr>
<td>5.</td>
<td><strong>Manufacture, properties and application of the commoner explosives</strong>: TNT, TATB, HNS, DADNE, NTO, NG, NC, PETN, RDX, HMX, HNIW, ADN; primary explosives: LA, LS, MF.</td>
<td>2</td>
</tr>
<tr>
<td>6.</td>
<td><strong>Introduction to propellants and pyrotechnics</strong>: composition, manufacture and properties of gun and rocket propellants, heat, smoke, light, gas, noise generating pyrotechnics.</td>
<td>2</td>
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<tr>
<td>7.</td>
<td><strong>Advanced energetic compounds</strong>: new energetic CHNO compounds and all-nitrogen materials.</td>
<td>2</td>
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<tr>
<td>8.</td>
<td><strong>Advanced explosive compositions</strong>: novel melt-cast explosives, thermobaric explosives, nanomixtures and nanocomposites, reactive materials.</td>
<td>2</td>
</tr>
<tr>
<td>9.</td>
<td>Final exam</td>
<td>2</td>
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<td></td>
<td><strong>Total</strong></td>
<td>16</td>
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Laboratories:
1. Synthesis of DADNE, RDX or PETN (4 hours)
2. Synthesis of LA or MF and casting of TNT charges (4 hours)
3. Preparation and testing of firecrackers, flares, and smoke producing mixtures (4 hours)
4. Synthesis of triaminoguanidine azotetrazolate (TAGAZ) or 3,3'-diamino-4,4'-azoxyfurazan (DAAF) (4 hours)

Seminar’s subject matter:
1. Thermochemical calculations (4 hours);
2. Indirect methods of nitration (2 hours);
3. Pyrotechnic mixtures and devices (2 hours);
4. Energetic nanocomposites and reactive mixtures (2 hours);
5. Thermobaric explosives (2 hours).
7. BIBLIOGRAPHY

Obligatory:

Complementary:

8. REQUIREMENTS FOR THE SUBJECT'S ACCEPTANCE

The subject is accepted based on the positive result of examination procedure, which includes:
- Homework problems that will be assigned with due dates throughout the course and some homework assignments will be collected (announced and unannounced) for grading.
- The participation in lectures, labs, and seminars
- Final exam covering the theory and practice of energetic materials that has been presented during lectures, labs and seminars.

The subject's author
Prof. Stanisław CUDZIŁO

Manager of the unit responsible for the subject
Prof. Jerzy CHOMA